Geological Survey, Prague, Czechoslovakia
in collaboration with
The Association of Geochemistry and Cosmochemistry,
Working group on Geochemical Prospecting
and
The Association of Exploration Geochemists

1990 PRAGUE
GEOCHEMIE

International Symposium on Geochemical Prospecting

METHODS OF GEOCHEMICAL PROSPECTING

Extended Abstracts

GEOLOGICAL SURVEY, PRAGUE

METHODS OF GEOCHEMICAL PROSPECTING

1990 PRAGUE
GEOCHEMIE

Geological Survey, Prague, Czechoslovakia
in collaboration with
The Association of Geochemistry and Cosmochemistry,
Working group on Geochemical Prospecting
and
The Association of Exploration Geochemists

International Symposium on Geochemical Prospecting

METHODS OF GEOCHEMICAL PROSPECTING

Extended Abstracts

Editors: J. Janatka, T. Hlavatá, I. Barnet, E. Jelínek

Prague 1990
Geological Survey, Prague

International Symposium on Geochemical Prospecting
METHODS OF GEOCHEMICAL PROSPECTING

Editors' board: J. Janatka, I. Barnet, T. Hlavatá, E. Jelínek
Published by the Geological Survey (Ústřední ústav geologický), Prague
Book jacket: Miloslav Cihelka
Technical editor: Jaroslava Bedrnová
Contributions have been published as manuscript submitted
by the authors

PART I. ENVIRONMENTAL GEOCHEMISTRY

Barnet I.: Radon risk mapping in Czechoslovakia ... 15
Belogolovov V. F., Zjablitsev A. Yu., Tyzhiov A. V.: Technogenic pollution of the Baikal lake basin snow cover with chemical elements ... 16
Fortescue J. A. C.: The use of lake sediment cores to map environmental change in Ontario, Canada ... 17
Ganeyev A. A., Mashjanov N. R., Ryzhov V. V., Sholupov S. E., Oveshnikov G. D.: Mercury haloes in the atmosphere (Geochemical and ecological aspects) ... 18
Lapo A.V., Vdovets M.S.: A phytogeochemical method for studying heavy metal contaminations of the technosphere ... 19
Luchin I.A., Komarov V.A.: Regional stream drainage hydro- and lithogeochemical survey for ore element and ecological environment evaluation ... 20
Lukashev V. K.: Geochemistry of technogenesis ... 21
Nezhdanova I. K., Suetin Yu. P., Sveshnikov G. B.: Ecological-geochemical evaluation of urban soil condition ... 22
Pälchen W., Ossenkopf P.: Geological and environment-related results of the regional geochemical and heavy mineral prospecting in the Erzgebirge Mts(GDR) ... 23
Palinkas L. A., Sholupov S. E., Mashyanov N. R., Durn G. and Miko S.: Mercury in atmosphere over rural, urban and industrial parts of Zagreb city ... 24
Perelman A.I., Anokhin A. B., Borisenko E. N., Lamakina N. B., Samonov A. E.: Landscape geochemistry and environmental problems ... 26
Rogers P. J., Ogden J. G.: Geochemical background: implications for environmental geochemistry in Nova Scotia, Canada ... 27
Runnells D. D.: Relationships between environmental and exploration geochemistry, illustrated by sediment-water interactions in a desert stream contaminated by mine wastes, Arizona, USA ... 29
Saprikin F.J., Selenkov N.A.: Prospects and methods of soil-geochemical mapping as a fundamental stage on the way of settling environmental problems and raising the agricultural lands fertility ... 31
Sudov B.A.: Environmental geochemistry of a large industrial centre in the Mountains of the Caucasus ... 32
Tianxiang R., Lixin Z., Tianyu S., Hua Z.: Regional environmental geochemical study in China: some examples ... 33

PART II. GEOCHEMICAL MAPPING

Belyaev G. M., Velikoslavinsky S. D., Maksimovsky V. A., Pevzner V. S., Rudenko V. E.: Geochemical map of the region of the Baikal-Amur railway (geochemical zoning and metallogenic conclusions) ... 34
Burde B. I.: Structural-geochemical maps of ore districts ... 35
Burenkov E. K., Koval P. V., Mezhelovsky N. V.: Geochemial mapping in the USSR ... 36
Dedacek K., Matolin M., Rejl J.: Airborne radiometric measurement and its use in Czechoslovakia ... 37
Demetriades A., Zangouroglou C.: Regional geochemical mapping of Eastern Macedonia and Thrace, N. E. Greece ... 38
Dubov R. I.: Geochemical mapping for geology and ecology ... 39
Eden P.: Global geochemical sampling:- some problems and results from Fennoscandia ... 40
Chaffee M. A.: Selecting appropriate sample densities in the arid environment of a part of the western United States and implications for sampling design for a global geochemical map ... 41
Chebotarjov A. A.: Color visualization of data on a polyassociative geochemical map ... 42
Shiro Itoh: Geochemical map project in Japan ... 43
Koljonen T., Malisa E.: Sampling density in regional geochemical mapping ... 44
Koljonen T., Malisa E.: Small-scale geochemical maps: a way to delineate areas promising for mineral exploration ... 45
Koval P. V.: Regional geochemical mapping of granitoids (Mongol-Okhotsk zone) ... 46
Kozlov V. D., Svadkovskaya L. N.: Principles of geochemical mapping of granitoids aimed at forecast ... 47
Lobanova A. B.: Special geochemical mapping of covered areas for the purpose of prospecting for deep-seated deposits ... 48
Maksimovsky V. A., Belyayev G. M., Velikoslavinsky S. D., Tolmacheva E. V., Sobolev A. O., Tikhomirov L. I.: Geochemical-zoning of the continent-Pacific ocean transitional zone (Asiatic part) ... 49
Maksimovsky V. A., Smyslov A. A., Titov V. K., Shor G. M.: Radiogeochemial zoning of the USSR ... 50

Matheis G., Utke A., Schreier C., Siad A. M.: Regional geochemical soil mapping in the tropical environments of West Africa: bedrock reflection and resources assessment of Proterozoic volcano-sedimentary sequences 51
Nikkarinen M., Salminen R.: Regional geochemical mapping in Finland using heavy fraction of till 52
Novikova L. N.: Employment of large-scale landscape-geochemical maps for interpretation of geochemical anomalies in humid and arid landscapes 53
Pasquali J., Marrero S., Melendez W., Montero R.: Regional geochemical reconnaissance of the La Paraqua river drainage, Venezuela 55
Petukhova N. N.: Geochemical mapping of the soil cover of the Byelorussian SSR 56
Plant J. A., Cooper D. C., Green P. M., Reedman A., Simpson P. R.: Regional distribution of As, Sb, and Bi in the Grampian Highland of Scotland and the English Lake District: implications for gold metallogeny 61
Plyusnin A.M., Tolochko V.V., Korsak V.A.: Mapping the closed areas of ore regions by a hydrogeochemical method 62
Prohic E., Pirc S., Zupanic N.: Geochemical map of a carbonate terrain based on soil sampling 63
Smith R. E., Birrell R. D., Anand R. R., Bridgen J. F., Grunsky E. C., Pedrix J. L.: Geochemical mapping in lateritic region of the Yilgarn block in Australia 64
Rogers P. J., Fortescue J. A. C., Ogden J. G.: Baseline geochemical mapping using lake sediments 65
Steenfelt A., Thorning L., Tukainen T.: Thematic maps of southern West Greenland 67
Tauson L. V., Kravtsova R. G., Zaripov R. H.: Geochemical mapping of primary and secondary settings in ore-bearing regions 68
Zagorsky V. E., Peretyazhko I. S., Kuznetsova L. G.: Mineralogical-geochemical mapping of rare-metal and miarolitic pegmatite fields aimed at prospecting 69

PART III. MATHEMATICAL METHODS

Bezvoda V., Jezek J., Saic S.: Scope of image processing methods in geochemical exploration methods 70
Burenkov E. K., Ginzburg L. N., Kogan B.S.: Investigation of spatial geochemical information for prospecting purposes using computers 71
Bugrov V. A., Markevich A. K.: Processing of geochemical data using "Moving average" method for the solution of certain prospecting and prediction tasks 72
O'Connor P. J., Reimann C.: Application of exploratory data analysis in regional geochemical mapping in Ireland 73
Evdokimova V. N., Kitaev N. A.: Improved automation system for processing of geochemical information via the method of multi-dimensional fields 74
Galetsky L. S., Gorlitsky B. A.: Regional database of geochemical anomalies of the Ukraine 75
Grunsky E. C., Smith R. E.: Anomaly recognition applied to laterite geochemistry, Yilgarn block, Western Australia: application of data analysis and statistical techniques 76
Hajek J., Grym V., Zacek M.: Application of a new approach to predict ore deposits from archive data 77
Janakova K.: Statistical evaluation of geochemical data on Western Carphatian granitoids 79
Kramar U.: The role of semi-variograms in geochemical prospecting 80
Machek P., Matysek D.: Robust analysis of chemical composition of teschenite association rocks 81
Makedon I.D., Sadikov M.A.: Software for the technology of metallogenic forecast 82
Obst P.: Modified cell method - 3D geochemical modelling 83
Ovsov M. K., Pitulko V. M.: Structural analysis of geochemical data in a local mineral prediction 85
Romanov V. A.: Quantitative assessment of potential metal resources from stream sediments 86
Sadikov M. A.: Hierarchy of systems in ore-searching geochemistry 87
Shvarov Yu. V.: The evaluation of lithochemical dissipation flows 88
Vakhromeyev G. S., Shestakov Y. G., Mulin P. N.: The imitation of geochemical and geophysical prospecting on a personal computer 89
Voitsekhovskaya M. B., Borisov M. V.: Computer modelling of mercury ore-forming process 90
Wackernagel H.: Geostatistics for the interpretation of geochemical anomalies 91
Wang W., Luo X., Yiang Z., Liu Y.: Esige - the expert system in geochemical exploration 92
Xie Xuejing: A computer system for the rapid evaluation and sorting of multi-element geochemical anomalies - RESMA 93
Zolotarev V. G.: Principles of storage and retrieval of geochemical information in data bases on mineral deposits 94

Zacek Z., Prochazka Z.: Threshold of anomality - base problem of prospecting geochemistry ... 95

PART IV. GEOCHEMICAL PROSPECTING

Akhmadulin F. A., Sanina N. V.: Assesment of ore potential of the gold-bearing region at geochemical mapping ... 97

Altman E. L., Krcmar B.: Unfiltered form of trace elements in atmospheric air - a new geochemical prospecting tool ... 98

Arkhangelsky A. N.: Pecularities of the volumetric mapping of the massive sulphide ore-bearing area ... 99

Asadulin A. A.: New approach to the geochemical prediction of gold occurrences in black shales ... 100

Badanina-Syritso L. F.: Geochemical model of rare-metal ore-genesis and its application to ore prospecting and prediction ... 101

Baranov E. N.: Geochemical forecast of massive sulphide deposits based on the convective model ... 102

Baranov V. D. Geochemical mapping and modelling of Rudnyi Altaj ore districts ... 103

Barsukov V. L., Baranova N. N., Kozerenko S. V.: Behavior of gold in postmagmatic and hydrothermal conditions and new approaches to prediction of gold ore deposits ... 104

Barsukov V. L., Kozerenko S. V., Baranova N. N., Bannikova L. A.: Investigation techniques and nature of ammonium haloes on gold deposits ... 105

Baumshtein V. I., Zorina L. D.: Construction of geochemial models of deposits based on principles of their polygenic and polychronic formation ... 107

Belogova G. A.: The use of stream sediments for forecast geochemical maps ... 108

Bertman E. B. : Geologic-geochemical model of the Uzbek stratiform gold deposits ... 109

Bogatyrev P. V., Kitayev N. A.: A model for formation of stream sediments in intermontane depressions ... 110

Bravo I., Iglesias G.J., Loredo J.: Geochemical prospecting in strata-bound Pb-Zn ore deposits from Cantabria (Spain) ... 111

Breiter K.: Connection of tin ores with granites of the Nejdek massif ... 112

Bugrov V. A. : Choise of sampling fractions in the solution of prospecting tasks using secondary aureoles and dispersion trains ... 113

Burago A. I., Kosterov N. F.: Geochemical methods for quantitative estimation of mineral deposits in Primorski Krai, the USSR ... 114

Burenkov E.K., Erukhimovich I.Ja., Kogan B.S.: On the theory of geochemical differentiation of elements in processes of hydrothermal metamorphism and ore forming ... 115

Cubukcu E., Erler A., Karahangolu.: Comparison of stream-sediment, soil, and rock sampling in Basyurt Yayla /Giresun -Turkey ... 116

Davenport P. H., Garrett R. G., Green P. H., Simpson P., Steenfelt A. : Geochemical correlation and comparison between Labrador and Greenland ... 117

Davenport P. H., Nolan L.: Image-processing of geochemical data to map geological structures and alteration zones ... 119

Demetriades A., Zangouroglou C.: A soil geochemical study of the Kato Thermes mineralized zone, Xanthi prefecture, N. E. Greece ... 120

Divinec L., Volko P.: Results of geochemical prospection in the Slanske vrchy Mts, Eastern Slovakia ... 121

Dodin D. A.: Geochemistry of sulfide-nickel ore-magmatic systems as a basis of new approach to prognosis and exploration of deep-seated deposits ... 122

Dodin D. A., Sadikov M. A., Sidorov I. I.: Geochemical models of ore districts and fields, and principles of their construction using a nickel-bearing province as an example ... 123

Dubinska E., Szafranek D.: The origin of contact zone between serpentinite and granite, Jordanow, Lower Silesia, Poland ... 124

Durasova N. A., Barsukov V. L., Ryabchikov I. D., Kochnova L. N.: Geochemical modelling of high temperature processes of copper mobilization ... 125

Duris M., Hak J., Majer V., Sanka V.: Geochemical exploration in selected areas of Syrian Arab Republic ... 126

Erler A., Atabey E., Doganeli C.: Geochemical soil survey in Kozlu (Tokat-Turkey) ... 127

Erokhin A.: Evolution of mineral-forming medium during the formation of quartz-cassiterite Iultin deposit ... 128

Jiang Fengliang, Xu Ping: Application of geochemical methods to research of active faults ... 129

Filatov E. I., Abramson G. Y., Ermolaev A. N., Motozov V. I., Panajotov A., Pyrvanov V.: Experience in the local geologic-geochemical forecasting and estimation of ore deposits of main geologic-comercial types in PRB ... 130

Galetsky L. S., Gorlitzky B. A., Pochtarenko V. I.: Geochemical map of pre-Cambrian of the Ukrainian shield 131

Galetsky L. S., Olshevskaya E. I., Egorova T. M.: Rational complexes of geochemical methods in sedimentary-covered areas as exemplified by the Ukrainian shield 133

Gapon A. E., Prokopchuk S. I., Lomonosov I. S., Shimansky A. A.: Complex geochemical mapping in gold-bearing regions 135

Garrett R. G., Beaumier M., Davenport P. H.: The relationship between geochemical provinces and the major tectonic division of the Eastern Canadian shield 136

Gerel O., Batsaikhan E.: Gov-Ugtaal tin-polymetallic ore-magmatic system, Central Mongolia 137

Goldberg I. S.: Ore prospecting according to anomaly subtraction 138

Golubovskaya E. V.: Minor elements distribution in oolitic iron ores in the Kerch deposits 139

Golynko I. N.: Geochemical models of ore-magmatic systems in volcanic regions 140

Wang Gongque, Tian Jianguo: Researching of micro-prospecting mineral marks and geochemical prospecting at Hatu gold deposit in west Jungerl Basin, China 141

Grabezhev A. I., Bachtina A. P.: Ore geochemical models for the porphyry-copper deposits of Ural 142

Grebenschikova V. I.: Geochemical classification of endogenic gold deposits from the mode of sulphur, selenium and tellurium distribution 143

Gubac J.: On the ore potentiality of granitic rocks in the Dumbier zone of the Nizke Tatry Mts. in the context of their crustal origin 144

Gutsalo L. K., Plotnikov A. M.: Carbon izotope fractionation in carbonate system and methane during transition of thermal fluid 145

Gvozdkov A. N., Sandimirov I. V.: Heavy metals in deep-water sediments of the southern Baikal depression 146

Chetvertkov Yu. I.: The application of geochemical models of gold deposits in the process of forecast and prospecting 147

Chuchupalov V. N., Chulanov E. I.: Syngenetic anomalies in an allochthon as an evidence of crypto-buried mineralization 148

Ilyinsky Y. V.: Geochemical systems of open ore-concentrating lineaments 149

Janatka J.: Geochemical prospecting for gold in the Bohemian Massif 150

Janatka J., Vana T.: Pisek - Vrcovice Au, Ag district: probable occurrence of gold-bearing shear zones in the Moldanubicum of the Bohemian Massif 151

Klosiewicz A.: Gold-bearing pyrite in quartz-sericite-chlorite schists with graphite near Nielestno (Lower Silesia) 152

Knesl J.: The main results of the geochemical exploration for gold within the Central Slovac neovolcanic area 153

Kniazev S.: The weathering zone of the Coctencol deposit of rare metals in the central Kazachstan: geochemistry of Mo, W, Bi in weathering products of ore-bearing rocks 154

Kolotov B. A., Rubeikin V. Z., Kiseleva E. A.: Use of element metastability for applied purposes by phytohydrogeochemical method 155

Koshelev V. K., Tonkopii M. S.: Geochemical-mathematical modelling of stratiform polymetallic deposits in Kazachstan 156

Kravtchenko E. S., Ryabov V. V.: Problems of geochemical exploration for deep-seated copper-nickel sulfide deposits 157

Lahermo P.W., Peuraniemi V.: On hydrogeochemistry in ore exploration in Finland 158

Lawrance L. M., Butt C. R. M.: The dispersion of ore elements within the weathering profile at Hannan South gold mine, Western Australia 159

Lecomte P.: Metallic anomalies occurence according to the nature of constituents in the weathering profile of the mineralized Mborguene area (East Cameroun) 160

Lepky S. D.: Surficial uranium deposits - an alternative source in the nuclear fuel cycle 162

Litvinenko: Geochemical model of auriargentiferous deposit 163

Zhou Liyi, Yang Shaoping, Sun Xiaoling: Application of sequential extraction technique in prospecting for hidden ore deposits 164

Lomonosov I. S., Gapon A. E., Arsentjeva A. G., Zagoskin V. A., Zagoskina A. I., Zelikson V. S., Lozhkin V. I., Kobeleva G. I.: Mapping of natural and man-made stream sediments and dispersion haloes in the Taiga topography of eastern Siberia 165

Malikova I. N.: Geochemical characteristics of rare-metal granites from Kalgutinsky massif 166

Marmi R.: Methodology of geochemical prospecting applied for Pb-Zn ore in carbonate medium at Djebel Bou Arif; Batna (Algeria) 167

Matvejev A. A.: A summary data of the lithochemical surveys of 1:200,000 scale with a purpose of metallogenic analysis and regional prediction 173

Shen Minzi, Tong Wei, Zhang Zhifei, Zhu Meixiang: Application of geochemistry to geothermal exploration in Tengchong geothermal areas in China 174
Mironov A.G.: Geochemistry of the gold-bearing magmatic systems and prediction problems of gold deposits 175
Moon C. J.: Geochemical exploration in heavily contaminated areas: the experience of the last 20 years in South West England 176
Moon K. J.: A modelling approach to develop a new technique for finding a hidden skarn-type orebody in the Cambrian limestone beds of the Taebaeg Basin in South Korea 177
van Moort J. C.: The use of electron paramagnetism and trace element content of vein quartz in mineral exploration 178
Morsy M. A.: Geochemical orientation survey for tin and rare elements in Igla and Abu Dabbab areas, Eastern Desert, Egypt 180
Morsy M. A., Makky A. M. A.: Prospecting and evaluation of copper mineralization through their geochemical aureoles in Khashm el Fakh area; Sinai; Egypt 181
Nadareishvili J. G., Sudov B. A.: Geochemical prospecting of deeply concealed ore bodies in the Caucasus according to the secondary superimposed dispersion haloes 182
Naumov G. B., Yanosh N. Ye.: Composition of ore-associated haloes and mechanisms of their forming 183
Nekrasov I. Y.: The distribution of silver between fluid and melts and genesis of volcanogenic gold-silver deposits 186
Novikov Yu. A.: Condition of formation and major parameters of diffusive-defluction secondary dispersive haloes of the Soviet Carpathians ore deposits 187
Ovcharenko Yu. K.: On primary aureoles of dispersed hyddrocarbon gases 189
Palchen W., Rank G., Zernke B., Harpke B.: Geochemical soil and rock surveys in search for tin in the Eastern Erzgebirge (GDR) 190
Pedro A. M. A., Pinto S. M.: Geological exploration in Mosambique 191
Pevzner V. S.: Geochemical zonation of main stages of the Llavraziy Belt platform evolution 192
Piskorski N. P.: New local prediction methods applied to ore deposits under exploration based on mineralogic-geochemical data 193
Pitulko V. M.: Geochemical fields of multilevel convective ore-bearing systems 194
Pokryshkin V. I.: Geochemical features of granual phosphorites: prospecting aspects 195
Pöllmann H., Khoury H. N.: Geochemical anomalous water and metamorphic mineral assemblages in Dada- and Marquin areas of Jordan - comparison to laboratory results 196
Rentzsh J., Birke M., Eichberg M.: Contribution of the stream sediment geochemistry to the finding out of the endogenous ore-controlling zonality and to the indicating of hidden granites 197
Rojkovic I., Novotny L.: Geochemical characterization of the U-Mo-Cu mineralization in the Permian of the Slovenske Rudohorie Mts., the West Carpathians 198
Roslyakova N. V.: Geochemical prospecting for gold at the deep levels of deposits 199
Jiang Ruijin, Red Tianxiang: Hydrogeochemical exploration for metallic minerals in basalt-covered region, Jilin province, China 200
Ryss Yu. S., Goldberg I. S., Voroshilov N. A.: Geoelectrochemical methods of prospecting for ore deposits 201
Shatov V. V., Plushchev E. V.: Geological and geochemical models of ore fields as a basis for solution of problems in forecasting and prospecting (on the example of Kazakhstan) 202
Shcherbov B. L.: Products of near resedimentation as an important information source for mapping the weathering crusts 203
Shor G. M.: Geochemistry of rare and trace elements in the sedimentary mantle of young platforms 204
Schwab R. G., Herold H., Götz Ch., de Oliveira N. P.: Chemical mobilities of Na, Ca, Sr, Ba, Pb, REE, P, and As in lateritic soils 205
Sibbick S., Fletcher W. K.: An application of cyanidation to gold exploration in glaciated terrain, British Columbia, Canada 206
Siegel F. R., Xuejing Xie, Vaz E.: Thermoluminiscence dosimetry (TLD) radiometrics in oil exploration, Takla area, Tarim Basin, Western China 208
Shrivastava J. P.: Cold extractable Cu and total Cu in soils: a study from Malanjkhand copper deposit, India 209
Skyseth T., Reitan P.: The geochemistry of the carbonate-hosted, disseminated gold deposit at Gautelisfjell, Rombak proterozoic basement window, Northern Norway 210
Spiridonov A. M., Gnilusa B. A., Kozlov V. D., Goreglyad A. B., Ignatov V. V.: Geochemical mapping of rare element ore knots of mountain-steppe regions in Mongolian Altai 211

Taisaev T. T.: Some cryogenic geochemical anomalies of gold ore deposits in Bald mountains - Taiga landscapes in Siberia 212
Tichomirova E. V.: Principal component method in shelf geochemical investigations 213
Titov V. K., Landa E. A., Galetskyi Z. S.: Geochemical mapping of ancient platform shields used for regional metallogenic analysis 214
Tole M. P.: Correlation between chemically and physically transported barium anomalies over the Vitengeni lead/barite mineral deposit, Coast province, Kenya 215
Troshin Yu. P., Grebenschikova V. I., Mitichin M. A.: Classification of endogenic geochemical anomalies of ore regions 216
Vairinho M. M., Cardoso C. J., Fonseca E. C.: Enhancement of Cu geochemical anomalies using partial extraction techniques. Application in geochemical exploration (Portugal) 217
Vallius H.: Regional variations in major element and trace metal contents in the fine fraction of till 218
Varsanyi I.: The effect of withrawal on groundwater chemistry 219
Viegas L., Vairinho M. M., Rodriguez L., Fonseca E. C., Muge F.: Geochemical prospecting in Portugal: a review 220
Viladevall M., Font X., Ferrer A., Marimon R. M., Casas A., Vaquer R., Carmona J. M., Cardoso M.: Geochemical exploration in the northeastern part of Catalonian Coastal Ranges (NE Spain) 221
Vildyayev V.M.: Geochemical anomaly of Altai ore fields 222
Vinh N. K.: Geochemical prospecting for ore deposits in Vietnam 223
Volodko S. A:, Filatov E. I.: Experience in geologic-geochemical forecasting of chalcopyrite-base metal deposits of South-West-Guissar type 224
Vriend S. P., Dekkers M. J., van Gaans P. F. M.: The hydrogeochemistry of a sedimentary basin at Idanha a Nova, Portugal. Thermodynamic modelling used in uranium exploration 225
Zhmodik S. M., Kulikov A. A., Shestel S. T.: The autoradiography study of gold distribution in a process of the black schist metamorphism 226
Zhmodik S. M., Mironov A. G.: Low-temperature sorption of gold and silver by the sulphide minerals (according to an autoradiography) 227
Zlenko B. F., Gubanov A. M.: Improvements in methods of evaluation and exploration of complex silver-base metal deposits according to the data of mineralogical-geochemical investigation 228
Zorina L. D., Kulikova Z. I.: Patterns of element distribution in post-magmatic formations of the Darasun ore-magmatic system 229
Zubov M. A., Drnzik E.: Application of the methodic bases development in the USSR for geochemical exploration and evaluation of gold-antimony mineralization in Slovak deposits 230

PART V. HEAVY MINERAL PROSPECTING

Alapieti T., Forsström L., Peuraniemi V.: Glacial dispersal of chromite ore in northern Finland 231
Karvinen W. O.: Ore-related alteration as a guide in boulder prospecting 232
Maurice Y. T.: Some pros and cons of using the heavy fraction of overbunden in geochemical exploration 233
Nikolayev J. L., Gurbanov A. G., Rekharsky V. J.: Geochemical features of scheelites for prospecting of tungsten deposits 234
Patyk-Kara N. G.: Geochemical methods for shelf placers searching 235
Patyk-Kara N. G.: Geochemical evolution of placers 236
Peuraniemi V.: On the mode of occurrence of zinc in glacial till and its applicability to the use of heavy mineral geochemistry to search for zinc ores 237
Simek J.: Heavy mineral prospecting in the North-West part of the Bohemian massif 239
Viladevall M., Marturia J., Espiell F., Camacho G., Llobet A.: The gold panning exploration in the Eastern Pyrenees and Catalonian Coastal Ranges (NE Spain) 242

PART VI. BIOGEOCHEMISTRY

Camacho G., Espiell F., Viladevall M.: Biogeochemical gold exploration in the Old Rigart River mine in the Pyrenees (Catalonia, NE Spain) 243
Demidov V. V., Kogan B. S.: On the geochemistry of heavy metals in the geomicrobial barrier systems 244
Dunn C. E.: Biogeochemical exploration for noble metals in western Canada 245
Hetenyi M., Kedves M. A.: Relation between the hydrocarbon genetic features of kerogens and their biological precursor material 246

Ivashov P. V.: Biogeochemical method of tin ore deposit searchings in the Far East 247
Kovalevskii A. L.: The main models of the biogeochemical exploration for mineral deposits 248
Kovalevskii A. L., Kovalevskaya O. M.: Biogeochemical haloes of gold in various species and parts of plants 249
Kovalevskii A. L., Kovalevskaya O. M.: Biogeochemical prospecting for silver ore lode bodies and deposits 250
Lapaev G. P.: Briogeochemical method - theory and practice 251
Neybergh H., Moureau Z., Remacle J., Swings J., Verraes G., Sulten E., Champenois B., Hambuckers-Berhin F., Kersters K., Vanhonacker K., Verdonck L.: Study of the Bacillus cereus-Mycoides-Thuringiensis complex present in auriferous soils 252
Opekunova M. G.: Experience in biogeochemistry metod applied to prospecting under permafrost 253
Ping Gao: Biogeochemical exploration in loess environment in China 254
Prasad E. A. V., Gupta M. J., Dunn C. E.: Geobotanical and biogeochemical zonation in termite mounds 255

PART VII. ANALYTICAL METHODS

Ganeyev A. A., Mashjenov N. R., Sholupov S. E., Svesnikov G. B.: High-selectivity atomic absorption analysers for the determination of the mercury concentration in gas, liquid and solid samples 256
Hall G. E. M.: Progress in the application of ICP-mass spectrometry to analytical geochemistry 257
Klika Z., Kolomaznik I.: Use of optimization procedures for the quantitative determination of minerals and for the distribution of Cr, Ni, and Co in laterites 258
Sorokina N. A., Efremova L. B.: Concentration of rare earths by various cation exchange resin types for ICP-AE analysis of geological samples 259
Sotskov Yu. P.: Chemical-analytical provision of geochemical works 260

PART VIII. TEACHING IN GEOCHEMISTRY

Murty K. S.: Teaching in geochemistry: India 261
Solovov A. P.: Education in geochemical prospecting 262

FOREWORD

The Geological Survey, Prague (Ústřední ústav geologický) together with other geological institutions of Czechoslovakia have organized the 14th International Geochemical Exploration Symposium of the Association of Exploration Geochemists (AEG) and the 5th Symposium on Methods of Geochemical Prospecting of the International Association of Geochemistry and Cosmochemistry (IAGC), Working Group Geochemical Prospecting.

This volume contains the abstracts received by the end of May, 1990. The Organizing Committee would like to thank the authors for their contributions to the Symposium.

The submitted papers have been included into the volume even if some of them are not directly related to the major topics of the Symposium. Such papers may sometimes generate new ideas or new research approaches.

The contributions were arranged into individual thematic blocks to make the volume easy to use. However, the classification is only approximate since some abstracts cover several topics or correspond with none of the given topics precisely.

The contributions have been published as manuscripts submitted by the authors. The editors´ board (J.Janatka, I.Barnet, T.Hlavatá and E.Jelínek) holds no responsibility for contingent imperfections of individual papers.

Major scientific results of the Symposium will be published in the Proceedings by the beginning of 1991. If you are interested in publishing your contribution please turn to the Editors´ Commission.

The Organizing committee welcomes you to Prague and wishes you all the best.

František Mrňa

RADON RISK MAPPING IN CZECHOSLOVAKIA

Ivan Barnet
Geological Survey Prague, Czechoslovakia

In 1989 the radon risk mapping project started in Czechoslovakia. The joint project of Geological Survey, Prague, Uranium Exploration, Liberec, Geophysics, Prague and Faculty of Science, Charles University, Prague is aimed to produce radon risk maps of the western part of Czechoslovakia (Bohemia and Moravia) in the scale of 1:200 000 till the end of 1990.

The radon risk maps will be delivered to authorities of urban planning to eliminate the building activities in the most hazardous areas. The district centers of Hygienic Service will employ the radon risk maps when planning the indoor radon measurements and considering the necessary sanatory works in houses. Paralelly the site investigations in the scales of 1:10,000 to 1:1,000 are performed by Uranium Exploration. In advance some municipal authorities require detailed measurements at the building sites of nursery schools, basic schools and family houses.

Data used for radon risk maps construction

1. Field measurements of ^{222}Rn in soils - performed by SAN method (alpha card modification, developed by Uranium Exploration Enterprise);
2. Airborne radiometric maps (Geophysics Enterprise); scale 1:200,000 (total gama activity) and 1:25,000 (K, U, Th spectrometry); confining the areas of enhanced natural radioactivity;
3. Database of Uranium Exploration Enterprise - catalogue of natural and man-made anomalies, environmental impact of uranium exploration;
4. Geological maps (Geological Survey) - scale 1:200,000; lithology, areal distribution of granitoids and rock types with enhanced radioactivity; tectonic setting;
5. Pedological maps (Geological Survey) - scale 1:200,000; types of soil cover; types of weathering crust; areal distribution of rocks accumulating radon (river terraces etc.);
6. Hydrogeological maps (Geological Survey) - scale 1:200000; areal data on transmisivity and permeability; confining the areas of permeable rock types.

In some geological units there is a lack of primary radiometric data. These areas are covered by measurements located on the test sites representing the prevailing rock types (at least 15 to 25 measurements on each test site). The reliability of radon risk maps in the scale of 1:200 000 was tested by comparing the results of field radon measurements. The comparison has proved a good agreement with data expressed in radon risk maps.

The regional stage will be followed by radon measurements in a more detailed scale according to the demands of local municipal authorities. In this stage, the indoor radon data, data on radon in waters and building materials will be taken into consideration to evaluate the total radon risk.

TECHNOGENIC POLLUTION OF THE BAIKAL LAKE BASIN SNOW COVER WITH CHEMICAL ELEMENTS

Vladimir F. Belogolovov, Alexander Yu. Zyablitsev, Alexander V. Tyzhinov,
Buryat Research Centre, SB, USSR Academy of Sciences

The urgency of atmospheric pollution study in the water-protected zone of Baikal is determined by:

- the regional character of the most dangerous crisis situations because of direct influences (Aral, Chernobyl, Alyaska, etc.);
- the priority of inorganic pollutors (lead, zinc, fluorine, etc.) considered "ecologically the most dangerous ones" for Baikal;
- the complexity of prognosis, control and influence control on atmosphere, especially for Baikal limnoclimate. Atmospheric processes considerably determine the relations in the region ecosystem upon which and this way its stability depends.

In 1987-1989 on the territory of the Baikal water-protected zone a snow geochemical survey on a small scale (1 sample/200 sq. km) was made. The results obtained are the first estimation of atmospheric pollution according to depositing medium realized in space. The contrastive multi-measured anomalous geochemical field was found. Its size is from 10 to 80% of the whole territory, the contrastity is by 2-5 orders more, in some cases exceeding the maximum concentrations for water and soil. The usual pollutors are sulphate ion, nitrates, lead, vanadium, copper in filtrate and lead, zinc, copper, vanadium in solid sediment, and specific one for the region is fluorine. The influence was estimated according to the values of the summary index of pollution and technogenic load. The structure of technogenic geochemical anomalies epicentres in some cases adds to the ideas of position and parameters of the concentrated anthropogenic influence places.

With the help of the snow geochemical survey on a middle scale (1 sample/1 sq. km) the structure of technogenic geochemical field of the main industrial centres was determined. The temporal division into districts was realized. As for Ulan-Ude 65% of its territory is modern pollution, 10% is a stable one and other 10% is a relic one.

The formation of groundwork fall on the snow cover is connected with the far transfer from the west direction. The hightened accumulations (deposits) of dustgasthrowings in between mountain depressions are connected with the high potential of atmospheric pollution. Thus, the determination of a special zone of nature use is expedient, including the Baikal lake and neighbouring hollows.

THE USE OF LAKE SEDIMENTS CORES TO MAP ENVIRONMENTAL CHANGE IN ONTARIO; CANADA

John A.C. Fortescue
Ontario Geological Survey, Ministry of Northern Development and Mines, 77 Grenville Street, Toronto, Ontario
Canada M7A 1W4

Examples will be described of the use of lake sediments cores (1) to describe the pH history of acid Ontario lakes during the past 100 years and (2) how pre- and post-Ambrosia lake sediment core material may be used to map areas where increased levels of As, Pb, Cu, Ni and Zn (due to antropogenic fallout) occur in surface sediment. Results of recent pre- and post-Ambrosia based, regional lake sediment geochemical mapping near Wawa, Ontario, will be described to illustrate how baseline geochemistry can be successfully completed in areas of significant metal pollution. Some implications of this research in relation to global change and global geochemical mapping will be discussed at the end of the paper.

MERCURY HALOES IN THE ATMOSPHERE [GEOCHEMICAL AND ECOLOGICAL ASPECTS]

Alexander A. Ganeyev, Nicolaj R. Mashjanov, Vladimir V. Ryzhov, Sergej E. Sholupov, Gleb D. Oveshnikov

Leningrad State University, USSR
and

Nina A.Ozerova
Institute of Ore Deposits Geology, Petrology, Mineralogy and Geochemistry of the Academy of Science, USSR

There are two practical aspects in the atmospheric mercury investigations: ore, oil and gas explorations on mercury haloes in the atmosphere and the environment pollution control.

It is known that mercury is a universal element-indicator of endogenic ore deposits and its vapours form haloes in soil and air.Recently new regularities of mercury distribution in oil and gas basins have become available and the understanding of 'global' mercury geochemistry has improved [N. A. Ozerova, 1986; N. A. Ozerova et al.,1989].

Mercury is the priority pollutant of the environment since directly or indirectly this element takes part in many technological processes. A major proportion of mercury transfers from anthropogenic sources to deponent components of the environment [sediments,soils and biota] through the atmosphere.

In the Leningrad University the original technique of direct [without sampling or preliminary enrichment] determination of mercury concentration in ambient air or in complex gas mixtures has been elaborated. It is based on differential atomic absorption spectroscopy. High selectivity of analysis is provided by Zeeman or spectral-phase effects [G.B.Sveshnikov et al.,1980; A.A.Ganeyev,Yu.I.Turkin,1989].

Realizing these techniques portable spectrometers permit to carry out the geochemical survey in real time with low limit detection of mercury in air. There are back-pack and helicopter versions of our instruments. When natural gas is analyzed high selectivity is allowed to avoid the interference of matrix on results. Special techniques have been worked out for the detection of some volatile mercury components and for analysis of mercury isotopes in ore minerals.

Natural investigation has shown that mercury vapour haloes in the atmosphere are the pathfinder of most types of the endogenic ore deposits under various landscape, geochemical and climatic (subarctic,moderate and arid) conditions. In ore districts the helicopter survey can help to locate the perspective plots where ore objects may be discovered by the detail geochemical and geophysical methods. Other types of the vehicles give us the possibility to map regional haloes connected with the deep faults on the continents or the oceans.

Direct determination of this metal in hydrocarbon gases shows the increasing mercury concentration in number of gas and oil fields.This reason and existence of atmospheric mercury haloes over the gas-penetrated faults gives the possibility to use the method in question in oil and gas explorations.

Anthropogenic mercury emissions have been investigated by means of a helicopter, car and ship survey near the local and distributed sources. Some examples of the differential atomic absorption spectrometers application to exploration geochemistry and atmosphere pollution control under various conditions are given.

A PHYTOGEOCHEMICAL METHOD FOR STUDYING HEAVY METAL CONTAMINATIONS OF THE TECHNOSPHERE

A.V.Lapo and M.S.Vdovets

All-Union Scientific-Research Geological Institute
Leningrad, USSR

A phytogeochemical method occupies a special place among various methods used for studying contaminations of the technosphere; it gives information on heavy metals which are involved in the biogeochemical cycle and ore, therefore, especially dangerous for man's health.

Cadmium, mercury, lead, zinc, copper, nickel and, possibly, cobalt and antimony contents in plants, are determined, apart from physiological demands of plants, by contents of these elements in environments (Adriano, 1986; Kabata-Pendias, Pendias, 1985). This conclusion is a methodological basis both for phytogeochemical method of prospecting for base metals and for the same method used in technospheric studies. The experience gained in prospecting phytogeochemistry, however, has a limited significance for technospheric contamination studies since metal bearing solutions travel from bottom to top during the formation of dispersion haloes associated with ore deposits, whereas technogenic heavy metal contaminations are largely affected through air (Golenetsky, Malachov,1985). For this reason the phytogeochemical prospecting predominantly deals with plants with a root system that grows downwards, whereas technogenic studies are focused on plants with a subsurface root system and horizontal rhizomes. A.L.Kovalevsky (1984) has proposed to divide bioobjects (including plants) into a) barrier-free; b) practically barrier-free; c) barrier and d) background barrier bioobjects, depending on their ability to concentrate microelements. The possibility of the usage for technogenic contamination studies is increased from background barrier to barrier-free plants.

Studies of technogenic heavy metal contaminations by the phytogeochemical method are implemented by comparing heavy metal contents in plants of the same name within the studied background areas. Plants that are selected as biogeochemical indicators must have the highest values of heavy metal concentration coefficients, must be widely spread in the area under study and posses an adequate phytomass.

The following plants can be used for heavy metal contamination technospheric studies in humid moderate zones by the phytogeochemical method: the pine-tree (bark, branches, cones, needles), the European fir-tree (branches), the gray alder-tree (bark, leaves), the aspen (bark), the cordate lime-tree (leaves),the mountain ash (bark), raspberry-canes (sprouts), red bilberries, bilberry-bushes, officinal dandelion, wormwood, dioecious nettle and creeping clover (the whole surface part is studied for shrubs and herbaceous plants). Out of the listed plant species we can choose a standard set of plants of different stages (1-2 species for a stage), depending on the composition of vegetation in the studied area. This provides certainly an information on the environmental heavy metal contamination.

From phytogeochemical studies in the Baltic industrial areas a technogenic lead-zinc-nickel-copper association with weak correlations, which is invloved in the biogeochemical cycle, has been recognized. The phytogeochemical method gives information on technogenic heavy metal contaminations for the live-period of the studied plant organs, whereas studies of litter, for the same period (for its initial plant remains) and for the formative time of litter studies of soils yield information on the whole period of soil formation, of snow, only for winter months of the year. Comprehensive studies of all listed technospheric components may provide the most complete information on the state of environments. In monitoring it is recommended to combine the phytogeochemical method with geochemical studies of the snow cover.

REGIONAL STREAM-DRAINAGE HYDRO- AND LITHOGEOCHEMICAL SURVEY FOR ORE ELEMENT AND ECOLOGICAL ENVIRONMENT EVALUATION

I.A.Luchin, V.A.Komarov
NPO "Rudgeofizika", Leningrad, USSR

Large-scale multi-element hydro- and lithogeochemical survey is an effective and cost-saving tool, which allows both to evaluate ecological environment and to delineate areas of anomalous natural and technogenic toxic concentrations including radionuclides and stuffs used in agro-industrial complex.

The sampling materials are water and bottom sediments (fine-grained and thermomagnetic fractions). The survey density is about 1 sample per 100 sq. km.

The efficiency of hydro- and lithogeochemical survey depends on the following factors: the homogeneity of sampled geochemical materials, low sampling density (1 sample/100-120 sq. km), high depth of investigation, the possibility of simultaneous multi-element determination and quantitative resource evaluation of each element anomaly obtained over a given drainage system.

The survey can be conducted over the known ore regions to re-evaluate their resources and to estimate the raw material potential for mining industry of a region.

Results of such a survey are used to delineate anomaly areas of thousands and ten thousands sq. km with element concentrations exceeding background values by a factors of 5-10 and more.

The methodology of survey developed in the Soviet Union involves quantitative resource evaluation for a range of elements. The results of covering 8 million square km with surveys indicated that all economically significant deposits occur within hydro- and lithogeochemical anomalies. The calculated estimates for known and potential resources are nearly equal. At the same time there exist such anomalies, which have not been explored yet and which should be the target of future investigations. The results on Au, U, Mo, F,etc.are of special interest.

Data on macro- and microelement water content obtained during the survey can be used for ecological evaluation of areas investigated.

It is supposed to cover all accessible regions of the country with regional hydro- and lithogeochemical surveys.

Question: In the hydrogeochemical surveys what is the size of the stream catchment basins sampled?

GEOCHEMISTRY OF TECHNOGENESIS

Lukashev V.K., Institute of Geochemistry and Geophysics of the Byelorussian Academy of Sciences, Minsk, USSR

Fersman (1955) recognized technogenesis as a major factor in geochemical studies of the supergene environment. Lukashev (1980) and Lukashev and Lukashev (1980 a,b) developed Fersman's ideas further and defined geochemistry of technogenesis as that branch of geochemistry which deals (1) with the role of mankind in those geochemical processes involving the migration, dispersion and concentration of chemical elements and compounds in the hypersphere (specifically the biosphere); (2) in the alteration and transformation of this zone from a natural to a technologic state; and (3) in the formation of new natural-technologic systems and areas with different geochemical properties and environmental parameters. The general and principal goals of technogenic geochemistry is the utilization of the body of knowledge gained by science and technology as a whole, and by the Earth sciences in particular, in order to understand the laws governing the development of the biosphere (also called noosphere), and to control processes operating in the biosphere on the basis of a better understanding of the mechanisms which control geological and geochemical development in nature. In view of the above, systematization of human impact factors on the environment and an estimation of their geochemical effects, are of primary importance.

The present state of technogenic geochemistry can be characterized, in general, as the stage of "geochemical inventory". It consists of detailed data collection for all elements in the periodic table and, primarily, geochemical mapping of affected environments. The latter is represented by maps of element distributions in soils and streams of urban areas, as well as maps of element distribution in snow and vegetation covered areas, etc. These maps are of great importance for detecting man-induced (technogenic) geochemical halos, estimation of the environmental conditions, and in making logical ecological decisions. This is illustrated by several maps showing the distribution of Zn, Pb, Cu, Cd, Hg, Bi, W, etc. in urban areas (towns) of Byelorussia.

The inventory also involves investigation of the global and local migration cycles of technophilic elements, determining those factors which characterize the formation of technogenic anomalies in the vicinity of particular industrial complexes, and analysis of various industrial effluents and wastes.

Various kinds of aerosol-trapping devices, chemical assays of shown and dust, and a range of biological methods particulary involving lichens, assist in evaluating the quantity and effects of aerosols. The epiphytic lichen Hypogymnia physodes was used as the test material and selected element distributions were mapped.

Monitoring of the environment requires the rapid estimation of the metal contents of air and water, the rate of their uptake, and knowledge of their modes of occurrence. To achieve this goal, the author and his co-workers employ various kinds of artifical sorbents to monitor heavy metal contamination of water and soil (Lukashev, 1987).

Of great importance are the landscape and geochemical zoning maps of the Byelorussian area, especially when these are integrated with Quaternary geological characteristics, bedrock composition, geomorphological processes, water and climatic conditions and vegetation characteristics, as well as maps of the industrial complexes with particular attention to affects related to their economic development.

The lack, or excess, of some chemical elements in the environment are significant geochemical factors to be considered when studying endemic diseases. In recent times, technogenic pollution of the biosphere by vast amounts of chemical compounds from industrial wastes, automobile exhausts, domestic garbage, toxic chemicals, etc., has tended to enhance the development of such diseases. In certain countries, higher rates of carcinogenic, cardiovascular and other disease have been ascribed to the above effects.

Research performed by Byelorussian scientists (e.g. K.I.Lukashev, 1984) has demonstrated that oncological diseases are related in some way to low radioactivity in the environment, pesticides contained in foods, the nitrate content of water food, residual traces from nuclear tests performed in the 1950's, heavy metals,etc.

The impact of Chernobyl on the ecology of the BSSR is very serious. Maps show that radioactive fallout covered the regions with high and low cancer rates. This formed a mottled and complicated ecological environment. Only in 12 - 15 years it will be clear whether radioactivity essentially affected cancer rates in the BSSR. There are different opinions among scientists concerning this problem.

References:

Fersman A.E. (1955): Selected Works, Vol. III. Izd. Akad. Nauk SSSR, Moscow (in Russian).

Lukashev K.I.(1980): Geochemistry of technogenesis: Problems and tasks. In Geochemical methods of monitoring (ed. V.K. Lukashev), 16 - 26. Nauka i Tekhnika Publishers, Minsk (in Russian).

Lukashev K.I.(Editor) (1984): Geochemical Research of the Landscapes in Byelorussia. Nauka i Tekhnika Publishers, Minsk (in Russian).

Lukashev V.K.(1987): Geological Aspects of Environmental Protection. Nauka i Tekhnika Publishers, Minsk (in Russian).

Lukashev V.K. and Lukashev K.I. (1980a): Some problems in geochemical monitoring of the environment. In Geochemical methods of monitoring (ed. V.K. Lukashev), 26 - 33. Nauka i tekhnika Publishers, Minsk (in Russian).

Lukashev V.K. and Lukashev K.I. (1980b): Scientific Fundamentals of Environment Protection. Vyshshaya Shkola Publishers (in Russian).

ECOLOGICAL-GEOCHEMICAL EVALUATION OF URBAN SOIL CONDITION

I.K.Nezhdanova, Yu.P.Suetin, G.B.Sveshnikov

Leningrad State University, USSR

Under the influence of anthropogenous activities the natural ecological systems are being replaced by the agrogenous and technogenous ones which acquire new geochemical features. The most intensive transformation of environmental geochemistry takes place in the technogenous ecological systems - in cities, urban zones, because these are the places where the most active various and large-scale anthropogenous pressures on the original landscape occur. Taking for example the large cities with numerous and various industrial and municipal enterprises we can study these main tendencies which seem to be spread over the vast areas and in some extent over the whole biosphere. The evaluation of ecological-geochemical condition of urban landscape can be based on the study of geochemical element content in soils. It accumulates the material corresponding to the whole period of city's existence and reflects the processes of geochemical evolution of technogenous ecological systems, which were installed in the past, exist in the present time and will exist in the future. As a result of technogenous influence, the original geochemical field, peculiar to the given geochemical province and corresponding to the region, is being transformed to the mosaic set of technogenous anomal fields, comparatively small in size but having various associations of elements and their content levels. The distribution of discovered technogenous anomalies over the city's territory is connected with the disposition of industrial zones and buried dumps, industrial and municipal wastes and also corresponds to the age of specific city regions in accordance with the following principle: the older is a region, the more alterated are soils.

The technogenous soils are characterized by the redundant zonal soils of a wide range of rare and dispersed elements in comparison with the typical soils. In the technogenous geochemical associations the role of technophyle elements, having in natural soils low Clarke concentrations, is increasing. The occurrence of negative anomalies for a number of elements and the great disbalance of microelements, which undoubtedly transmits to the contiguous spheres including living organisms living there, is characteristic of the technogenous soils. The existence of the ''forbidden'' geochemical associations and the large contrast and complexity of discovered anomal fields appeared to be an important feature of the technogenous landscapes. Such geochemical parameters of urban inhabitance environment as the redundant and insufficient content as well as the disbalance of rare and dispersed elements create the prerequisites for the occurrence of wide range of a man pathologies, called microelementoses.

GEOLOGICAL AND ENVIRONMENT-RELATED RESULTS OF THE REGIONAL GEOCHEMICAL AND HEAVY MINERAL PROSPECTING IN THE ERZGEBIRGE MTS (GRD)

Pälchen, W.; Ossenkopf,P.

The Erzgebirge - Vogtland region in the GRD was covered by geochemical stream sediment survey and heavy mineral panning. The sampling density was 1 to 2 samples per km^2. Stream sediment (fraction -0.2mm) was analyzed for 17 elements and stream water for F, pH and electrical conductivity. In panned heavy mineral concentrates more than twenty minerals were determined semiquantitatively.

Despite some changes of absolute concentration of elements by different supergenic processes the geochemical features of outcropping rocks are clearly reflected in the secondary environment, e.g. basic and ultrabasic rocks by high content of Cr, Ni, Ti; pyroxene, ilmenite ± olivine; parametamorphic rocks (phyllite, mica schist, gneiss) by different concentration of B, Ti; granites of Younger Variscan intrusive complex by evident geochemical and mineralogical specialization (Sn, Li, F, Be, cassiterite, topaz, fluorite). Mineralized areas are very well indicated by association of characteristic elements and minerals, e.g. tin mineralization by Sn, F, Li, W, Be, cassiterite, topaz, fluorite; polymetallic veins of quartz-sulphide formation by Pb, Zn, Cu, As, and near the source area also by sulphide minerals; barite-fluorite veins by Ba, F, barite, fluorite. Areal distributed mineralizations with a well-developed primary halo (e.g. Sn, W) are well reflected in the geochemical or heavy mineral maps, whereas vein mineralization (especially barite veins) show only point-shaped anomalies of high contrast.

Natural supergenic environment is indicated by pH in stream water and by some characteristic element associations in stream sediment, especially Mn-Co-Ni±Zn±Be. Local anthropogenic influences are recognizable by samples with erratic anomal contents for "civilization" elements (e.g. Pb, Zn, Cu, Sn), by slag globes and metallic chips and wires in the heavy mineral concentrate. Intense cattle breeding effects high values of electrical conductivity in stream water.

Mercury in atmosphere over rural, urban and industrial parts of Zagreb city

Ladislav A. Palinkaš [*], Sergej E. Sholupov [**],
Nikolai R. Mashyanov [**], Goran Durn [*] and Slobodan Miko [*]

[*] Mining-Geology-Petroleum Engineering Faculty,
University of Zagreb, Pierottijeva 6, 41000 Zagreb, Yugoslavia

[**] Intitute of the Earth Crust, University of Leningrad,
Univerzitetskaya neberezhnaya, 199164 Leningrad B-164, USSR

Key words: Mercury, Atmosphere, Pollution in Zagreb, Zeeman atomic absorption analyser.

Permanent increase of inorganic solid and gaseous pollution in atmoshere over inhabited areas, caused by uncontrolled growth of cities and unplanned urbanization in stricktly industrial regions with still "dirty" industry, makes a serious ecological problems. Mercury is also one of the most dangerous pollutants in modern human environment and study of its concentration, distribution and environmental cycles is of primary importance.

In recent years Zagreb city encounters severe pollution problems in aquatic, terrestrial and atmospheric environment. A random or permanent monitoring of some inorganic gaseous pollutants in atmosphere has already been organized and published elsewhere. By means of a sophisticated mercury vapor analyser with a Zeeman effect background corrector, however, continuous registration along two traverses (monitoring routes) over the atmosphere of Zagreb city has been elaborated for the first time. Recent development in construction of sensitive and selective mercury vapor analysers enables measurements of background values and pollution control in rural and urban areas. Continuous registration of mercury in ambient air in the research has been performed by a Zeeman atomic absorption analyser with attached circulating cell in the compartment between the light source and mirror and by air pumping at a rate of 4 $\mathrm{l\,min^{-1}}$.

Data, presented by geochemical contour mapes, show strong anthropogenic influence in the Žitnjak industrial area. The anomaly high 105 $\mathrm{ngm^{-3}}$ Hg, on the 21 October moved slightly to the downtown by change of wind direction on the 31 October. Intensity raised as much as 155 $\mathrm{ngm^{-3}}$ Hg, 15 times augmented in comparison to a background value on the Medvednica mountain. Explanation should be sought in denser public traffic, change of wind direction and lowering of atmospheric pressure.

The presented research is an attempt to record possible anthropogenic influence, backround values and rough distribution of mercury. Future measurments will be taken more comprehensively regardin length and direction of monitoring routes and different weather conditions for better understanding of pollution precesses, sources and construction of pollution maps.

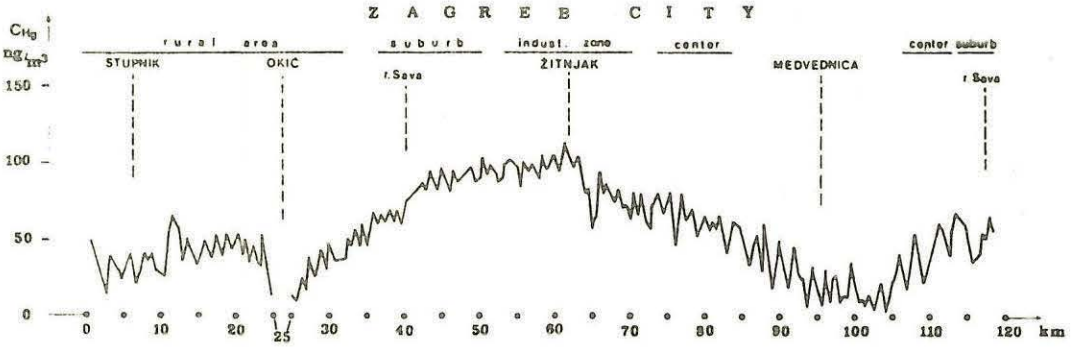


Fig.1 Monitoring route I, on the 21 October.

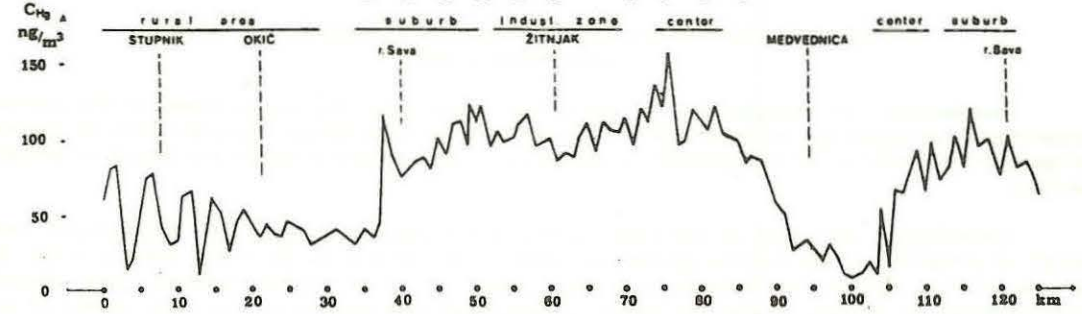


Fig.2 Monitoring route II, on the 31 October.

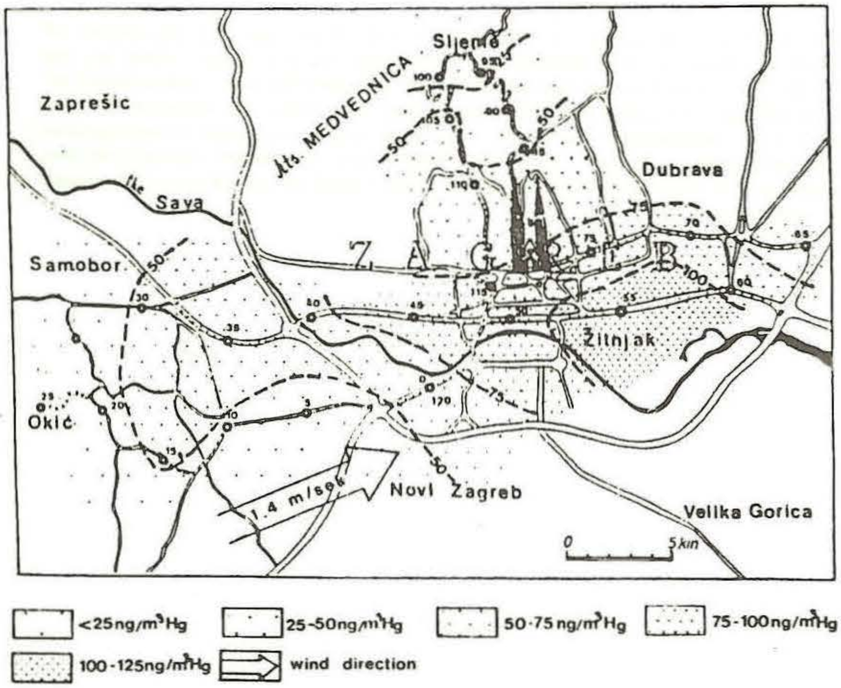


Fig.3 Mercury distribution on the 21 October, 1989.

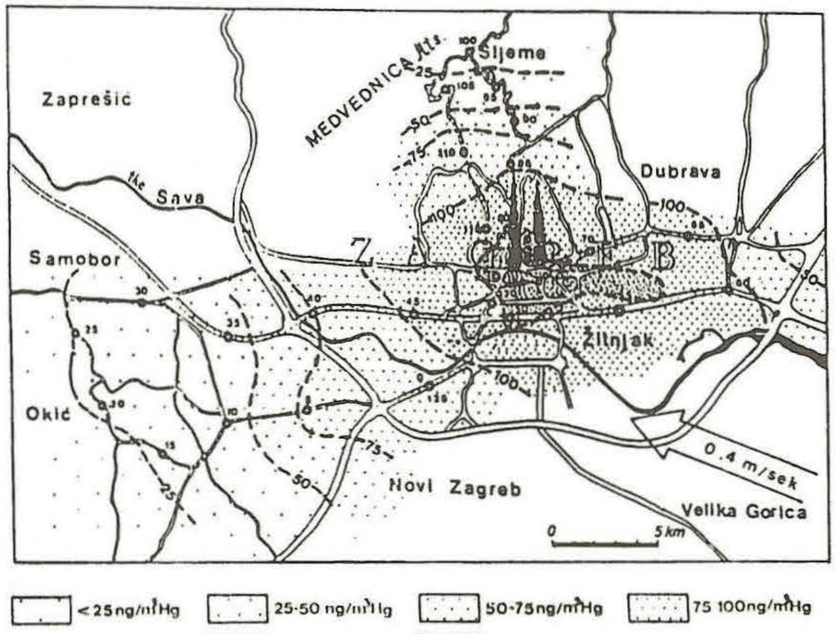


Fig.4 Mercury distribution on the 31 October, 1989.

LANDSCAPE GEOCHEMISTRY AND ENVIRONMENTAL PROBLEMS (methodology, theoretical bases, practical usage)

A.I.Perelman, A.B.Anokhin, E.N.Borisenko, N.B.Lamakina, A.E. Samonov,
IGEM, Moscow, USSR

1. Geochemistry of landscape has a fundamental meaning for solving problems of the environmental geochemistry - struggle against pollution. Presentation about geochemical deferentation of the biosphere and neosphere, conception of the geochemical barriers in the concentration of the matter of pollution are important.

2. Technological pollution of the same sources (mills and factories, roads, agricultural landscape, cities) is different in the various geochemical conditions: tundra, taiga, step, desert, hills, plateau, badlands, plains, regions with basalts, granites, sands, limestones, shales and other rocks. Therefore for solving problems of the environment geochemistry needs landscape-geochemistry mapping. Models of such maps of different parts of our country are created by authors. During these investigations geochemical classification of anthropogenetic landscapes are provided.

3. The theory of the geochemical barriers is quite meaningful for the fight against pollution of nature. On the geochemical barriers an increase of the geochemical anomalies occurs which leads to the higher quality of the geochemical monitoring, reduction of the quantity of the samples and improvement of their information. Localization of the pollution occurs on the geochemical barriers. On account of this problem it is necessary to create artificial geochemical barriers. The experience with such investigation in the different regions of the USSR is very great. The earlier established types of element concentrations on the geochemical barriers may be used in the fight against pollution. The types of concentration depend on landscape-geochemistry conditions and type of pollution.

GEOCHEMICAL BACKGROUND: IMPLICATIONS FOR ENVIRONMENTAL GEOCHEMISTRY IN NOVA SCOTIA, CANADA

P. J. Rogers[1] and J. G. Ogden III[2]

Since the early 1950s exploration geochemical surveys have been carried out on a variety of surficial materials in Nova Scotia. To date most of this effort has been directed exclusively at resource potential applications with the intention of stimulating development in the mineral sector of the economy. During this exploration phase an extensive geochemical database has been collected. A traditional mineral producer, Nova Scotia has a high population density sharing a relatively small area. This demographic reality exacerbates a land use issue often represented as a conflict between the desire for a clean environment versus the need to generate wealth from the abundant mineral resources of the province. The impact of mineral development on the landscape and quality of life is an important environmental issue in North America and especially Maritime Canada.

Most geochemical exploration activity has concentrated on stream or lake drainage systems by sampling sediments and(or) surface waters. Lake and stream catchment basins are important repositories of geochemical information concerning the composition and characteristics of their drainage areas. Modern drainage systems can be considered as mass storage devices (Ogden et al., 1988) which contain the 'geochemical genetic code' for each catchment. The extension of the catchment basin concept to exploration geochemistry (Bonham-Carter et al., 1987) forms a bridge to environmental geochemistry. This paper will consider studies of a number of catchment basins in Nova Scotia.

One of the principal aims of exploration geochemistry is the estimation of geochemical background to define threshold levels and indicate anomalies. Recognition of 'natural' background levels in surface materials of various elements is needed to define baseline element levels and principal controls and to monitor changes in the ecosystem. Widely different element levels can be found in stream and lake systems. It is possible to define various natural and imposed geochemical controls present in stream and lake drainage systems. Principal geochemical factors governing background levels include catchment lithology, chemical mobility, and dispersion and dilution of metals during transport. pH is one of the most active geochemical factors and also the one most readily affected by imposed external loading such as from acidified rainfall. To estimate the pH effect on heavy metal mobilities, background levels and vector properties of these metals in natural systems must be elucidated.

Catchment basin analysis (CBA) has been used to characterize background for 1500 stream sediment and water samples from the Cobequid Highlands. Background is modelled for element concentrations in stream sediment as a function of the areal proportion of map units occuring within each catchment basin. Step-wise regression uses areal proportions of mapped units as independent variables to model geochemical background for Cu, Pb, Zn, Ag, Fe, Mn, Ni, Co, As, Hg, U and Mo in sediment and U, F and pH in water for each of 65 mapped lithologic units. Calculated background levels for each map unit are given as weighted means for each element. The model thereby determines a measure of the association between the geology and surficial geochemistry. Volcanic and granitic units of the central upland core have much higher background levels for most elements when compared to other units. After subtraction of background the residual variance of catchment basins reveals areas of anomalies, which as elevated concentrations could be seen as potential hazards in terms of heavy metal content. The CBA model also distinguishes variance due to scavenging by Fe and Mn and pH effects on the mobility of elements such as U, Mo and As. Catchment basin plots for these elements clearly outline the pH response in terms of the underlying geology.

We call attention to, and illustrate, two important properties of limnic systems:

(a) Catchments with definable sub-watersheds can show distinctive biostratigraphic and geochemical signatures throughout the lake basin. We describe Soldier Lake, Halifax County, Nova Scotia (Ogden and Rogers, 1988) which has a hydrogen ion $[H^+]$ gradient from distinct sub-watershed units ranging from 0.7 μeq L^{-1} (pH 6.2) to 102.3 μeq L^{-1} (pH 2.99). Mass balance studies (Ogden and Machell, 1985) indicate retention (presumably by deposition) of 33% of Al, 63% of organic C, and 85% of Fe entering the lake. Outlet pH values of 4.6 (25.1 μeq L^{-1}) imply neutralization of 38% of the $[H^+]$ entering the lake. We show the presence of distinct geochemical and biostratigraphic (diatom) domains related to water chemistry, independent of regional (allocthonous) pollen deposition.

(b) Sediment cores from three connected lake basins in the St. Margaret's Bay area, Halifax County, Nova Scotia, which have shown substantial acidification, with pH values from 6.0 to 6.3 in 1979 and from 4.8 to 5.6 in 1987, reveal four goechemically (and biostratigraphically) distinct horizons or zones:

(1) Initial (ca. 12,500 RYBP (Radiocarbon Years Before Present)) high energy meltwater deposition of

---

[1] R.R.4 Shubenacadie, N.S. B0N 2H0

[2] Department of Biology, Dalhousie University, Halifax, Nova Scotia, B3H 4J1

coarse (sand and gravel) sediment including a large proportion of extra-catchment materials, with little or no organic matter.
(2) A silt to clay transition horizon (ca. 11,500 RYBP) with very little organic carbon and very low hydraulic permeability (Ogden, 1986), which effectively seals an initial catchment geochemical signature unaffected by biological modification.
(3) A mid-postgalcial period of warm/dry conditions (3500-5500 RYBP) of reduced hydraulic throughput, increased organic production, and longer water residence times which provided increased opportunity for organic/inorganic geochemical interaction.
(4) A post-colonization period of increasing anthropogenic influence, land disturbance, and changing atmospheric geochemistry.

In the St. Margaret's Bay area, development and construction activities have been primarily limited to the Five Island Lake catchment area, and are mostly residential and seasonal cottage developments. A number of new residential developments are currently under way in this watershed and may be expected to change both runoff and water quality as development pressures continue to affect many of the present hydrogeochemical parameters. With increasing acidification we infer the development of geochemical deposition domains in these lakes in future, similar to those described for Soldier Lake.

REFERENCES

Bonham-Carter, G. F., Rogers, P. J. and Ellwood, D. J. 1987: Catchment basin analysis applied to surficial geochemical data, Cobequid Highlands, Nova Scotia; Journal of Geochemical Exploration, v. 29, p. 259-278.

Odgen, J. G., III 1986: The concept of the perilimnion; Proceedings of the Nova Scotia Institute of Science, v. 36, p. 137-144.

Ogden, J. G., III, Carrigan, L. M. and March, K. L. 1988: The geochemical care and feeding of mud; In Prospecting in Areas of Glaciated Terrain 1988, eds. D. R. MacDonald and K. A. Mills; Canadian Institute of Mining and Metallurgy, p. 293-303.

Ogden, J. G., III and Machell, J. 1985: Ionic and mass balances in a dilute acidified brown water lake; Proceedings of the Nova Scotia Institute of Science, v. 35, p. 75-90.

Ogden, J. G., III and Rogers, P. J. 1988: Biological and geochemical sedimentation along a pH gradient in Soldier Lake, Halifax County, Nova Scotia; In Hydrogeology of Cold and Temperate Climates and Hydrogeology of Mineralized Zones, ed. C. L. Lin; International Association of Hydrogeologists, p. 201-210.

RELATIONSHIPS BETWEEN ENVIRONMENTAL AND EXPLORATION GEOCHEMISTRY, ILLUSTRATED BY SEDIMENT-WATER INTERACTIONS IN A DESERT STREAM CONTAMINATED BY MINE WASTES, ARIZONA, USA

Donald D. Runnells
Department of Geological Sciences, University of Colorado,
Boulder, Colorado, 80309-0250

INTRODUCTION

Boulder Creek comprises one of the major watercourses in an otherwise arid region of western Arizona, USA. Areas of the drainage of Boulder Creek are highly mineralized a variety of metals. The abandoned Hillside complex, on the banks of the creek, includes tailings, waste piles, and collapsed adits and shafts. The mine, which operated from the 1880's to the 1950's, extracted chiefly gold and silver, with quartz, pyrite, and arsenopyrite as major gangue minerals. A variety of other precious-metal and base-metal ores from the surrounding region were also processed at the mill.

Seepage of metal-rich waters from tailings and from a collapsed adit enter the stream at two distinct points. At seasonal low water, heavy precipitates of Fe, As, Al, Cu, and other metals form almost instantaneously below the points at which the contaminated waters mix with creek water. The loss of metals from the water is clearly mirrored by the gain of metals in the stream sediment.

COMPOSITIONS OF WATERS

Water in the upstream non-polluted portions of Boulder Creek has a pH as high as 8.5, alkalinity up to 282 mg/L as $CaCO_3$, and is rich in dissolved oxygen. The water is predominantly Na-Ca-HCO_3 in composition. A maximum concentration of 515 mg/L TDS was measured in the upstream portions of the stream at low water in August. The high rate of evaporation causes an evaluation in chemical composition of the stream water similar to the chemical evaluation of waters in alkaline lakes.

Below the mine and mill complex the alkality, bicarbonate, and pH decrease, with increases in sulfate, TDS, and dissolved and particulate metals. Two distinct seepages from the mine and mill wastes into the stream can be recognized. The first and most important is an acidic seepage from the base of the uppermost tailings pile. This water has a pH of 2.4 and total concentrations (in mg/L) up to 8550 TDS, 5240 SO_4, 260 Al, 34 As, 100 Cu, 610 Fe, 52 Mn, and 92 Si. The tailings seepage appears to be oxygenated, with iron in the Fe (III) state. Filtration using a 0.45 um membrane filter shows that from 30% to 95% of the metal in the seepage water is in dissolved form, depending on the metal.

The second seepage comes from a collapsed mine adit downstream an additional 1250 meters. The water from the collapsed adit has a pH of 5.4 and contains total concentrations (in mg/L) up to 2640 TDS, 1480 SO_4, 21 As,68 Fe, 45 Mn, 9.5 Zn, 19 Si, but non-detectable concentrations of Al and Cu.The adit water is lower in oxygen than the tailings seepage, with iron largely in the Fe (II) form.

As the seepage waters mix with stream water, heavy precipitation occurs. Immediately downstream from the tailing seepage, a heavy floc of reddish-brown material forms, and during low-water it quickly settles to the bottom of the stream. Chemical analysis shows that this material is mainly iron oxyhydroxide, enriched in As and SO_4. About 20 meters farther downstream a heavy greenish-white precipitate forms and is rich in Al and Cu. However, at a distance of approximately 1100 meters downstream, the water is clear, the pH has again risen to 8.4, and most of the metals have precipitated.

It is obvious that the alkaline, oxygenated water of the stream is highly effective in causing the precipitation and removal of the most toxic metals and thus allowing a rapid recovery of the stream.Such a rapid recovery would certainly not be the case for less alkaline, more dilute streams in a more temperate climate. For example, in the mountains of Colorado, USA, severe contamination of streams may extend for tens of kilometers below similar point sources of acid-mine drainage.

Upon entry of the seepage waters into Boulder Creek, Fe and As are the first metals to precipitate, followed by Al and Cu, with Mn, Zn, and Cd being the most mobile. Lead is undetectable in the water, despite the fact that it is abundant in the waste tailings and in the stream sediment. Depending on the season and the metal, as much as 90% of the metal transported in the stream water is in particulate form.

The participation and removal of dissolved metals from the water is very clearly reflected by increases in the metals in the stream sediments at the corresponding locations. Computer modeling (WATEQF - Plummer et al., 1976) suggested that the Fe-rich precipitate is probably a jarosite and that the Al-rich precipitate is probably jurbanite, in agreement with similar studies by Nordstrom (1982), Chapman et al. (1983), Filipek et al. (1987), and Karathanasis et al. (1988). During periods of high flow, the metal content in the sediment may be lowered by orders of magnitude due to mixing, dilution, and covering with normal sediment from the drainage basin.

SUMMARY

Although the main purpose of this investigation was environmental, the results have significant implications for geochemical exploration in arid regions. In particular, the rapid loss of metals from the water suggested that prospecting in arid climate should utilize the stream sediments. Zinc, Mn, and Cd are the most mobile of the metals in the water and yield the longest dispersion trains. Seasonal fluctuations in water flow exert a major influence on the geochemistry of the water and of the sediment. The dilution and mixing of sediment during periods of high-water flow indicate that exploration using stream sediments in a similar region would be most effective during low-water flow.

REFERENCES

Chapman, B.M., Jones, D.R., and Jung, R.F.1983. Processes controlling metal ion attenuation in acid mine drainage streams. Geochim. et Cosmochim. Acta 47:1957-1973.

Filipek,L.H., Nordstrom, D.K., and Ficklin, W.H. 1987. Interaction of acid mine drainage with waters and sediments of west Squaw Creek in the West Shasta Mining District, California. Environ. Sci. Technol. 21:388-396.

Kararthanasis, A.D., Evangelou, V.P., and Thompson,Y.L.. 1988. Aluminum and iron equilibria in soil solutions and surface waters of acid mine watersheds. Jour. Environ. Qual. 17:534-543.

Nordstrom, D.K. 1982. The effect of sulfate on aluminum concentrations in natural waters: some stability relations in the system Al2O3-SO3-H2O at 298K. Geochim. et Cosmochim. Acta 46:681-692.

Plummer, L.N., Jones, B.F., and Truesdell, A.H., 1976, WATEQF - a FORTRAN IV version of WATEQ, a computer model for calculating chemical equilibrium of natural waters. U.S. Geol. Survey Water Res. Invests. 76-13, 61 pp.

PROSPECTS AND METHOD OF SOIL-GEOCHEMICAL MAPPING AS A FUNDAMENTAL STAGE ON THE WAY OF SETTLING ENVIRONMENTAL PROBLEMS AND RAISING THE AGRICULTURAL LANDS FERTILITY

F.J.Saprikin, N.A.Selenkov
All-Union Scientific research Institute, USSR

The distinctive Noosphere peculiarity is an appearence of additional technogenic pressure on biosphere, which influences much more than all natural processes all together.

Ecosystem: soil-plants-living organisms is exposed to the most active influence. The topsoil, which has been formed for tens and hundred thousands of years is destroying by man for months and years.

It promoted by:

1. Engineer-technical transformations: building of large industrial enterprises, reservous, electric power stations, minerals exploitation, especially, open-pit mines etc. All that changes earth coner structure at a depth of 200-400 meters. According to UNO information 2-3 billion tonnes of rocks are moved every year in the process of building and stripping;

1.1. Unwise realization of melioration leads to swamping or graining of large territories;

1.2. Moved up rocks and wastes of ore-dressing plants occupy large territories, as a rule, agricultural lands;

1.3. All this results into sharp reduction of the agricultural land stock of the USSR. So, if in 1960 there were 1,03 hectare of arable land per head, just by 1980 - 0,84 hectare. It also helps increasing to a number of people. Reduction of the stock, especially, can be sensed at the industrial regions of the country. So, in Leningrad region there are 0,07 hectare of arable land per head. It should be also added that productivity of the USSR lands is 2,2 times lower than in USA. 60% of arable lands of the USSR are situated at droughty and half-droughty zones.

2. Soil-cover pollution by dust and smoke outbursts, especially in large industrial center's suburbs, where, as a rule, most of agricultural enterprises, supplying inhabitants with food-stuffs are situated:

2.1. System of automobile roads which are crossing arable lands, pollutes soils with exhaust gas, as well as unwise use of chemicals and fertilizers. Their surplus, carried out from light mechanical structure soils to subsoil matters make them useless for drinking, while their carring out to rivers and reservoirs leads to eutrophisation of the last ones.

3. To settle environmental problems and to raise agricultural lands fertility a speeded up method of soils culturing and raising their fertility was offered, based on structural reclamation, where removed rocks, concentrating mill's waters, agro ores of non-conditional deposits and rocks, capable to keep moisture, igneous rocks, glauconitite sends and others as well as wastes of metallurgical and of constructional materials industries are used as reclamation substances. This method is marked by the bronze medal of the USSR Exhibition of economic achievements.

3.1. To select the definite (reclamation substances) for soils a soil-geochemical mapping is carried out. Mechanical composition of soils and content of microelements there, as an index of degree to provide normal or abnormal vital activity of organisms in biogenetic food chains: rock-soil-vital organisms - is taken as a principle of this method.

3.2. Reclamation substances carrying into soils result in improvement of their water-physical characteristics. It helps to raise sharply agricultural productivity and its quality and also makes it possible to decrease the amount of fertilizers carrying into soils, to reduce expences and utilize mining and processing industries wastes. It allows to use released territories and to improve much environment.

ENVIRONMENTAL GEOCHEMISTRY OF A LARGE INDUSTRIAL CENTRE IN THE MOUNTAINS OF THE CAUCASUS

B.A.Sudov

Caucasian Institute of Mineral Resources, Tbilisi, USSR

1. Combined ecological and geochemical research has been carried out in the territory of the city of Tbilisi occupying about 250 km^2 in a low-mountain relief area (350-1100 m above sea level) in the r. Kura valley. The climate is semi-arid; the landscape predominantly contains the Ca^{2+} - Na^+ - class of elements migration. The city is a large industrial centre of Transcaucasia, its chief industries being machine building, machine-tool building, instrument building, civil construction, electrotechnical, chemical, textile and food industries. The city is served by several heat power stations using different kinds of fuel (coal, oil, gas). The motor traffic is exceedingly heavy. The population of Tbilisi is 1.+million people.

2. The studies involved the general contents of chemical elements (3580 samples) and their mobile phase (1160 samples) in soils, surface waters (80 samples) and in a temporary snow cover (35 samples). It was found that the content of 23 elements exceeded the soil clarkes. Concentrations of a number of elements (lead, mercury, copper, nickel, chromium, zinc) are significantly higher than their admissible limits. The levels of manganese, vanadium, molybdenum, silver, barium, cobalt, scandium, tin and zirconium are much higher than the soil clarkes.

High lead, cobalt and manganese contents exceeding the maximum admissible limits in water, were observed in the Kura and its tributaries.

The snow cover analysis evidenced that the concentrations of titanium, iron, lead, zinc, antimony, cadmium also exceeded the tolerable limits in many sites of the city.

3. Technogenic geochemical anomalies, amounting to 142, were discovered all over the city area, being associated with the particular industries polluting the environment, where the industrial emission into the air was predominant. The distribution of the pollution is related in the first place, with the valley circulation of air-masses. The steep mountain slopes are also important, since they hinder the upward technogenic migration of elements.

The investigation results make it possible to concentrate intently on the most important problems of geochemical monitoring of the Tbilisi environment and are highly significant from the methodological points of view for industrial centres situated in similar landscape conditions.

REGIONAL ENVIRONMENTAL GEOCHEMICAL STUDY IN CHINA; SOME EXAMPLES

Ren Tianxiang, Zhu Lixin, Sun Tianyu and Zhang Hua

Institute of Geophysical and Geochemical Exploration Langfang, Hebei 102849 P.R.China

Relationship of the background value and distribution pattern of some trace elements with the growing and harvesting of crops, the occurrence of esophagus cancer, hypertension and diabetes diseases were studied in an area of more than ten thousand square km in Quinglong, Hebei by making use of the data of regional stream sediment survey in 1:200,000 scale. The results indicted that the content of Cu, Zn, Co, B and Mo is in close relationship with the growing and harvesting of crops. Agricultural environmental geochemical maps of these elements were drawn. It was also found that regional geochemical background value and distribution characteristics of Mo are related to esophagus cancer to a certain extent, and Cr to hypertension or diabetes, and some potential districts of local diseases were predicted.

Geochemical soil and hydrogeochemical survey investigations were carried out for local diseases in an area of 720 square km in Sanhe, Hebei. The results showed that content of iodine in soil and groundwater is clearly negatively related with the local goiter disease. The content of available form of fluorine in soil and that of fluorine in groundwater are positively related with local fluorine-poisoning disease. The distribution districts of these two diseases are basically correspondent to the variation of iodine and fluorine in soil and groundwater.

Geochemical characteristic of different media, including soil, groundwater, surface water and crops, have been investigated in an area of 1,300 square km in Zhengzhou city and its surrounding, Henan Province of China. It has been discovered that the content of Hg, Se, Cd, Pb and Cu are distinctly increased in soil layer near surface in the district irrigated by sewage, which reaches light-middle environmental pollution. The contents of As, Sb, Cu, Ph, S, Fe and Ca were obviously raised in the district irrigated by water of the Yellow River, these elements mainly come from mining activities in the upper reaches of the Yellow River. According to the differences of the content of Si, Ti and Fe between upper and basal layers of soil, it was found that the area of sandy loam (or sandy land) has a trend to extend continuously. Some ideas for controlling environmental pollution and deterioration of soil have been suggested to the local government.

GEOCHEMICAL MAP OF THE REGION OF THE BAIKAL-AMUR RAILWAY (GEOCHEMICAL ZONATION AND METALLOGENIC CONCLUSIONS)

G.M.Belyaev, S.D.Velikoslavinsky, V.A.Maksimovsky, V.S.Pevzner, V.E.Rudenko, All-Union Geological Institute, Leningrad, USSR

Polyelemental geochemical map of the Baikal-Amur Railway region on 1:3,000,000 scale on the structural-formational basis, including about 40 structural-formational comlexes of various ages was compiled on the basis of principles of geochemical mapping, developed in the All-Union Geological Research Institute (VSEGEI). Geochemical load of the polyelemental geochemical map reflects types of geochemical associations of elements and levels (R) of their accumulation relative to a clark K ($R < 1.5$ K; $1.5\ K \leqslant R \leqslant 2.5$ K; $2.5\ K \leqslant R \leqslant 5K$; $R > 5K$) in the structural-formational complexes and geological formations with an accent on revealing of geochemically specialized geological complexes as potential sources of oreforming elements. Such geological formations ($R \geqslant 2.5$ K) occupy about 20% of the territory of this region.

The analysis of the polyelemental geochemical map showed that essential geochemical distinctions between separate geoblocks and their fragments accumulated in the process of geological development of the region from the Early Archean through the Cenozoic. This data serve as a basis of zonation of the territory distinguishing the structures in the rank of geochemical provinces, districts (zones) and regions. Geochemical units are in the definite hierarchial relationships with geological and metallogenic structures; in particular geochemical provinces are of the same rank as folded districts and platforms as well as metallogenic provinces, which gave the possibility to improve some debatable boundaries between geological and metallogenic structures of the region.

Geochemical units in the rank of provinces and districts are confirmed in variances of geochemical zonation of the territory, when geochemical information is summarized from structural-tectonic units (anticlinoria, sinclinoria and so on) either from data of ore element distribution in the local concentrations with $R > 10$ K (deposits and ore manifestations). In the general case at the level when contents of oreforming elements are higher than clark ($R > 1.5$ K), the geochemical field of the region of the Baikal-Amur Railway possesses heterogenious structure. Almost every structural-formational complex is individual from geochemical viewpoint, i.e. it is characterized by one, two or more chemical elements with their weighted average contents in geological formations higher than 1.5 K.

Geochemical stages which age boundaries are determined by the change in geotectonic regimes are distinguished in a history of geological development of this region.

Inheritance of some geochemical characteristical properties of the primary protocrust composition from epoch to epoch is establisjed on the one hand, and widening of the spectrum of oreforming elements involved into geological processes and hence and increase in diversity of mineral deposits on the other hand.

Analysis of relationships between geochemical and metallogenic structures shows that geochemical regions, established by local concentrations, and metallogenic zones correspond to each other most completely. When passing to the level of geochemically specialized geological complexes, this relationship weakens: the type of association is the same, but the spectrum of oreforming elements is changed. These data enable to distinguish bew potential ore-bearing structures in the ranks of ore regions and knots.

STRUCTURAL-GEOCHEMICAL MAPS OF ORE DISTRICTS

B.I.Burde
Far East Institute of Mineral Raw Materials,
Khabarovsk, USSR

The paper discuses the application of cartographic methods of investigations for delineating geochemical fields of epigenetic ore occurrences that have hydrothermal-metasomatic origin. Such investigations employ modeling based on the experience from studies of tin and rare metal ore districts. The model of the hierarchical geochemical system which is largely controlled by linear structural elements is outlined as certain principles. Elementary geochemical targets are delineated including their temporal, genetic and spatial relations, the hierarchy of the targets, relations between the zonation, continuity and transformation at different hierarchical levels. Periodical structures are most important among symmetry phenomena.

The relation between the structural elements of geochemical fields and productive metal contents permits making the level prognosis for ore occurrences and evaluating the extension of mineralizations.

The structural-geochemical map, on the whole, is a model for the geochemical structure of the field of the superimposed metal occurrences. Structural-geochemical maps on 1:50,000 and 1:25,000 scales for some ore districts in the Far East are demonstrated.

GEOCHEMICAL MAPPING IN THE USSR

E.K.Burenkov
Institute of Mineralogy, Geochemistry and Crystallochemistry of Rare Elements, Moscow

P.V.Koval
Institute of Geochemistry, Irkutsk
and

N.V.Mezhelovsky
Ministry of Geology of the USSR.

The main bulk of geochemical mapping carried out in the USSR from the fifties up to eighties is the survey that was combined with compiling geological maps on 1:200,000 scale. This survey was largely performed on the secondary environments (soils, bottom sediments, or, more rarely, water and vegetation) by semi-quantitative spectral analyses and was aimed at solving research tasks. In recent years ecological tasks were added to them. The above survey covered over 50% of the Soviet Union. The survey resulted in the compilation of a number of mono-elemental and complex prognosis-geochemical maps. Together with these maps auxiliary maps, as a rule, are compiled, showing the geochemical coverage and landscape-geochemical regionalization in terms of application of geochemical methods.

Special-purpose geochemical maps have been compiled in the past years to solve research, ecological, scientific and methodological tasks. These also include maps of ecological troubles morbidity, snow-geochemical, atmogeochemical maps etc. Their common scale is 1:50,000 and larger.

General geochemical maps for the whole country or large regions, as a rule, are made at 1:1,000,000 or 1:10,000,000 scale. Maps for solid rocks show geochemical patterns of structural-formational zones and geological complexes. They are usually accompanied by geochemical regionalization schemes which identify geochemical provinces and zones, deep faults and epigenetic process types (Geochemical map of the Ukrainian crystalline shield basement, 1:1,000,000, V. K. Titov,1984; Geochemical map of the Eastern Baltic shield, 1:1,500,000, VSEGEI, 1967,etc.). An example of the general map showing secondary environment is the Hydrogeochemical map of the Soviet Union, 1:10,000,000, VSEGEI, and landscape-geochemical maps of the Lower Don and Northern Caucasus, (1:500,000, V.A.Alekseyenko).

Complex multi-purpose geochemical surveys at intermediate (1:200,000) and small (1:1,000,000) scales are under way or planned using secondary environments (Uzbekistan, Southern Siberia, etc.). The main purpose is to evaluate the ecological and agrogeochemical state of large regions (Uzbekistan, the Angara area, etc.). In this respect, of particular importance is a project of compiling a geochemical map of the Soviet Union at the 1:1,000,000 scale which is expected to be accomplished by 1995.

AIRBORNE RADIOMETRIC MEASUREMENT AND ITS USE IN CZECHOSLOVAKIA

Karel Dědáček, Geofyzika Brno, Czechoslovakia
Milan Matolín, Jindřich Rejl, Faculty of Science, Charles University, Czechoslovakia

A systematic airborne radiometric and magnetic survey has been performed in Czechoslovakia since 1957. At the present time the airborne gamma-ray spectrometry survey is carried out by Geofyzika Brno. The airplane AN-2 is equipped with a 256 channel Geometrics GR-800D airborne gamma-ray spectrometer with detector NaI(Tl) 33.6 litres, air radon correction unit with NaI(Tl) 4.2 litres, an automatic energy gamma spectrum stabilization based on 1460.8 keV ^{40}K peak and an electronic navigation Mini Ranger III. The calibration is carried out over three natural test strips, the height of contemporary survey is 80 m, profile separation 250 m, aircraft speed 150 km h^{-1} and data are registered digitally in 1 s scans. The computer data processing yields maps of contours of K, U, Th, their ratios, maps of total count and ternary radioelement maps. The resultant standard deviation of data are 0.1 % K, 0.3 ppm eU, 0.7 ppm eTh and 0.7 Ur, the mean deviation of navigation is 20 m. The original recorded data and the resultant concentration of K, U, Th in a net 125x125 m, oriented N - S, are stored in a data bank. The map of radioactivity of rocks in Czechoslovakia is based on the airborne TC radiometric measurement from the period 1957 - 1972, the detailed airborne gamma-ray spectrometry covers approximately 50 % of the area of Czechoslovakia.

Airborne radiometry has been applied in geological investigation and for monitoring the radiation of environment.

The regional investigation of radioactivity of rocks in Czechoslovakia yielded basic data on the natural radioelement distribution in magmatic, sedimentary and metamorphosed rocks and in individual geological units, enabled the comparison of geochemical features of the Bohemian Massif and the West Carpathians, and outlined perspective areas for mineral exploration.

The uranium prospecting and exploration made use of the regional and detailed airborne radiometric survey and K, U, Th data processing to specific parameters indicating U accumulations. Generally, very few U accumulations were indicated directly from the airborne measurements.

Airborne gamma-ray spectrometry maps of ratios of the natural radioelements K, U, Th were found indicative for rock alterations sometimes associated with mineralization. Positive results were reached in the areas of polymetallic mineralization in the Jeseníky Mts. (Northern Moravia) and in the area of the Tertiary neovolcanic rocks in central Slovakia.

Airborne radiometric maps were used for defining the levels of natural environment radiation in Czechoslovakia. The mean values of the absorbed dose rate of gamma radiation in air of terrestrial origin 19.4 pGy s^{-1} in the Bohemian Massif, 13.9 pGy s^{-1} in the West Carpathians and 17.0 pGy s^{-1} in the whole area of Czechoslovakia enable the comparison with the estimated average value 15.3 pGy s^{-1} for the world. The airborne gamma-ray spectrometry analysis of U in rocks is an indirect data base for the compilation of the radon risk maps.

Airborne gamma-ray spectrometry measurements were used to monitor the level of nuclear fallout contamination in selected areas of Czechoslovakia in 1986. Periodical measurements have been carried out in the environment of nuclear power plants. Study experiments initiated in 1989, based on airborne and ground gamma-ray spectrometry, will enable the airborne quantitative determination of ^{137}Cs and ^{134}Cs nuclear fallout radioelements in the nature and their reporting in Bq m^{-2}.

REGIONAL GEOCHEMICAL MAPPING OF EASTERN MACEDONIA AND THRACE; N.E. GREECE

A. Demetriades and C. Zangouroglou

Institute of Geology and Mineral Exploration, 70 Messoghion Street, 115 27 Athens, Greece.

The reconnaissance stream sediment survey over Central and Eastern Macedonia and Thrace began in 1971 and was completed in 1980. Its aim was to delineate uranium and base metal anomalous areas. The present work discusses only the base metal distribution results (Cu, Pb, Zn, Co, Ni, Mn) over Easter Macedonia and Thrace due to purely technical reasons.

The sampling density generally varied between 1.3 to 3.2 samples per square kilometer. The -80 mesh (-177 m) fraction was analyzed by atomic absorption spectrophotometry after a partial hot acid (HNO_3 + HCl) extraction. The geochemical data were smoothed by a weighted moving average method in an attempt to reduce the amount of random error.

The reconnaissance exploration survey succeeded in delineating a number of base metal anomalous targets. The most significant anomalous areas are: Kirki-Essimi-Virini (Cu-Pb-Zn), Xilayani (Cu-Pb-Zn), Thermae (Pb-Zn-Mn) and Palaea Kavala (Pb-Zn-Cu-Mn). Elements such as a Co and Ni were able to map basement mafic-ultramafic complexes and Mesozoic to Tertiary basic lavas.

Element distribution maps directly related to the generally accepted phyto-toxic and -deficiency levels have been plotted for environmental geochemistry purposes. It is believed that these maps, together with the normal isopleth element distribution maps used in mineral exploration, offer the environmental geochemist, the agricultural scientist, the medical researcher and decision makers in general, a chance to study in more detail (a) natural element depletion or excess with respect to plant, animal and human health, and (b) the impact of anthropogenic pollution in the environment.

Finally, it is hoped to present the results of an orientation survey using overbank sediments. This sample medium appears to be suitable for the low density sample scheme, i.e. 1 sample/500 square kilometers, which will be used for the preparation of the Western European Countries geochemical atlas. The corollary of this survey may be that overbank sediment samples should be used by all countries that are participating in IGCP project 259 "International Geochemical Mapping".

GEOCHEMICAL MAPPING FOR GEOLOGY AND ECOLOGY

R.I.Dubov
Tula branch of Central Scientific research
Geological Prospecting Institute, USSR

Results of geochemical mapping can be used for the abstract investigation of the territory, for the search of minerals for the assessment of the mutual influence of the environment on the man and of the man on the environment. For such a complex use, it is reasonable to change slightly the way of mapping. These field explorations, which were done by the search of minerals only on selective areas (atmo-, hydro-and biochemical methods) now are desirable to be done almost everywhere together with lithochemical survey. Some rise in the cost of explorations is worth it:earlier, by search surveys, the minerals of use were discovered only on the little part of the area investigated; now, when the ecological tasks are subscribed, all the information about any territory is of use.

Complexity of the data interpretation for large areas requires to conform to some demands. Principal of them are the following ones.

1. Co-ordination of the results obtained by different enterprises on the adjoining areas.

The practice showed, that in places of overlapping of the survey-areas of different enterprises, the results differ quite often two, three and even more times. To receive sufficiently exact picture, it is necessary to apply the new mathematical method, taking in the account the real probabilistic distribution of the errors of the samples substance-analysis and of the natural substance fluctuations.

2. Construction of complete geochemical fields optimized in the sense of exactness.

Display of only the relatively intensive anomalies points out previously the objects easily observed and already known. This is insufficient for finding deep objects by the search of minerals and for display of important ecological phenomenons. The maps are to be built in isolines with suppression (smoothing) of the random interferences (errors and fluctuations) and with indication of the picture exactness achieved.

3. Combined interpretation of geochemical and other data.

Effectiveness of geochemical surveys increases many times if their data are interpreted jointly with the data of other methods. The same fundamental algorithms of interpretation can be used in many cases by geological search for minerals and by ecological investigations, if to substitute in these algorithms corresponding initial data and quantaties of outcome.

It is necessary to make the following remarks.

Widespread norms for the environment pollution with separate substances are insufficient for the economy optimization. The quantitative assessment of the harmfulness of the real complex pollution in the real, specific conditions is needed. Especially important is combined interpretation of geochemical and medical data and its economic expression.

Geochemical anomalies, natural and made by men, of different substances, often reciprocally overlap. Specially developed mathematical method will give the opportunity in many cases to determine the kind, harmfullness and ecologic-economic loss from the pollution made with concrete revealed sources.

For instance, in one of the cities the functional connection of the stomach-intestine sickness rate with the pollution of the environment by wastes of the ashes from several boiler plants was found. The pollution was displayed on the maps of Be- and Ag- concentrations in the upper layer of the ground. In the places of the largest pollution the sickness rate of inhabitants proved to be 6% a year. According to the found connection, the removal of this pollution would decrease the sickness rate to 2,5%.

In other city the air-pollution was proved to increase the sickness- and death-rate of inhabitants. This pollution is conditioned by the difinite coal, burned in neating and energy-installations. Calculations showed that the replacement of the coal by other kinds would improve not only the health of the population but also increase the economic profit approximately to 50% of money spent.

The method described is represented in the form of the algorithms and computer-programmes fit for the widespread use by different organizations,

GLOBAL GEOCHEMICAL SAMPLING; SOME PROBLEMS AND RESULTS FROM FENNOSCANDIA

Peter Edén
Department of Geology
Åbo Akademi University
SF-20500 ÅBO
FINLAND

The ultimate object of the Global Geochemical Sampling (GGS) program under IGCP 259, is to collect large composite samples of different materials at 3000-5000 stations over the whole globe. A pilot project over Fennoscandia was initiated at the Åbo Akademi University in 1989. The aim is to collect bulk composite samples of humus (A horizon of soil), till from the upper part of the C horizon, overbank stream sediments and stream water from 50 drainage areas 500-5000 km^2 in size.

Composite water samples (0.5 l monthly at each site during one year) and overbank sediments from two depths are being collected from the down stream apex of each area. One kg of till and 1.5 l of humus are sampled at 20 randomly selected sites within each drainage area and these are composited into one grand sample for each material.

The project is faced with many problems, both practical and scientific. Stream sediments e.g. were abandoned at an early stage, because difficulties in finding samples of high quality and in getting sufficient amount of the fine fraction made sampling extremely slow and expensive. It is also difficult to get reliable analyses of the very low metal contents in the water samples. Besides, sampling over several countries causes financial and practical problems. The big size of the samples gives problems with containers, transportation, drying, sieving, storage, etc.

At present, chemical analysis of stream water (one sample from each site) from Finland and from the northern parts of Sweden and Norway, and of overbank sediments from Finland, are available. The filtered and acidified water was analysed with mass ICP and the fine fraction of the sediments with ICP after leach with hot nitric acid.

The element contents in both sample types form regional anomaly patterns related to geological features. The water samples from Norway have distinct variations in element abundances, depending on whether they drain Upper, Middle or Lower Allochton Nappes or the Autochton of the Caledonides. Ore districts in the drainage area are also reflected in elevated metal contents in the water. In Finland and Sweden there are differences between Archean and Proterozoic Svecofennian areas and even within these major geological domains there are variations, which in most cases can be related to known geological features. Areas of sulfide-rich clays and till are reflected in high metal contents in the rivers of western Finland.

The overbank sediments also show clear differences between the major geological provinces and between areas of different geology within these. Some of the samples seem to be anthropogenically contaminated, while others are affected by precipitated Fe-Mn-oxides.

SELECTING APPROPRIATE SAMPLE DENSITIES IN THE ARID ENVIRONMENT OF A PART OF THE WESTERN UNITED STATES AND IMPLICATIONS FOR SAMPLING DESIGN FOR A GLOBAL GEOCHEMICAL MAP

Maurice A. Chaffee
U.S.Geological Survey, Federal Center, MS)/£, Denver, Colorado 80225 USA

A major concern in regional geochemical sampling surveys is achieving the sample density that will provide the maximum amount of information relative to the money spent and the objective(s) of the survey. The conventional meaning of the term "sample density" is not appropriate for describing surveys in all areas; two definitions for sample density are suggested. Gross sample density is herein defined as the total number of samples collected in a given area divided by the total land area of the project. In contrast, net sample density is defined as the number of samples collected divided by the total area of outcrop. Gross samples densities are best used in discussing sampling in primarily humid regions, where stream channels are generally well developed and integrated. Net sample densities are best used in discussing sampling in arid regions, which usually have poorly developed and incompletely integrated drainages as well as relatively high percentages of non-outcrop area.

As a test of the effects of differing sample densities in the arid (<380 mm annual precipitation) environment, analytical data for part of the Walker Lake 1° x 2° quadrangle, which lies along the California-Nevada border between 38° and 39° North Latitude, were examined in detail. In this area of about 14,700 km^2, 590 samples of minus 60 mesh (<0.25 mm) stream sediment were composited from drainages throughout the quadrangle and analyzed for 36 elements. Twenty-three of these elements (B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Ni, Pb, Sb, Sc, Sr, Ti, V, Y, Zn, and Zr) were selected for this study. Data for these elements were gridded and contoured to produce 'anomaly' maps. Subsets giving relatively uniform coverage of the quadrangle and representing approximately 50%, 25%, and 10% of the original number of samples in the data set were then selected and new anomaly maps were made. Maps at each sample density were compared to identify the density level at which major anomalies were compared to identify the density level at which major anomalies were no longer obvious. The results suggest that selection of the optimum sample density to adequately characterize any given area is difficult and can be influenced by many parameters, such as the gross lithologies present; the present and past climate; the relief and geomorphology; the size, shape, and range of chemical contents of each geologic unit; the end use of the analytical data; and the algorithms used to grid and contour the chemical data.

Relatively detailed sampling is necessary for geochemical mapping for a regional mineral assessment; whereas, considerably fewer samples are generally needed for a region mapping program. In the case of the Walker Lake quadrangle, a net sample density of 1 stream-sediment sample/14 km^2 (equivalent to a gross sample density of 1 sample/25 km^2) is considered to be necessary to evaluate the arid part of this quadrangle for a mineral assessment survey. In contrast, to delineate the general variations for most elements in this quadrangle on a regional or crustal scale, a significantly lower net density of about 1 sample/60 km^2 is probably adequate.

At a global scale, no single net sample density will work for all regions of the world because of the many different parameters that affect the optimum sample density. As a result, the sample density for each region will need to be selected based on the parameters that are most important for that region.

COLOR VISUALIZATION OF DATA ON A POLYASSOCIATIVE GEOCHEMICAL MAP

Chebotarjov A.A.
Geological Institute, Burjat Scientific Center, Siberian Branch of the Academy of Sciences. Ulan-Ude. USSR

The approach to the visualization of data on a polyassociative geochemical map built on the basis of observed chemical elements association mapping and to the drawing up a legend to it is proposed.

When substantiating the approach the following circumstances haven been taken into account: Objects studied by a geochemical mapping are macroinhomogeneities of matter upon the Earth's surface. Any matter inhomogeneity can be portrayed by means of a set of chemical elements which contents dispersions are mostly characteristic to it. Common tendencies of measuring elements contents to a changeability serve as criteria to single out detached combinations - associations among the whole number of studied parameters.

The principle of mapping presupposes the refusal from a traditional study of structural characteristics of geochemical fields on the basis of choosing a background, revealing and mapping of anomalous signals etc. Operating with these concepts seems to be inevitable when stating and working on special tasks concerned with investigations of dimensional structures of studied parameters fields. But in this case either statistically detached associations (e.g. factors in Q-mode) or a vector of normal contents dispersion weights are put in conformity to every cell of a regular network. Parameters of network cells conform to a sampling step according to a scale of survey carried out. Thus, a mapping consists in explaining of an element associations-parageneses change.

Visualization of Data Mapped and Drawing the Legend

The change of an element composition of associations is explained on a map with the help of the range of colors. Agreed color (unique colour index) is assigned to each element of the Mendeleev's table. The color of association is synthesized by combining colors of elements which compose it. Thus, gradual or sharp transitions from areas with one composition of associations to areas with another one look like correspondingly smooth or contrast passages of some colors to other colors. The color indexes distribution scheme on the periodical system is the following: violet, blue and bright blue colors are appertained to elements whose atoms fill their quant orbits according to the "cupro" model. These are metallogenic elements. In endogenic processes their geochemical partner in overwhelming majority of cases is sulphur and its analogues. Their natural concentrations and combinations are genetically found in indirect relationships with magma crystallization processes. P, S and halogens - green colors. Rare gases are colorless. Yellow - elements with atoms of "rare gases type" up to the 4th group. Elements with atoms of transitional type with filling of inner quant orbits are "colored" by orange and red. These are petrogenic elements characterized more often by the affinity to O, Si and Al. Their main quantities and concentrations are timed either to magma crystallization processes or visible genetic relations can be found with them. Sections of the legend correspond to typical (according to A.E.Fersman) geochemical associations. Every section consists of synthetized color images of natural associations characteristic of certain geochemical concentres. Algorithms of associations mapping and representing them in color images have been developed. The sharpness of abrupt boundaries posing depends on a sampling step only. The example of such a map building on one of the regions is demonstrated.

The principle proposed allows to visualize and make easily available reading for different practical purposes an element composition of associations obtained in fact.

GEOCHEMICAL MAP PROJECT IN JAPAN

Shiro ITOH
Geological Survey Japan

Preliminary studies related to the geochemical map project of Japan have been started recently by the Geological Survey of Japan. For determining the standardized methods concerning sampling, analysis and data processing, the model field of about 4 000 km^2 located around 100km north of the Tsukuba city has been sampled for stream sediments with the density of one sample per square kilometer. With the analytical method of ICP-AES, some 9 major and 7 minor elements have been analyzed routinely at the rate of 300 samples per month.

A highly automatized neutron activation analysis has been developed to determine the elements which are difficult for accurate analysis by ICP-AES method due to low abundance. Analytical results of some standard rock samples by the method were in very good agreement with reference values. Rare earth elements as well as Hf, Ta, Th, U, Zr, Au and Cs in the stream sediment samples from the model field have been analyzed by the method at the rate of 50 samples per month.

The drainage areas which are considered to be represented by each stream sediment sample were lineated and converted to digital polygonal data. Analytical data, field data, the polygonal data of the drainage area and geographical distribution data of the sample have been stored for use to computer processing. In further computer processing, all these data can be combined through sample number.

Each lineated area is coloured with a different colour according to concentration level of each element. A net of 3 km meshes is covered over the preliminary coloured areas. The concentration level of elements for each mesh will be given as a mean value that is calculated from the weighted values of samples corresponding to the size of area within the mesh. These mesh values become basic data for the further statistic calculation and to make various kinds of geochemical maps.

SAMPLING DENSITY IN REGIONAL GEOCHEMICAL MAPPING

T. Koljonen /1/ and E. Malisa/2/
1/ Geological Survey of Finland, Espoo, Finland
2/ University of Dar es Salaam, Dar es Salaam, Tanzania

Geochemical mapping of whole countries or continents with sampling density as low as one sample per several hundred or even several thousand squàre kilometers has been proposed and vigorously discussed at recent geological meetings. Some geologists have nevertheless expressed skepticism about the usefulness of this kind of mapping. Skills in regional mapping have increased considerably of late, and we believe that much valuable geological information can be obtained through this kind of mapping. We think that these studies should be continued and the problems encountered should be studied and discussed more thoroughly than has been done so far.

Finland was mapped with a sampling density of one sample per 300 km^2 for the purposes of the Geochemical Atlas of Finland. This means that the whole country, altogether about 340 000 km^2, was covered with 1047 composite samples of till. The density was selected at the planning stage as an "educated guess". The results have nevertheless proved highly satisfactory from the geological point of view, and have provided considerable empirical information regarding the selection of sampling densities, as we discuss here.

The sampling density in regional mapping needs to be chosen based on large-scale geological features and processes, characterizing areas of perhaps thousands of square kilometers, where similar chemical compositions are manifested as distinct geochemical anomalies. In our view, the most important variables in this respect are 1) the thickness of the crust (10-70 km^2), which affects the dimension of magmatic and metamorphic rock suites, 2) the breadth of the surface features associated with the collision and subduction of plates (20-100 km or more), 3)the distance between a subduction zone and its island arc(300 km) and 4) the breadth of mobile belts and rift zones with their associated volcanism (20-100 km).

Many geochemical features appear as zones some tens of kilometers broad and hundreds of kilometers long. To be visible on geochemical maps, at least 2 or 3 samples would need to be taken in a transverse section of these zones. This defines the sampling density to be one sample per 200-400 km^2 or less. In continental shields, on the other hand, vast areas are covered with silicic magmatic and sedimentary rocks of relatively homogeneous chemical composition. For these to show up on geochemical maps, a sampling density of one sample per 500-3000 km^2 or more should be sufficient. On the ocean floor the density could generally be very low, possibly one sample per 10 000 km^2 or more.

Based on the results obtained in the highly metamorphic, Proterozoic - Archaean Fennoscandian Shield we propose that a grid of varying sampling density should be used in geochemical mapping when sediment or bedrock is used as sampling material. In areas where the variations in chemical composition of bedrock are expected to be small, a sampling density of one sample per 500-5,000 km^2 can be used, while in areas where volcanism or hydrothermal processes have occurred, a density of one sample per 30 - 500 km^2 is recommended.

SMALL-SCALE GEOCHEMICAL MAPS: A WAY TO DELINEATE AREAS PROMISING FOR MINERAL EXPLORATION

T. Koljonen* and E. Malisa**
* Geological Survey of Finland, Espoo, Finland
** University of Dar es Salaam, Dar es Salaam, Tanzania

The Geological Survey of Finland has carried out a mapping project to produce, fast and economically, geochemical maps covering the whole country. The material studied was the fine fraction of till (< 0.06 mm) and the sampling density one sample/300 km^2. The maps produced reveal that the country can be divided into geochemical domains and these into provinces with characteristic chemical compositions similar to those of the bedrock.

Most of the known ore mineralizations in Finland are reflected in the larger surrounding area as above average concentrations of the elements occurring in the mineralizations. Reversely, we are proposing that areas promising for mineral exploration can be deduced from geochemical maps. This is especially true for hydrothermal deposits, since the chemical composition of these differs sharply from that of the common rocks.

In Finland the following geochemical provinces, are considered the most promising to host economic sulphide, oxide, and other mineral deposits:

- The areas where basaltic greenstones, komatiites, and layered intrusions prevail in the northern and eastern Finland. Potential for the mineralizations of Au, Cr, Ni, Pt, and Ti.

- The granulite zone in Lapland. The zone is a boundary between converging continental plates. Concentrations of Au, Ni, Cu, and Zn are anomalous in till over a large area and although no economic deposits have been found in the Finnish part of it, the zone is considered likely to contain gold, sulphide, and other mineralizations associated with mafic rocks.

- The Lake Ladoga - Gulf of Bothnia zone (often referred to as the main sulphide belt). The zone is the boundary of converging oceanic and continental plates, which divides the country into the northern (Archaean) and southern (Proterozoic) domains. The zone is characterized by elements typical of mafic rocks (oceanic crust) - Fe, Mg, Mn, Ni, Sc, Ti, and V - and of hydrothermal formations - Ba, Cu, Co, Ni, Pb, and Zn. The barium in mineralizations presumably derives from a depositional environment, because many of these mineralizations (e.g., Outokumpu copper ore) are volcanic-exhalative in origin and were deposited on the sea floor where barium was available from sea water and sediments.

- The volcanic-sedimentary belt of south-southwest Finland. This belt has many known sulphide mineralizations and is similar to the Lake Ladoga - Gulf of Bothnia zone. The occurrence of polymetallic sulphide ores and granite pegmatites carrying elements like Ta, Sn, Rb, and Cs is probable, because over a large area till is enriched in elements characteristic of such deposits.

- The granitoids of central and southern Finland. These granitoids comprise suites of rocks of different age and origin, each with characteristic trace element composition. They are enriched in such elements as Au, Mo, W, and U. Excluding the post orogenic rapakivi granites rich in elements like tin, granitoids occur mixed with the gneisses and do not show well up as separate rock units on present geochemical maps. The ore mineralizations associated with granitoids will be more easily studied when maps based on a sampling density of one sample/4 km^2 become available in the mid-90's.

REGIONAL GEOCHEMICAL MAPPING OF GRANITOIDS (MONGOL-OKHOTSK ZONE)

P.V.Koval, Institute of Geochemistry, Siberian Br. USSR Ac.Sci., Irkutsk, USSR

The representation of the geochemical essence in geological objects on the maps is a goal of geochemical mapping of primary settings. Compilation of such geologo-geochemical maps necessitates the geochemical systematic arrangement of rocks. One of possible approaches is exemplified by the map of geochemical types (1:1500000) of the Mesozoic granitoids in the Mongol-Okhotsk intracontinental mobile zone.

The granitoids occupy the area over 150000 km^2. They are subdivided into geochemical types and important facies. This geochemical classification is based on rock groups and families (SiO_2 as the main parameter), rank of alkalinity (Na_2O+K_2O mineralogical criteria), series (K/Na, etc.); distribution of fully mobile trace elements (Rb, Ba, partly Sr) and F; distribution of accessory trace elements (REE, Nb, Zr, Ta, Hf) defined by the stratum composition and alkalinity of the system; the patterns of the geochemical evolution of intrusions and associated ore mineralization.

The next geochemical types have been recognized: palingenic of normal (small scale Sn-W mineralization), subalkaline of K-Na (small scale Sn-W mineralization) and monzogranite (Mo, Au) ranks of alkalinity; syenite-alaskite subalkaline (Zn, Pb, Sn, W, Au) and alkaline (Be, CaF_2-?) ranks of alkalinity; rare-metal normal (Sn, W, Ta, Li), subalkaline (W, Mo, Be) and alkaline (REE, Nb, Zr-?) ranks of alkalinity; trachyandesite (Cu, Mo, Au, Ag), latite (Au, Pb, Zn) and tholeiitic series; the granitoids of alkaline basite-syenite series (REE, Sr).

The average contents of 45 petrogenic and trace elements in granitoids of distinguished types and facies, as well as the Mesozoic granitoids are evaluated considering their spatial distribution.

The analysis of spatial distribution, specific composition and ore mineralization of geochemical type associations revealed the main patterns of mosaic-blocky zonation of magmatic areas and its relation to the geological structure of the region and location of endogenic mineralization in the areas of Early- and Late Mesozoic stages of magmatic activity.

As distinct from the approach of B.Chappell and A.White (1974), this one also takes into account the variations of alkalinity and the mechanism of granite formation (intensive parameters of systems) and correspondingly provides a more detailed classification.

Six basic models of granitoid intrusions (granodiorite, gneiss-granite, syenite-alaskite, rare-metal, gabbro-diorite-granite, final anchieutectic phases of granitoid plutons) have been formulated. They were used to analyse the geological and geochemical specific features of different geochemical types of granitoids and relations between them. The basic amount of granite formation can be interpreted in terms of two genetic models: (i) intracrustal granitization and subsequent transformation of palingenic magmas generated by mantle and magmatic fluids (>80% of granitoids amount), and (ii) crystallization differentiation (granitoids of the latite, trachyandesite, tholeiite series, final anchieutectic differentiates of granitoid plutons).

PRINCIPLES OF GEOCHEMICAL MAPPING OF GRANITOIDS AIMED AT FORECAST

V.D.Kozlov, L.N.Svadkovskaya, Vinogradov Institute of Geochemistry, Irkutsk, USSR

At present, the major goal of geochemical mapping is forecast of mineralization and solution of ecological problems.

The geochemical mapping of granitoids has some specific features determined by their constant spatial relationship with the rare-metal (Sn, W, Mo, rare metals) mineralization which, as geochemically proved [1] has genetic essence. Therefore, the geochemical mapping of granitoids should be aimed at forecast of rare-metal mineralization.

The geochemical studies revealed the main indicative role of contents of granitophile, including volatile and ore-generating elements (F, B, Li, Rb, Be, Sn, Sn, W, Mo, Pb, Ta, Nb, etc.) only with respect to rare-metal mineralization associated with granitoids. The degree of concentrations of these elements in granites was termed "rare metallicity" of granites [2] , the degree of which in a general case is proved to be proportional to that of ore bearing capacity of intrusions. The non-granitophile Sr and Ba (their concentrations are noticeably lowered in rare-metal ore-bearing granites) are also the indicators.

In accordance with this pattern, the methods of quantitative assessment of rare metallicity of granites based on their element formulae and the concentration coefficient have been developed [2] . Considering the indicative role of granitophile elements, as well as Sr and Ba, the forecast geochemical mapping of granitoids should reflect particular features of these elements distribution. The contents characteristic of the mapped granitoid fields may be substituted by rare metallicity of granites (number of clarkes of granitophile elements). This allows to avoid producing numerous mono-element maps of averaged distribution of indicator elements by producing only an integral geochemical map. Because of the granitoid homogeneity the representative data on the average concentrations of indicator elements in phase-facies varieties of granitoids under mapping may be obtained from a limited number (10-20) of geochemical samples. These data may also serve as background concentrations in solution of ecological problems.

The approach proposed is used for geological-geochemical survey of granitoid massifs intended at forecast and understanding their geochemical infrastructure which is defined by geochemical fields of phase and facies granitoid varieties with different levels of rare metal contents. The boundaries between the fields are established by geological mapping of phase-facies varieties while detailed elaboration of geologo-geochemical mapping is determined by the given scale.

A number of prospecting targets may be achieved using the above principles of geologo-geochemical mapping of granitoids depending on the map scale. They include:(i) to distinguish the geochemical areas of granitoid magmatism having an appropriate metallogenic specific character (small-scale regional mapping and metallogenic zonation, (ii) to reveal geochemical heterogeneity of areas of granitoid magmatism and to rank individual granite massifs according to the degree of potential ore bearing (small- and average scale mapping) and to recognize massifs of potentially ore-bearing granites; (iii) to reveal the internal geochemical structure of individual massifs and the most ore-bearing differentiates. The regions of their localization define the position of probable productive mineralization (large-scale geologo-geochemical mapping and local forecast of mineralization).

References

1. Kozlov V.D., 1985: Geochemistry and ore bearing of granitoids of rare metal provinces p. 304, Nauka, Moscow.
2. Kozlov V.D., 1985 : The system of geologo-geochemical assessment of rare-metal ore bearing in granite intrusions. Geologicky zbornic - Geologica Carpathica, 36, 3, 315-322, Bratislava.

SPECIAL GEOCHEMICAL MAPPING OF COVERED AREAS FOR THE PURPOSE OF PROSPECTING FOR DEEP-SEATED DEPOSITS

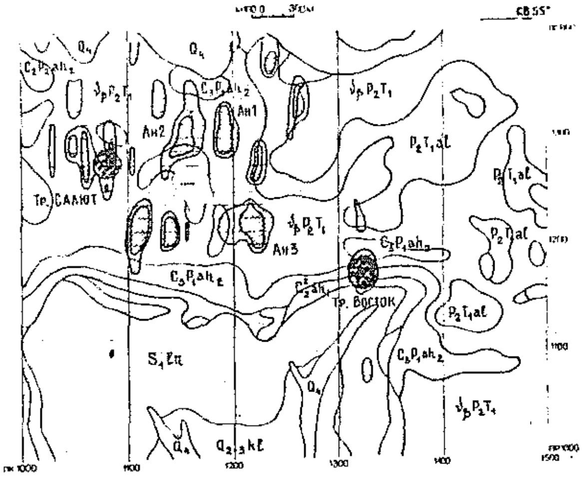
Adelaida B. Lobanova, Baltic Regional "MOST" Association, Leningrad, USSR

When prospecting for deep-seated mineralization, the buried and obscurely overlapped deposits turn out to be most problematic. We have established the relation between primary and secondary geochemical fields through a continuously moving flow of diffusing ions. Taking the kimberlite pipes overlain by the traps as an example, we show that the substance diffusing towards the surface contains all of those elements which are present in different concentrations in orebodies and overlying rock formations. Moving in a wall-boundary layer of a fluid film the ions help to preserve the elements paragenesis of orebodies. This enabled us to formulate the unbiased principles of interpreting the secondary halos of diffusion in terms of paragenetic analysis. To detect and interpret vague secondary halos of buried ores, we recommend a special geochemical survey to be done with an X-ray fluorescence analysis (XRF) using a field measuring device of RRK-103 "POISK" type. In this case the salt blooms and plants are the best for sampling. A "film water - plant" natural system proves to be highly informative, for the plants are good accumulators and concentration of ions from the film water goes unbarred. Because of the latter fact the plants inherit the elements parageneses of the underlying ore deposits. Results of biogeochemical research helped to disclose a regularity in the parageneses correlation between primary and secondary geochemical fields of diffusion origin, with the overburden of any type being up to 350 metres thick.

Salt blooms and aridic plants are extremely favorable targets to be studied by XRF methods for their composition, because in such technique the analyzed layer makes up the first millimetres of the surface. Analyzed distribution pattern of heavy metals in a plant tissue proved the cortex of the plant to be most rich in them.

A field XRF analysis is a rapid quantitative method. The possibility of defining elements composition 'in situ' enables special geochemical survey with XRF to be effected in ecologically harmless and economically beneficial way. One area in Yakutia (see fig.) is taken as an example of such survey applied to prospecting for kimberlite pipes overlain by traps. Total survey area is some 20 km^2, line spacing 125 m, sampling interval 50 m. Sampled was a reindeer moss which was analyzed for the principal kimberlite tracers Ni,Cr,Ti and V as ΣFe, and Zr+Nb as ΣZr. Correlated anomalies of ΣFe and ΣZr were assumed to be the manifestations of a diffusion halo of ascending migration from the kimberlite pipes buried under the traps, and of the detached-off-pipes primary halos. As seen from the figure, number of the anomalies picked with a complex index of contrast (θ_2^2) is much more than that of known pipes in the area. Interpretation of these anomalies in terms of paragenetic analysis has revealed here two promising anomalies associated with the previously unknown kimberlite pipes.

Geochemical anomalies of complex index (θ_2^2) function, as based on XRF data on ΣZr & ΣFe in reindeer moss samples



▨ anomaly confidence 95% ⬚ anomaly confidence 99.9% ◌ kimberlite pipes

Symbols: $Q_{2-3}kl, Q_4$ - Quaternary sediments; $\nu_{\beta}P_2T_1$ - dolerite; P_2T_1al - sandstone; $C_3P_1ah_2$; $C_2^2ah_1$ - silty sandstone; S_1ln - limestone.

References:

On the relationship between primary & secondary geochemical fields in deep-seated deposits. //Thesis in Transactions of XII IGES - IV SMGP, Orléans, France, 1987, p. 105-106.

GEOCHEMICAL-ZONING OF THE CONTINENT-PACIFIC OCEAN TRANSITIONAL ZONE (ASIATIC PART)

V.A.Maksimovsky, G.M.Belyaev, S.D.Velikoslavinsky, E.V.Tolmacheva, A.O.Sobolev,
L.I.Tikhomirov, All-Union Geological Institute, Leningrad, USSR

The continent-oceanic transitional zone has a complex heterogenic composition and includes the following geological structures: oceanic trenches, island arcs, marginal seas, marginal-continental plutonogenic-volcanogenic belt. This zone is of interest due to its position as a zone of active interaction of two plates-continental and oceanic.

Heterogeneities of various aspects (geologi, tectonic, petrochemical, metallogenic, geochemical, morphostructural, etc.) and of various ranks (global, regional, local) were established in the continent-oceanic direction.

Geochemical aspect of zoning in volcanic (plutono-volcanic) belt of various classes: midland, marginal-continental, margibal-oceanic, oceanic from the Masoziuc to the Recent is discussed in the paper. Analysis of data was carried out on the basis of geochemical zonation of polyelemental maps on various scales (1:10,000,000 - 1:1,500,000 and larger), compiled specially for the transitional zone of the north-eastern part of the Asiatic continent.

Global geochemical zoning is expressed in the consistent alternation of typical associations of chemical elements in the continent-oceanic direction, namely, from lithophylic (Y, Yb, Nb, Be, K, Rb, La, and other) in the continental belts through litho-chalcophile (Pb, Zn, Sn, Hg, Sb, Au, Ag and other) in marginal - continental to chalco-siderophile (Cu, Mo, Co, Ti, Bi, Au and other) in marginal-oceanic and siderophile (Cr, Ni, Mn, Fe) in oceanic basalts. Indicator ratios alternate towards the ocean: Ni/Co, Th/U, Rb/Sr, Fe/Mn. For example, the ratio Rb/Sr decreases from 1-0,2 through 0,1 to 0,03-0,07, europium minimum decreases and charts of rare earth element distributions flatten out. A tendency to decreasing of strontium isotopic ratio ($^{87}Sr/^{86}Sr$) from typically crust ratui to typically mantle is revealed. Marginal-oceanic and oceanic belts are characterized by more acid gases in deep fluids, than in continental fluids.

Regional and local geochemical features are manifested in longitudinal and transversal geochemical zoning of belts and specific volcano-tectonic structures and geological bodies.

Analysis of spacial distribution of ore regionsm metallogenic zones and belts and determined geochemical zoning of various ranks, are closely relationed.

RADIOGEOCHEMICAL ZONING OF THE USSR

V.A.Maksimovsky, A.A.Smyslov, V.K.Titov, G.M.Shor. All-Union Geological Institute, Leningrad, USSR

Lateral and vertical radiogeochemical zoning of earth's crust blocks and geological bodies was determined in the process of compilation and analysis of the Radiogeological Map of the U.S.S.R. on the 1:1,000,000 scale and on larger scales for some geological structures.

The pocedure of compilation of these maps was developed in VSEGEI by A.A.Smyslov and his collegues. It is based on well-known principles and statements of academicians V.I.Vernadskys and E.A.Fersman's theory and also on laws of radioactive elements migrations in geological processes. Main principle statements used during the procedure development are the following:

1. Processes of metal concentrations in the earth's crust are closely related to the events of scattering and mobilization of ore elements and are a component part of the common directed migration and differentiation of substahce.

2. Formation of the geochemical field of element distributions is resulted from a wide spectrum of interrelated and interconditioned geological processes of endogenic and exogenic cicles.

The analysis of the relative role of separate geological processes for the formation of the zoning of uranium and thorium distribution established in the map, enabled to estimatic the direction of their migration in the Earth's crust during varios periods of geological evolution. Inppurticular, a substantial evacution of uranium and to a lesser degree of thorium from lower parts to upper was established from regional metamorphism in deep zones of Pre-Cambrian regions. During the platform period of the earth's crust development transportation of the uranium in two forms resulted in the appearance of two various types of radiogeochemical provinces. The zoning manifested in gradual decrease of the uranium and thorium migration from miogeosyncline zones to eugeosyncline is a characteristical radiogeochemical feature of the Phanerozoic folded regions.

REGIONAL GEOCHEMICAL SOIL MAPPING IN THE TROPICAL ENVIRONMENTS OF WESTAFRICA: BEDROCK REFLECTION AND RESOURCES ASSESSMENT OF PROTEROZOIC VOLCANO-SEDIMENTARY SEQUENCES

(A contribution to IGCP 259 "International Geochemical Mapping")

Guenter Matheis, Alfred Utke, Christophe Schreier and Abdi M. Siad

About one quarter of the earth's land surface is covered by thick accumulations of lateritic soils which limit the occurences of easily detectable bedrock exposures, hence, leaving these regions among the least explored ones in terms of natural resources. The most successful way to establish the badly needed geological and mineral inventories of these areas is the regional application of geochemical mapping, complemented by remote sensing and geophysics.

Chemical weathering kinetics are particularly high in the humid tropics, resulting in extensive leaching of the major rock-forming chemical elements Mg, Ca, Na, K and partly Si which simultaneously leads to extremly poor soil-fertility. Most of the trace elements, however, retain their relative bedrock abundances, i.e. the lithologically determined concentration ranges are not overruled by weathering processes. In order to gain detailed information on potential bedrock reflection, orientation surveys have been carried out in different climatic zones of West Africa, ranging from the rain forest to the dry savannah. The main lithological targets were Proterozoic greenstone type volcano-sedimentary sequences of Nigeria and the Ivory Coast, respectively. Total as well as selective leaching methods were applied to gain information on clay adsorped, hydroxid adsorped and total geochemical dispersion, respectively, all of which are complemented by IR-analysis. Compilation and interpretation of both geochemical and mineralogical data are supported by geomathematical methods.

The evaluation of secondary geochemical dispersion patterns is equally important for applications in both exploration and environmental geochemistry. Another field of increasing importance is the role of geochemists to assess regional patterns of soil fertility as well as exploring suitable rock material as directly applicable "slow release fertilizers". Due to the rather complex chemical processes which overprint all weathering products, the application of selective leaching methods as well as detailed studies of the clay mineralogy are the basics of any senseful interpretation. Infrared-Spectometry (IR) provides a rapid and simple method to evaluate mineral species and compositions both qualitatively and quantitatively; it has the additional advantage to detect non-crystalline phases which may be very important as adsorptive agents for secondary dispersion. Flame-AAS has been developed as the most versatile analytical tool in the evaluation of the cationic secondary dispersion patterns. Both types of analytical instruments may be even used in generator-powered mobile field laboratories.

A comparison of the resulting geochemical and mineralogical data with available geological maps clearly demonstrate the advantages of geochemical mapping under conditions of intensive weathering. Comparable studies in central Europe, directed towards bedrock reflection as well as monitoring of environmental dispersion patterns, are equally in support of the need for combined geochemical and mineralogical approaches at the regional scale.

References:

Chesworth W., van Straaten P. & Semoka J.M.R. /19989/: Agrogeology in East Africa: the Tanzania-Canada project. - J.African Earth Sci. 9, 2, 357 - 362, Oxford/UK

Matheis G. /1981/: Trace-element patterns in lateritic soils applied to geochemical exploration. - Journ.Geochem.Expl. 15, 471 - 480, Amsterdam

Matheis G. & Pearson M.J. /1982/: Mineralogy and geochemical dispersion in lateritic soil profiles of northern Nigeria. - Chem.Geol. 35, 129 - 145, Amsterdam

Schreier C.M. & Bowitz J. /1987/: Quantitative and qualitative determination of minerals and weathering products by infrared spectroscopy. - C.I.F.E.G. Occas.Publ. vol.1987/12, 127 - 128, Paris

Siad A.M. /1988/: Application of geostatistical techniques in the evaluation of the Wabo uranium deposit, Galgudu region, Somalia. - M.Sc. Thesis, 70p., I.T.C. Delft

Utke A. /1987/: New aspects on the evolution of the late Proterozoic crust in NW-Nigeria. In: Matheis G. & Schandelmeier H. (eds.) Current research in African earth sciences, 73-78, Rotterdam

REGIONAL GEOCHEMICAL MAPPING IN FINLAND USING HEAVY FRACTION OF TILL

Maria Nikkarinen
geological survey of finland, p.O. Box 1237, sf-70701 kuopio,
Finland

Reijo Salminen
Geochemical Survey of Finland, SF-02150 Espoo, Finland

The geochemical mapping program in Finland is traditionally based on the chemical analysis of the finest fraction of till. Large areas in Finland have been mapped by analyzing the heavy fraction of till as well. Results from an area of $5500 km^2$ in the southern part of Finland are in this study under consideration. The main purpose in using heavy fraction is to get information of the distribution of the elements that are not analyzed from the finest fraction: W, S, Sn, Nb, Zr, La, Ce, Th and U.

Sample grid in the heavy mineral mapping was $1/16\ km^2$ and the samples (8l) are combinations of four subsamples taken at intervals of two kilometers. The sample were preconcentrated in the field by panning. The concentrates (grain size 2 mm - 0.06 mm) were further upgraded by heavy liquid (bromoform d=2.89 g/cm^3) in laboratory. The analytical method adopted for nonmagnetic heavy fraction consisted of energy dispersive X-ray fluorescence spectrometry (EDX). Ferromagnetic fraction was removed before analysis and the weighed amount of magnetite is one parameter which has been used in interpretation.

One element maps based on the analysis of heavy fraction reveal ore potential zones and are most effective for the elements which have great anomaly/background contrast e.g. sulphur. There is good correlation between aeromagnetic maps and the amount of ferromagnetic minerals in till. This reveals the very regional scale of both methods.

Integration of the results based on the element contents both in fine and in heavy fraction of till make it possible to interprete the mineralogical origin of anomalies. Anomalies originating from micas and clay minerals are frequent in the maps based on the finest fraction but are lacking in the maps based on the heavy fraction. Generally the most noteworthy are the anomalies found by both methods.

Pathfinder elements serve as an important tool in interpretation of heavy mineral results. Yttrium e.g. proved to be a good pathfinder element in a zone containing Zn-Cu mineralizations.

EMPLOYMENT OF LARGE-SCALE LANDSCAPE-GEOCHEMICAL MAPS FOR INTERPRETATION OF GEOCHEMICAL ANOMALIES IN HUMID AND ARID LANDSCAPES

Larisa N.Novikova,Institute of Mineral Resources,Ministry of Geology,USSR

As a result of large-scale lithochemical survey in two regions of the USSR(Kuznetskii Alatau - the south of the Western siberia - and the Western Near-Azov region -the south of the Ukraine) the large group of lithochemical anomalies has been revealed.Their interpretation is given on the basis of maps of elementary geochemical landscapes to a scale 1 : 5 000 - 1 : 10 000.

In Kuznetskii Alatau humid south-taiga landscapes of aqueous migration acid class prevail.Depending on genesis of Quaternary deposits several species of elementary landscape are singled out: (a) ortho-eluvial;(b) neo-eluvial and (c)eluvial-super-aqueous.

Employment of large-scale landscape-geochemical maps to a scale 1 : 10 000 and of a larger scale made it possible to carry out classification of lithochemical anomalies with singling out of several genetic groups: (1)secondary dispersion haloes of gold-bearing mineralization zones;(2)rock anomalies;(3)technogenous anomalies;(4)anomalies on sorptive and gleyic geochemical barriers;(5)anomalies of neoeluvial landscapes;(6)anomalies of eluvial-superaqueous landscapes.

Lithochemical anomalies on sorptive and gleyic geochemical barriers are confined to marginal zones of eluvial-superaqueous and orthoeluvial landscapes of acid gleyic class of aqueous migration - on their conjugation with orthoeluvial landscapes of acod class of aqueous migration.The group of hypergene lithochemical anomalies of molibdenum,fluorine, mercury and lead has been classified as anomalies of geochemical barriers.

Detailed landscape-geochemical mapping made it possible to single out lithochemical anomalies of gold and its elements-satellites(accessory elements) in neoeluvial landscapes on Middle-Quaternary - Upper Quaternary deluvial-proluvial deposits,originated by redeposition of the crust of weathering. Geochemical spectrum and intensity of hypergene lithochemical anomalies in indicated neoeluvial landscapes are highly close to those in secondary dispersion haloes of gold-bearing mineralization zones.

Geochemical anomalies of eluvial-superaqueous landscapes are formed in deluvial-proluvial and alluvial-proluvial deppsits,generated at the expense of redeposition of Upper Quarternary and recent eluvial-deluvial formations.Geochemical spectrum of these anomalies is reduced(gold,arsenic).These anomalies are characterized by significant productivities,anomality coefficients and indices of contrast range.

Both groups of landscape anomalies do not have connection with mineralization and are due to weak auriferousness of deposits,in which they had been developed.

Secondary dispersion haloes and its accessory elements have been revealed within the limits of autonomous eluvial and gently sloping trans-eluvial landscapes on eluvial-deluvium of various thickness.Singling out of secondary dispersion haloes,perspective for gold mineralization,was carried out on the basis of geocheminal indices of zoning of mineralization (V),areal productivity of haloes(P) and their coefficients of residual productivity(k).Estimation og a group of the secondary dispersion haloes made it possible to reveal two zones of ore mineralization.

Geochemical landscapes of the Western Near-Azov - are para-eluvial landscapes and belong to dry-steppe landscapes of neutral(calcic) class of aqueous migration.The thickness of loose deposits,overlying ore-bearing formations - is 80 - 100m.The most widespread species of elementary geochemical landscapes of the region are: (1) autonomous eluvial and gently sloping transeluvial landscapes with ordinary black soils,forming on Quarternary loess-like loams;(b) eluvial-accumulative gently sloping landscapes on alluviated black soils;(c) transeluvial landscapes on shallow black soils,forminh on Lower Neogene deposits.

Buried superimposed secondary dispersion haloes are typical for two former species of elementary geochemical landscapes. Within the limits of transeluvial landscapes, forming on Lower Cretaceous deposits, open superimposed secondary dispersion haloes of buried carbonatite mineralization have been established. They are represenred by contrast complex haloes of lanthanum, cerium and barium, which develop directly over large bodies of carbonatites on a level of horizons B and BC of soil-eluvial formations. The revealed secondary dispersion haloes represent hypergene neogenesis on sorptive, evaporative and oxygenous geochemical barriers.

The fulfilled works give evidence that forestalling large-scale landscape-geochemical mapping makes it possible to increase substantially efficiency of geochemical search for ore deposits, including buried deposits(in arid landscapes).

REGIONAL GEOCHEMICAL RECONNAISSANCE OF THE LA PARAGUA RIVER DRAINAGE, VENEZUELA

Jean Pasquali, Universidad Central de Venezuela, Venezuela
Santiago Marrero, Williams Meléndez and Ramón Montero, CVG-Tecmin, Venezuela

A regional geochemical reconnaissance of a Precambrian area of 30.000 Km^2 at the head waters of the Paragua river of Venezuela is being reported. This area is covered by tropical wet forest, and has suffered essentially no contamination, being inhabited by around 100 persons. It has been examined through two types of fine-grained drainage sediments whose mineralogical composition is dominated by quartz and kaolinite, with minor gibbsite and muscovite. Samples were analyzed for copper, zinc, rubidium, strontium, yttrium, zirconium, niobium and gold, in the minus 230-mesh fraction.

Samples were obtained from streams of orders 4, 5, 6, 7, 8 and 9 which have corresponding drainage areas of around 7, 35, 370, 1900, 9400, 45000 Km^2. The two types of samples analyzed were obtained as follows: 1) Material deposited in low-energy environments as mud, either dried out, wet or submerged (D); and 2) Samples obtained by seiving material deposited in higher energy environment (T).

At each collected site of stream order 6 or higher three sub-samples of each type were taken, which allows the estimation of within-site variation coefficient (VC = $\frac{\sigma}{\bar{X}}$ 100) for each element for each type of sample. They are included in Table 1.

Samples types D and T, although for certain elements seem to have a similar background, are not comparable and in certain cases give rise to anomalies that are not geographically coincident.

The analysis of chemical results allows the identification of several types of anomalies:

1) Caused by values of concentration of one element that are higher than $\bar{X} + 2\sigma$; 2) Caused by a coincidence of higher than average concentration of several elements at one site; 3) Caused by an anomalous ratio of two elements, such as Rb/Sr: and 4) Caused by a geographical sequence of $X_i > \bar{X}$ of tributaries of one margin or both margins of main rivers.

It has been found that in this type of terrain about 30 anomalies of the four types mentioned are produced, or one anomaly per 1000 Km^2. Commonly, anomalies of the first three types group into anomalies of type 4, which in turn, are generally indicated by broad water conductivity anomalies easily detected in the field.

In the area studied four anomalies of type 4 were found which are of the order of 300 Km^2.

TABLE 1

AVERAGE CONCENTRATION OF ANALYZED ELEMENTS (ppm) IN SAMPLE TYPES D AND T ($\bar{X}$), WITH THEIR AVERAGE VARIATION COEFFICIENT (CV $\bar{X}$) FOR THE WHOLE POPULATION (140); AND AVERAGE VARIATION COEFFICIENT (VC) FOR WITHIN-SITE SUB-SAMPLES BASED ON 54 SITES.

ELEMENT	Cu	Zn	Rb	Sr	Y	Zr	Nb
$\bar{X}$ ppm (D)	26	71	83	38	62	1150	28
CV $\bar{X}$ (D)	36	49	27	31	24	45	30
$\bar{X}$ ppm (T)	30	81	79	40	54	1700	30
CV $\bar{X}$ (T)	40	32	28	33	32	55	33
CV (D)	17	9.8	9.4	12.3	9.7	12	11.5
CV (T)	9.7	8.9	9.5	11.4	13.8	16	11.7

GEOCHEMICAL MAPPING OF THE SOIL COVER OF THE BYELORUSSIAN SSR

Petukhova N.N., Institute of Geochemistry and Geophysics of the BSSR Academy of Sciences, Minsk, BSSR

The territory of the Byelorussian SSR is situated in the west of the USSR European part. Its area covers 207,6 thousand sq.km and extends from north to south to about 560 km, and from west to east - 650 km.

The historical-geological past and present are closely related to the evolution of the East-European platform, as Byelorussia is a part of this platform and reflects structural and genetic peculiarities of the latter. Modern topography of the territory presents intermittent hilly uplands and flat plains, or slightly concave lowlands and lake basins with absolute elevation marks ranging from 85 to 346 m.

A complex of Anthropogen deposits forms an overburden with the thickness varying from several metres to 300-350 km.

The thickest strata are confined to buried Upper-Pliocene and Lower-Pleistocene valleys. The formation of Anthropogen strata is mainly due to repeated changes of glacial and interglacial epochs, glacial and water erosion and accumulation. Cover beds are represented by various genetic types of glacial, lake-glacial, aqueo-glacial, alluvial, lake - boggy and eolian sediments. Glacial and aqueo-glacial formations are mostly abundant. Eluvial accumulations of the old and modern crust of weathering are found in southern Byelorussia, where granite rocks are exposed. However, these are not abundant.

Byelorussia is included to the taiga-forest landscape zone. Geochemical and biogeochemical processes are active in the hypergenesis zone there. Climatic conditions are favourable: precipitation is abundant (550-650 mm) most part of it coming to the soil because of a non-intensive evaporation.

Atmospheric precipitation partlymigrate to the deeper horizons of Quaternary strata, partly participate in various geochemical processes of hypergenesis.

Soil formation on the territory of the Republic reflects four main genetic types: soddy podzolic, boggy, soddy calcareous, and alluvial meadow ones. As a result of the existence of several soil formation types which are in different combinations and amounts, 165 soil phases are distinguished in the BSSR. Soddy-podzolic soils are mostly widespread and constitute about 70 % of the soil cover. The most important soil processes participating in hypergene migration of chemical elements in the existing environment are distinguished as those proper to Byelorussian Landscapes and conditions of their formation. Firstly, during soil formation, rocks and minerals are actively destructed and colloidal compounds are formed being one of the most important form of horizontal and vertical migration of the matter. Secondly, in landscape of Byelorussia under existing climate conditions and vegetative cover, the soil formation is accompanied by the accumulation of large amounts of organic matter. The organic matter when migrating in soil solutions and surface waters, takes an active part in sedimentary lithogenesis and formation of various geochemical facies of bioliths. Thirdly, soil processes are closely associated with the formation of natural water chemical composition with participation of easily mobile compounds of alkaline and alkaline-earth elements, as well as of iron. Fourthly, soil profiles reflect dominant trends of weathering processes and geochemical composition of residual products of soil formation and lithogenesis.

Basing on the above, a specific character of soil processes in hypergene migration of chemical elements in Byelorussian landscapes can be characterized in the following way. Hydrothermal regime of the earth surface favours an active migration of most of soil-forming elements in the hypergenesis zone. Abundant forest and herbaceous vegetation contributes to the formation of considerable amounts of organic matter which is accumulated as peat, humus and other organic compounds. Destruction and mineralization of the organic matter, surface and soil waters are enriched with CO_2, organic acids and mineral salts, become acid and highly reactive. An acid medium formed as a result contributes to a strong decomposition of the mineral mass. Alumosilicates are decomposed releasing silica, aluminium oxide and especially iron as hydrates, which migrate in the soil and weathering crust. Silicic and silicic-earth elements are removed to a large extent from the soil and participate in the formation of the chemical composition of natural waters and geochemical facies and sediments. Weathering and soil formation are accompanied by neogenesis of silica, clay minerals (hydromica, kaolinite, chlorite), carbonates (calcium, siderite, more seldom, rhodochrosite), iron and manganese oxides and hydroxides (goethite, hydrogoethite), as well as phosphates of ferric and ferrous iron (vivianite). The formation of geochemical facies of sediments are associated with them. The accumulation of O_2 in soils and cover rocks, carbonates -in lacustrine sediments and meadow marls, as well as the formation of boggy ores, peat and sapropel are characteristic of the Byelorussian region.

At present, zonal lithogeochemical, hydrogeochemical and pedogeochemical provinces have been distinguished on the territiry of the Byelorussian SSR, their geochemical properties have been revealed and characterized.

The Byelorussian region is related to a biogeochemical zone deficient in many important elements in soils and plants. Thus, mean contents of iron and copper in soils of the Byelorussian SSR are 1,5 times, aluminium, calcium and nickel - 2, titanium, manganese and vanadium - 3 - 3,5, magnesium, chromicum-5 times less than the clark values of these elements according to Vinogradov /1/. Only silica content in soil of Byelorussia are somewhat greater than the clark value, and potassium and zircon are within their clarks.(table 1).

Table 1. GEOCHEMICAL BACKGROUND OF THE SOIL COVER OF THE BYELORUSSIAN SSR

Soil	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O
			%				
content for the BSSR at large	82,23	6,31	3,40	0,98	0,53	1,76	0,67
clak values according to Vinogradov	70,62	13,57	5,43	1,92	3,32	1,64	0,85
ratio of BSSR clark to Vinogradov'sclark	1,2	0,5	0,6	0,5	0,2	1,1	0,8

Soil	Ti	Mn	Cu	Ni	Co	V	Cr	Zr
				%				
content for the BSSR at large	156,2	24,7	1,3	2,0	0,6	3,4	3,6	33,6
clark values according to Vinogradov	460,0	85,0	2,0	4,0	0,8	10,0	20,0	30,0
ratio of BSSR clark to Vinogradov'sclark	0,3	0,3	0,7	0,5	0,8	0,3	0,2	1,1

Geochemical index of soils of the Byelorussian SSR is:

$$K_2O,\ Zr\ (1,1)\ \frac{SiO_2\ (1,2)}{Na_2O, Co(0,8), Cu(0,7), Fe_2O_3(0,6), CaO, Al_2O_3, Ni(0,5), Ti, Mn, V(0,3)}$$

Low concentrations of several minor elements in soil of the Republic manifest themselves by diseases caused by suppressing synthesis of B_{12} including cobalt, growth of thyroid gland and goitrous disease (due to cobalt and iodine deficiency), caries of teeth (fluorine deficiency), by abortion and drowning of cereals (copper deficiency in peat-boggy soils), etc.

According to natural conditions (topography, soil type, degree of wetting), complex of chemical elements in major types and phases of soils, character of their migration in a system "soil-forming rock-soil ", and peculiarities of their spatial distribution, the author was first to distinguish within the Republic's territory three soil-geochemical provinces - northern, central and southern ones (Fig.1) /2,3/.

The northern pedogeochemical province covers about 24,6 % of the BSSR territory. Soddy-podzolic soils dominate (42 %). Considerally smaller areas are occupied by sandy-loamy (21%), sandy (25 %) and boggy (7%) soils. This region is characterized by the lowest contents of SiO_2 (83,09 %) and highest concentrations of all the other microcomponents (Al_2O_3 - 8,91 %, Fe_2O_3 - 2,14, CaO - 1,16, MgO - 0,89, K_2O - 1,97, Na_2O - 0,76 %). Soils of this province include the highest amounts of such minor elements as manganese (44.10^{-3}%), chromium ($3,6.10^{-3}$) and nickel ($1,7.10^{-3}$%) (table 2).

Table 2. MEAN CONTENTS OF MICROELEMENTS IN SOILS OF THE PEDOGEOCHEMICAL PROVINCES OF THE BYELORUSSIAN SSR, $n.10^{-3}$% per-dry matter

Provinces	Ti	Mn	V	Cr	Ni	Cu	$\frac{Ni}{Cr}$	$\frac{Mn}{Ni}$	$\frac{Mn}{Cr}$
Northern	143	44,0	2,73	3,6	1,7	0,9	0,47	25,9	12,2
Central	126	29,0	3,24	2,9	1,2	0,9	0,41	24,2	10,0
Southern	148	19,0	3,17	3,6	1,0	1,2	0,29	18,3	5,3

A geochemical index where elements before a fraction show soil contents equal, or similar to those of underlying rocks (eluvial accumulation coefficient K_{ea} = 0,9 - 1,1), elements in numerator are those accumulating in soils ($K_{ea} > 1,1$), and in denominator - dispersed elements ($K_{ea} < 1,1$).

The geochemical index for soils of the northern province is as follow :

$$\mathrm{Ti,\ Ni}\ \frac{\mathrm{Mn}}{\mathrm{Cu,\ Cr,\ V}}$$

The central pedogeochemical province covers 42,38 % of the republic's territiry. Soddy-podzolic loamy, soddy-podzolic sandy-loamy, and soddy-podzolic (pale-yellow) soils on loesses and loess-like loams are widespread. The province is characterized by the following mean contents of major elements : SiO_2 - 85,23 %, Al_2O_3 - 6,69, Fe_2O_3 - 2,04, CaO - 1,18, MgO - 0,75, K_2O - 2,97, and Na_2O - 0,76 %. Among microelements the highest contents of vanadium ($3,24.10^{-3}$%) and the lowest contents of titanium (126.10^{-3}%) and chromium ($2,9.10^{-3}$%) are to be mentioned.

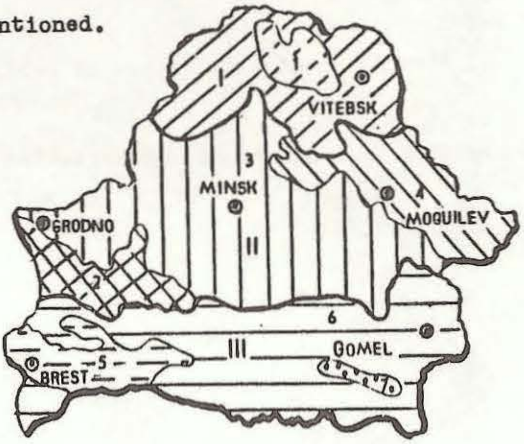


Fig.1. Map - scheme of pedogeochemocal provinces of the Byelorussian SSR

Provinces : I - Northern $\mathrm{Ti,Ni}\ \frac{\mathrm{Mn}}{\mathrm{Cr,V,Cu}}$; II - Central $\mathrm{Ti}\ \frac{\mathrm{Mn,\ V}}{\mathrm{Cr,\ Cu,\ Ni}}$; III - Southern $\underline{\mathrm{Ti,\ Mn,Cr,V,Ni}}$; Subprovinces : 1 - Polotsk $\mathrm{Ti}\ \frac{\mathrm{Mn}}{\mathrm{Cr,V,Cu,Ni}}$; 2 - Western (Grodno) $\mathrm{Cu}\ \frac{\mathrm{Ti,Mn,V}}{\mathrm{Cr,\ Ni}}$; 3 - Pre-Polessie $\mathrm{Ni}\ \frac{\mathrm{Mn,\ V}}{\mathrm{Ti,\ Cr,\ Cu}}$; 4 - Eastern (Orsha-Moguilev) $\frac{\mathrm{Ti,Mn,Cr,V,Ni}}{\mathrm{Cu}}$; 5 - Brest $\mathrm{Mn}\ \frac{\mathrm{Ti,Cr,V}}{\mathrm{Cu,Ni}}$; 6 - Polessie $\mathrm{Cr,V}\ \frac{\mathrm{Mn,\ Ni}}{\mathrm{Ti,\ Cu}}$; 7 - Mozyr $\frac{\mathrm{Ti,MM,Cr,V,Ni}}{\mathrm{Cu}}$

Geochemical index of the Central pedogeochemical provinces is as follows :

$$\mathrm{Ti}\ \frac{\mathrm{Mn,\ V}}{\mathrm{Cu,\ Ni,\ Cr}}$$

The Southern (Polessie) province occupies the lowest southern part of the BSSR territory covering 33,02 % of the whole republic's area. Soddy-podzolic sandy (57 %) and boggy (27 %) soil types dominate.

The Southern pedogeochemical province is characterized by the highest contents of SiO_2 - 90,48 % and the lowest Al_2O_3 - 4,83 %, Fe_2O_3 - 1,34, CaO - 0,53, MgO - 0,33, K_2O - 1,04 and Na_2O - 0,42 %. This province presents the highest contents of copper fixed mainly in the organic matter, and the lowest concentrations of the other minor elements.

The Southern (Polessie) province shows the following element ratios in the soil-rock system: Cu $\underline{\text{Mn, V, Ni, Cr, Ti..}}$

Biogene element accumulation in soils dominates. The separated provinces include 7 subprovinces, 18 soil-geochemical regions and 15 subregions.

The given data on the geochemical background of the soil cover of the Byelorussian SSR are at present of practical importance for carrying out technogenic geochemical reconstitution of Byelorussian soils and realizing measures in the field of the environment optimization.

References:

1. Vinogradov A.P. /1957/ Geochemistry of rare and dispersed elements in soils. Izd. Acad. Nauk SSSR, Moscow, 239 p.

2. Lukashev K.I., Petukhova N.N. /1970/ Chemical elements in soils. Izd. Nauka i tekhnika, Minsk, 229 p.

3. Petukhova N.N. /1987/ Geochemistry of soils of the Byelorussian SSR. Izd. Nauka i tekhnika, Minsk, 230 p.

Regional distribution of As, Sb and Bi in the Grampian Highlands of Scotland and the English Lake District: implications for gold metallogeny

J A Plant, D C Cooper, P M Green, A Reedman and P R Simpson (BGS, Keyworth)

Abstract

Regional geochemical data for the gold pathfinder elements As, Sb and Bi prepared by the BGS over the Grampian Highlands of Scotland and the English Lake District are discussed with particular reference to models for gold mineralization. In the Grampian Highlands the elements are enriched over the upper Middle and Upper Dalradian rocks, whereas in the Lake District concentrations occur over the Skiddaw Group and Eycott and Borrowdale Volcanics. In both regions, high levels of the gold pathfinder elements (and gold in panned concentrates) are associated with shale-turbidite sequences in tectonically controlled extensional basins and in the Lake District also with volcanic rocks.

The Dalradian orogenic basin has been related to trans-Caledonide extension possibly associated with movement of a predominantly transcurrent continental margin to the south. The Skiddaw Group has also been suggested to represent the deposits of a marginal basin, in this case located along the NW edge of the Avalonian-Cadomian continental plate bordering the Iapetus Ocean; sediment deposition in the basin having been interrupted by the development of a volcanic arc represented by the Eycott and Borrowdale Volcanic Groups. In both regions known gold mineralization and anomalous levels of the gold pathfinder elements and of gold in heavy mineral concentrates are associated with igneous intrusions or lineament systems cutting enriched metasediments or volcanic rocks.

The Grampian Highlands and English Lake District evolved as part of the American and European continental plates, which were separated by the Iapetus Ocean until they were tectonically juxtaposed during the late stages of the Caledonian orogeny. The similarity in the controls of the distribution of gold pathfinder elements and gold mineralization in the two regions thus provides information of importance for understanding the genesis of gold deposits in comparable tectonic settings elsewhere. The data are inconsistent with models involving a juvenile source of gold or its pathfinder elements. Instead, they support a model whereby gold and its pathfinders were initially concentrated in sedimentary sequences in rapidly subsiding, tectonically controlled basins and in associated volcanic rocks. Remobilization occurred subsequently, probably as a result of an increase in the oxygen fugacity associated with the influx of granite magmas into the crust and the establishment of hydrothermal convective circulation systems.

MAPPING THE CLOSED AREAS OF ORE REGIONS BY A HYDROGEOCHEMICAL METHOD

A.M.Plyusnin, V.V.Tolcchko, V.A.Korsak

Geological Institute of the USSR AS SD, Ulan-Ude,USSR

Regions of completed folding of Mesozoic tectono-magmatic activity contain great prospects for the discovery of gold-ore, rare-metal, fluorite and other mineralizations. Tectonic movements of activity showed themselves on a great territory and resulted in warping the earth's crust and shaping ridges and intermountain areas.

The conditions for mineral deposit search are complicated. Intermountain areas and their foothills are closed with polygenic sand, its thickness reaching dozens of meters. Low mountains and highlands are covered with pine forest and foothills and depressions take up dry steppes. This territory is a region of large population which is occupied with field-crop cultivation and cattle-breeding. The application of a hydrochemical method for mineral deposit search may be very useful under these conditions. Man-made reservoirs (holes and wells) as testing ones and drilled for the water-supply of the population and farms are added to the natural reservoirs (springs, surface-stream flows, lakes, etc.); it gives the possibility to regulate and to compact testing.

The separation of the associations of natural water parameters characteristic for occurring geochemical processes and water interaction with geological formations is laid into the basis of the interpretation of multicomponent information. It allows to thoroughly base choosing the places for carrying out detailed prospecting.

Due to the establishment of the characteristic association of elements it is possible to define a process which results in the formation of one or another water chemical composition. For example, within the crystalline rock masses of depression framing the formation of water chemical composition are mainly connected with feldspar weathering and anorthite, in the first place. Correlative bonds are established among calcium, magnesium, sodium, potassium, hydrocarbonate and the acid-basic index of medium. The synchronous delivery of fluorine, molybdenum and sulphate into the solution indicate the geochemical specialization of weathering alumosilicates in this region.

Within intermountain areas the formation of water chemical composition is taking place under the influence of some regional factors, as alumosilicate weathering, ion change and salting processes. Each of these factors is characterized by a definite element association. For example, the separation of the association of such parameters, as pH and HCO is characteristic for a salting process. Due to the value map of the separated association of parameters it is possible to choose the areas where this process is playing a dominating role.

The exploration of ore mineralization by a hydrogeochemical method may be carried out using direct and indirect parameters which are mineralization indicators. The rocks exploited hydrothermally can be used as the indirect indicators of mineralization. Their revealing is of great interest, as the dimensions of rocks changed are often found to be greater than ore bodies. Their revealing is quite possible by a hydrogeochemical method, as underground waters interacting with such rocks are enriched in a certain association of elements. For example, waters are enriched in potassium, lithium and silicium when interacting with propylite facies, fractured metasomatite and quartzite ones containing potassium. This element association is also established in underground waters of gold-ore manifestation known in this region. As a whole, such an element association is typical for the waters confined to the zone of dislocation with a break in continuity. Ore elements, such as silver, lead and nickel are marked parallel with the elements mentioned above, when underground waters interact with hydrothermalites in which there is ore mineralization.

Several element associations are chosen which can be used as the searching signs for rare-metal and fluorite mineralization. For example, in fracture waters and pore-stratal ones of a depression this type of mineralization is distinguished by the association of such elements, as molybdenum, tungsten, fluorine and calcium. The element association chosen is typical for ore manifestations of such a type in the region under investigation and it rouses quite a definite interest in prospecting.

GEOCHEMICAL MAP OF A CARBONATE TERRAIN BASED ON SOIL SAMPLING

ESAD PROHIĆ[+], SIMON PIRC[++] and NINA ZUPANČIĆ[++]

About one third of Yugoslav territory is composed of predominating carbonate rocks on which water is drained mostly underground, and stream sediment is not available for systematic geochemical mapping. Investigations performed in 1985 to 1988 in Slovenia, Croatia and Montenegro confirmed the possibility of producing stable geochemical maps for many elements by sampling soil, spring sediment and aquatic bryophytes. This was established by using sample designs based on the analysis of variance.

In 1989, about 4000 km^2 of Istria and a part of Slovenian Littoral, in NW Yugoslavia, was sampled with soil samples on a regular grid od 5 x 5 km. The territory consists of Jurassic, Cretaceous and Paleogene carbonate rocks, and of Eocene flysch. The flysch parts of the terrain was sampled in addition with stream sediment samples. The upper 15 cm of the soil profile were collected and the minus 2 mm fraction ground and reduced to minus 0,064 mm size for analysis. The minus 0,064 fraction of stream sediment was obtained by sieving the collected fines. Twenty elements (Al, Ca, Fe, Mg, Mn, Na and Ti; and Ba, Co, Cr, Cu, Ga, La, Mo, Ni, Pb, Sr, V, Zn and Zr) were deterismend by emission spectroscopy with a Zeiss PGS 2 instrument having a planar grating. The sampling design of analysis of variance enabled the estimation of variability among sampling media, between carbonate and flysch regions, between the 5 x 5 km cells, as well as the sampling and analytical error. Analytical accuracy was monitored by international geological standards. Operational realiability (sampling and analytical) were found satisfactory for mapping for the preponderant majority of elements.

Univariate and multivariate statistical analysis indicated differences in elemental composition between soils on carbonate substrate and flysch in Ca, Mg, Na and Sr, which are depleted, and Fe, Ti and Zr which are enriched in soil on carbonate rocks.

Differences between the flysch lithology of the two sedimentary basins is indicated in both soil and stream sediment samples by generally higher Ca and Sr and lower Fe and Ti in the southern flysch basin with recpect to the northern basin. Anamalous zones of Pb probably reflect environmental pollution. Computer-made geochemical maps of Istria for Pb and Ca is to be enclosed and results discussed with an emphasis on the lithology and enviromental pollution. Additionally the soil sampling credibility in the geochemical mapping will be examine.

[+]/ Institute for geological Investigations, Zagreb, Sachsova 2, 41000 Zagreb, Yugoslavia

[++]/ Institute of geology, University in Ljubljana, Aškerčeva 20, 61000 Ljubljana, Yugoslavia

GEOCHEMICAL MAPPING IN LATERITIC REGIONS OF THE YILGARN BLOCK IN AUSTRALIA

Raymond E Smith (1), R D Birrell(2), R R Anand(1),J F Bridgen(3), E C Grunsky(1), J L Pedrix(1)

(1) CSIRO Division of Exploration Geoscience. PO Wembley, WA 6014, Australia
(2) GEOCHEMEX Australia, PO Box 281,West Perth, WA 6005, Australia
(3) Sons of Gwalia NL, GPO Box, Darwin,NT 0801, Australia

The feasibility of carrying out geochemical mapping in lateritic terrain in Australia is demonstrated by examples of low-density sampling within the Archean Yilgarn Block and its periphery in a programme primarily designed for the purpose of research in developing methods for mineral exploration.

The prime sampling medium used was lateritic residuum, or its quasi-residual loose gravel equivalent, with samples typically being either 1 km or 3 km apart, depending upon the stage of exploration, target expectations, and bedrock characteristics. The approach was to use to advantage the products resulting from the period of long and intensive lateritic weathering.

Examples of some of the different types of geochemical patterns are presented. These include regional variations in base metals and chalcophile element levels in classes of ferruginous materials at surface; regional patterns in lithophile element levels in laterite that suggest related bedrock patterns; the presence of chalcophile corridors, observed in lateritic residuum and interpreted to arise from bedrock features, that cross the Yilgarn Block; and variations on a kilometer scale that derive from the presence of concealed ore systems.

Knowledge of regolith/landform relationships, from regional to district scales, are important for the design and execution of sampling programmes, and for presentation and interpretation of geochemical data. A workable sample classification scheme is also critical to success.

Limitations of the approaches described in this paper result where the favoured lateritic residuum has been removed through erosion. Even so, sporadic local areas of relict laterite can extend the terrain applicable to this approach. Furthermore, recent research involving several of the authors has shown that in some terrain even where lateritic residuum may be generally missing from the uplands because of erosion, large areas characterized by essentially complete laterite profiles can exist buried beneath colluvial and alluvial plains.

BASELINE GEOCHEMICAL MAPPING USING LAKE SEDIMENTS[1]

P. J. Rogers[2], *J. A. C. Fortescue*[3] *and J. G. Ogden*[4]

Lake drainage systems cover large parts of the Canadian landmass. For this reason lake sediments have been used extensively during the past 15 years as a medium for mineral exploration or resource appraisal geochemical mapping (Hornbrook, 1989). Grab samples of lake sediment provide large multielement geochemical databases well suited to mineral exploration purposes (Rogers and Chatterjee, in press). These grab samples may lack stratigraphic detail, however, and when mineral resource appraisal and geochemical baseline information is desired from lakes, sediment cores are required. Lake sediment is perhaps unique as a mapping tool as it defines both spatial and temporal aspects of the catchment's landscape evolution. Indeed, lake sediment has been likened to a mass storage device for historical geochemical data derived from the catchment (Ogden et al., 1988). Geochemical data from lake sediment cores may be used (1) for geochemical mapping, (2) in pollution studies and (3) in investigations of global climatic change. If lake sediment cores are used as a medium for geochemical mapping such mapping may relate to anthropogenic input of elements during the past few hundred years and/or to material laid down prior to the advent of modern man in lake catchments of interest.

These sediment cores are of two kinds: 'short cores' (30-40 cm long), which usually include sediment laid down during the past 200 years, and 'long cores', which penetrate the entire organic layer at the bottom of a lake and are usually 3-5 m long. Short cores are used in acid rain studies to trace the pH history of lakes during the past 200 years using geochemical and diatom inferred pH methodologies (Fortescue, 1984, 1985). Lake sediment long cores include material laid down since the last Ice Age and can be used to describe the geochemical, palynological and diatom history of lake catchment areas.

Data from Ontario and Nova Scotia demonstrate that spatial correlations and temporal markers from lake to lake can be established by these methods. For example, a ragweed (Ambrosia Spp.) pollen layer in Ontario and a Plantago Spp. pollen layer in Nova Scotia have both been used extensively to date the chemical stratigraphy of lake sediment cores collected from these areas.

Our lake sediment core case histories also describe at least four types of Canadian acid lakes. Some of these lakes are naturally acid and others have become acid due to acid rain, pollution and/or environmental degradation. The geochemistry of post-Ambrosia environmental disturbances has been noted from lakes near smelters in Ontario and from the post-Plantago layer at Chocolate Lake, Nova Scotia. Dramatic increases in baseline metal values (e.g. by Pb due to automobiles, Cu due to modern plumbing, V due to home heating oil, etc.) are observed in most lake sediment cores. Cores from some Nova Scotia lakes include a geochemically distinct 'backhoe' horizon caused by accelerated bedrock weathering due to excavation and construction activities in catchment areas about 40 years ago (Ogden et al., 1988). Certain elements can also be used as time and spatial or ballistic markers. For example Ni, Cu, U, Br, As, Sb and Co have been found useful in Ontario and Al and Zn at Soldier Lake in Nova Scotia (Fortescue, 1986; Ogden and Rogers, 1988).

All post-glacial lakes in central and eastern Canada show an increased organic content with time from ca. 10,500 to 9,000 radiocarbon years before present (RYBP). This increase is a consequence of decreased soil erosion and increasing vegetation as post-glacial warming permitted a re-establishment of closed boreal forests. In Nova Scotia, lake sediment cores record a distinct climatic change to a warm, dry maximum at ca. 3500-5500 RYBP, the xenothermal interval. Reduced precipitation and runoff during this time lowered flushing rates and increased organic sedimentation. The possible effects of future global warming can be inferred from such data on previous periods of global warming recorded in long cores.

---

[1] Abstract submitted to 14th IGES, Prague, Czechoslovakia

[2] R. R. 4, Shubenacadie, Nova Scotia, Canada BON 2N0

[3] Ontario Geological Survey, Ministry of Northern Development and Mines, 77 Grenville Street, Toronto, Ontario, Canada M7A 1W4

[4] Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1

Lake sediment short and long cores provide a means to establish both a spatial and temporal baseline datum for geochemical mapping. Short cores may provide detailed evidence for increased acidification and/or input of elements due to man's activities during the past several hundred years. Long lake sediment cores, taken from all ecological zones in the world, would provide unique spatial and temporal information pertinent to the preparation of a world geochemical map.

REFERENCES

Fortescue, J. A. C. 1984: Interdisciplinary research for an environmental component (acid rain) in regional geochemical surveys (Wawa area), Algoma District; Ontario Geological Survey, Map 80 713, Geochemical Series, compiled 1983.

Fortescue, J. A. C. 1985: Preliminary studies of lake sediment geochemistry in an area northeast of Sudbury, Sudbury and Temiskaming Districts; Ontario Geological Survey, Map 80 756, compiled 1985.

Fortescue, J. A. C. 1986: Geochemical stratigraphy of organic lake sediments from selected lakes north and east of Lake Superior; Ontario Geological Survey, Map 80 757, Geochemical Series, compiled 1985.

Hornbrook, E. N. W. 1989: Paper 32: Lake sediment geochemistry: Canadian applications in the eighties; *in* Proceedings of Exploration '87: Third Decennial International Conference on Geophysical and Geochemical Exploration for Minerals and Groundwater, edited by G. D. Garland; Ontario Geological Survey, Special Volume 3, p. 405-416.

Ogden, J. G. and Rogers, P. J. 1988: Biological and geochemical sedimentation along a pH gradient in Soldier Lake, Halifax County, Nova Scotia; *in* International Groundwater Symposium on Hydrogeology of Cold and Temperate Climates and Hydrogeology of Mineralized Zones; Proceedings, edited by C. L. Lin; Halifax, Nova Scotia, Canada, May 1-5, 1988, p. 201-210.

Ogden, J. G., Carrigan, L. M. and March, K. L. 1988: The geochemical care and feeding of mud; *in* Prospecting in Areas of Glaciated Terrain 1988, eds. D. R. MacDonald and K. A. Mills; Canadian Institute of Mining and Metallurgy, p. 357-382.

Rogers, P. J. and Chatterjee, A. K. in press: Metallogenic domains and their reflection in regional lake sediment surveys from the Meguma Zone, southern Nova Scotia, Canada; Journal of Geochemical Exploration.

Thematic maps of southern West Greenland

A. Steenfelt Geological Survey of Greenland
L. Thorning Østervoldgade 10,.
T. Tukiainen DK-1350 Kobenhavn K,
Denmark

Abstract

The Geological Survey of Greenland has commenced the production of sets of equally scaled and formatted geochemical, geophysical, geological, and mineral occurrence maps based on digital data information. The first series of maps cover 35000 km^2 at the scale of 1:1,000,000 of the Archaean shield in southern West Greenland including the Godthaabsfjord area where the oldest known part of the shield occur.

The maps may be used for visual studies and comparison whereas the digital data contained in them are well suited for image analysis of integrated data sets.

The crustal structures indicated by the geochemical and geophysical maps provide evidence for the existence of several early Archaean terranes in the region, as suggested by Friend and Nutman (1988) on the basis of recent field and isotope studies. The recognition of such terranes has implications for the geological history as well as for the evaluation of the resource potential of the region.

Reference:

Friend, C.R.L. and Nutman, A.P. 1988: Evolution and emplacement of Archaean terranes in the Kapisigdlit area, southern West Greenland. Rapp. Grønlands geol. Unders. 145, 59-64.

GEOCHEMICAL MAPPING OF PRIMARY AND SECONDARY SETTINGS IN ORE-BEARING REGIONS

L.V.Tauson, R.G.Kravtsova, R.H.Zaripov, Institute of Geochemistry, Irkutsk, USSR

The comprehensive geochemical mapping is made in one of ore-bearing regions of North-East USSR. Ore-bearing capacity of the area is determined by many-stage processes of Late Cretaceous magmatism and hydrothermal activity and represented by tin-rare-metal, tin-silver, silver-polymetallic mineralization.

The study of endogenic geochemical fields of concentration (GFC) shows that each ore-bearing formation is characterized by individual geochemical element association with quantitative ratios, which vary depending on the level of the erosion shear and the depth of mineralization formation. The geochemical models of vertical zonation have been made using mapping of the endogenic GFC of ore-bearing objects.

The comparison of geochemical maps, obtained from different scale surveys from the secondary haloes and stream sediments with results of study of the primary endogenic GFC showed, that their composition and structure correlate with the composition of the eroded and drained objects and the features of zonal development of ore mineralization, in most cases are explained by the composition and structure of exogenic GFC. The established qualitative-quantitative relations between lithochemical GFC in different media were used for contrusting comprehensive geochemical models: the primary halo-the secondary halo-stream sediments (Table).

Type GFC	Geochemical element associations															
	Endogenic					Exogenic										
	Primary halo					Secondary halo					Stream sediments					
Tin-rare-metal	$\frac{As^{*}}{750}$	$\frac{W}{600}$	$\frac{Bi}{450}$	$\frac{Sn}{50}$	$\frac{Mo}{20}$	$\frac{As}{650}$	$\frac{Bi}{400}$	$\frac{W}{90}$	$\frac{Sn}{30}$	$\frac{Mo}{15}$	$\frac{As}{140}$	$\frac{Bi}{44}$	$\frac{Sn}{34}$	$\frac{W}{11}$	$\frac{Ag}{11}$	$\frac{Mo}{2}$
Silver-polymetallic	$\frac{Ag}{500}$	$\frac{Pb}{250}$	$\frac{Hg}{75}$	$\frac{Mn}{25}$	$\frac{Zn}{6}$	$\frac{Ag}{95}$	$\frac{Pb}{40}$	$\frac{Mn}{14}$	$\frac{Hg}{10}$	$\frac{Zn}{5}$	$\frac{Ag}{25}$	$\frac{Pb}{4}$	$\frac{Hg}{2,5}$	$\frac{Mn}{2,5}$		

* - denominator shows average values of contrast coefficients of elements

The comparison of the secondary and primary haloes indicated the similarity of their qualitative composition on the background of concentration decrease, excepting the cases, when the thickness of loose sediments significantly increases.

Relatively low contrast coefficient and the common character of the development are characteristic features of lithochemical anomalies from stream sediments. In some cases, the quantitative element relationships are disturbed. Simplicity, speed, the possibility to obtain information on ore-formational and metallogenic features of the region are the favourable aspects of lithochemical survey from stream sediments.

The comprehensive geochemical mapping showed, that the vertical geochemical zonation is common not only for the deposits, but for the whole ore -magmatic system. The geochemical model of the endogenic vertical zonation of the ore-magmatic system includes: the source of ore substance (the chamber of granitoid magma)→GFC of the pneumatolite stage: tin-rare-metal- $\frac{As}{750}\ \frac{W}{600}\ \frac{Bi}{450}\ \frac{Sn}{50}\ \frac{Mo}{20}$ → GFC of hydrothermal stage: sulphide-polymetallic- $\frac{As}{150}\ \frac{Pb}{25}\ \frac{Cu}{20}\ \frac{Zn}{20}$ - tin-silver - $\frac{As}{175}\ \frac{Sn}{100}\ \frac{Ag}{65}\ \frac{Bi}{35}$ - silver-polymetallic - $\frac{Ag}{500}\ \frac{Pb}{250}\ \frac{Hg}{75}\ \frac{Mn}{25}\ \frac{Zn}{6}$

It was stated, that the principles and the methods of geochemical mapping should include the formation features of GFC of the entire ore-magmatic system, as they are the integral expression of subsequently developing processes and contain all necessary information on their peculiarities, trends and scales.

MINERALOGICAL-GEOCHEMICAL MAPPING OF RARE-METAL AND MIAROLITIC PEGMATITE FIELDS AIMED AT PROSPECTING

V.E.Zagorsky , I.S.Peretyazhko, L.G.Kuznetsova, Institute of Geochemistry, Irkutsk,USSR

The use of mineral geochemical features in mapping of geological objects is a promising trend in prospecting geochemistry. This problem is considered relative to pegmatites.

Li,Be,Cs,Ta,Nb,Sn deposits as well as the deposits of piezooptic and gem-stone raw materials are associated with rare-metal and miarolitic pegmatites. Several evolution geochemical (mineragenic) pegmatite groups are distinguished. They unite genetically and spatially connected assemlages of pegmatite bodies of the same specialization, but distinguished by the productivity degree for the major commercial minerals (or elements) in every group. Commercially, the beryllium, lithium and complex (Li,Be,Ta,Cs) evolution groups are the most important among rare-metal pegmatites [1], while the crystal-bearing, topaz-beryl, tourmaline and spodumene (kunzite, hiddenite) groups [2]have the largest significance among miarolitic pegmatites. Each evolution group is terminated by a certain commercial pegmatite type. But insignificant minority of pegmatite bodies within the fields and the veined series refer to commercial types. The prospecting and evaluation of the pegmatites with gem-stones and piezo-raw material are rather difficult since the useful mineralization in them is local and uneven.

The efficiency of prospecting-evaluation works in fields of rare-metal and miarolitic pegmatites significantly increases in mapping of geochemical features of different pegmatite minerals, especially feldspars and micas. Feldspars and micas are enriched in Li,Rb,Cs,Tl and depleated in Ba and Sr, simultaneously with K/Rb, Rb/Cs, Ba/Rb decrease as pegmatites productivity for rare-metal and crystal raw materials increases. Because of different conditions of formation each geochemical (mineragenic) pegmatite group is characterized by a certain set of mineralogical-geochemical indications of the commercial mineralization. Besides,the quantitative characteristics of each indication are distinctive for various specialized pegmatite fields.

Diverse special diagrams (forecast-evaluation pallets) based on the contents of two or three most informative elements and their ratios in feldspars and micas, are elaborated for the main groups of rare-metal and miarolitic pegmatites. These diagrams show the regions, corresponding to non-productive, weakly-productive and commercially productive pegmatites, considering their specialization. The correspondence of each sample to an appropriate region on the diagrams is reflected on the maps through special signs which are united in the correspondence fields.

The mineral samples weighing 1-2 gr are collected both from the original outcrops and from the alluvium-dilivium pegmatite piles. This is especially important for sorting of areas with poor outcropping. The mineralogical-geochemical mapping of different scales (from 1:25000 to 1:2000) of some rare-metal and miarolitic pegmatite fields of the USSR has been performed. The mineralogical-geochemical mapping permits to recognize the specific features of zonation of pegmatite fields, difficult to be established via other methods, to determine specialization and the potentials of fields, their seperate domains and individual pegmatite bodies,including the forecast of "hidden" zones productive for rare metals and gem-stone raw materials.

The available data on the fields studied may be used as "standards" for the evaluation of new pegmatite fields. Collecting mineralogical-geochemical data increases the reliability of the local forecast in each pegmatite field.

References

1. The fields of rare-metal granite pegmatites 1976, M.:Nauka, p.328
2. Zagorsky V.E., Shmakin B.M., 1987: Principles of miarolitic pegmatites classification. Recent problems of theoretical and applied geochemistry. Novosibirsk:Nauka, pp.57-63.

SCOPE OF IMAGE PROCESSING METHODS IN GEOCHEMICAL EXPLORATION METHODS

Václav Bezvoda, Charles University, Czechoslovakia
Josef Ježek, Charles University, Czechoslovakia
Stanislav Saic, Academy of Sciences, Czechoslovakia

The contribution is concerned with the possibilities of application of image processing microcomputer systems to the geochemical exploration data processing. Using such systems, it is possible to employ both standard methods (e.g. linear filtering, polynomial regression) and procedures typical for image processing (e.g. different nuance of colour or black and white vizualization, fast operations on large data sets, combination of different results). Such a way of processing is extremely sensitive to linear inhomogeneities.

The possibilities of the new way of processing and vizualization give a new dimension to tested methods developed for multidimensional data evaluation especially in the case of regular sampling grid in an isometrical region.

As a practical example of exploitation of above mentioned procedure the evaluation of metalometric data from the locality Narysov-Žežice (Middle Bohemia) is given. (For more geological and geochemical details see Bezvoda et al. (1986)).

The computation and vizualization has been performed on a French system PERICOLOR 2001. For the standard routines user oriented software of the microcomputer, for the two dimensional linear filtering (in frequency domain) a program package PERIGEO developed by dr. Ježek have been used. The description as well as a Fortran 77 program for this method of data processing is given in Bezvoda et al. (in print).

References:

Bezvoda V., Jelínková E. . and Segeth K. (1986): Evaluation of Geochemical Data Acquired From Regular Grids. - Mathematical Geology Vol. 18, No. 8.

Bezvoda V., Ježek J. and Segeth K. : FREDPACK - a program package for linear filtering in the frequency domain. - Computer and Geosciences. Accepted for publication in 1989.

INVESTIGATIONS OF SPACIAL GEOCHEMICAL INFORMATION FOR PROSPECTING PURPOSES USING COMPUTERS

E.K. Burenkov, L.N.Ginzburg,B.S.Kogan
Institute of Mineralogy, Geochemistry and
Crystallochemistry of Rare Elements,
Moscow, USSR

Prognostic possibilities of geochemical information are defined by the obtained geochemical field model, its structural presentation is based on the fundamental Clark-Vernadskii law: contents of all chemical elements differ from zero in any elementary Earth space and depend on special coordinates. Thus we consider the structure of a geochemical field as an area of spaces (Earth's crust or its part), where quantitative evaluations of contents of chemical elements correspond to every point of it. The main problem lies in non-uniform quality of primary data connected with the nature of geological objects, character and quality of analytical determinations which make it impossible to use directly the statistical methods for compilation of prognostic geochemical maps.

A universal system "GEOSCAN" has been developed for the effective analysis of median and small-scaled geochemical data, its algorithms are based on the conception of special behavior of multidimensional heuristic functions form coordinates characterizing the structure of the polyelemental geochemical field in details. Parallelly with the computer visualization of data heterogeneous anomalies are distinguished, background fields are differentiated and quantitative characteristics of separated elements of the structure are obtained.

A package of programmes "GEOSCAN-200" has been created for the processing of large-scaled geochemical data, its scanning algorithms are taking account of the geochemical field structure discreteness, which makes it possible to conclude about the time sequence of geological events, forming primary halos of deposits.

PROCESSING OF GEOCHEMICAL DATA USING "MOVING AVERAGE" METHOD FOR THE SOLUTION OF CERTAIN PROSPECTING AND PREDICTION TASKS

Victor A. Bugrov, Anatoly K. Markevich, VNIIZarubezhgeologia, USSR

1. In the process of geochemical prospecting fields of mineralized quartz veins with uncertain outlook often revealing. Areas of such fields can reach several square kilometers at a different extent and vein thickness. Vein fields can bear a various ore mineralization at a depth or can be indicators of unexposed ore stockworks or occuring at the initial stage of exposure. The study of endogenic zonation in the distribution of chemical elements in veins and assessement of their level of erosion plays an important role in their prognostic estimation. Similar problems may arise in studies of dyke fields with which can be associated concealed mineralization.

2. The study of primary geochemical aureoles of quartz vein fields indicates, that in them, endogenic zonation of mineralization usually manifests itself as in geological bodies associated with mineralization. It is very important for the estimation of such fields and prediction of a concealed ore deposits.

3. The study of such zonation by traditional methods using secondary or primary aureoles often fails to give expected results especially at their supra-ore level. Drawing of primary aureoles on each vein (or dyke) is very difficult and fails to yield a general picture of their structure. The greatest effect is achieved when constructing generalized schemes showing the distribution of anomalous chemical element contents, in veins themselves. To this end, the contents of elements discovered in veins are averaged by "moving window" (moving average) method and from them schemes are constructed for a generalized distribution of average elements contents within the entire field, as whole, and not from separate veins. Dimensions of "window" are chosen proceeding from particular geological conditions in order not less then 12-15 samples fall within it.

4. When making schems the endogenic zonation in the distribution of anomalous contents of chemicsl elements, permitting to predict a possible type of mineralization and to give a qualitative estimation for its level of erosion, is clearly marked. Quantitative expression of zonation is achieved by the determination of zonation indices by the calculation of average amount rations (or anomaly productivities) for chemical elements which tend to concentrate in ore bodies (or sub-ore horizons) to contents of elements typical for supra-ore horizons. The experience shows that a resolving power of such indices of zonality, for example, for molybdenum stockwork mineralization reaches to 10 million times.

This technique can be successfully used in studies of dyke fields and mineralization associated with them.

APPLICATION OF EXPLORATORY DATA ANALYSIS IN REGIONAL GEOCHEMICAL MAPPING IN IRELAND

Patrick J. O'Connor, Geological Survey of Ireland, Dublin, Ireland.
Clemens Reimann, Joanneum Research Association, Leoben, Austria.

The Geological Survey of Ireland has initiated a programme of regional geochemical reconnaissance based on stream sediments. Thirty-eight chemical elements (Ag, As, Au, Ba, Br, Cd, Ce, Co, Cr, Cu, Eu, Fe, Hf, Ir, La, Li, Lu, Mn, Mo, Na, Ni, Pb, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, U, V, W, Yb, Zn and Zr) are routinely determined by instrumental techniques (AAS and INAA) on the wet-sieved <150μm fraction of sediment. To date, a multielement database for some 2500 samples (covering about 7,500 km^2) has been acquired for three regions.

Data analysis employs resistent non-parametric techniques (Exploratory Data Analysis) for objective selection of outlier values (anomalies) and class boundaries for each elemental distribution. Such techniques are more appropriate to the treatment of geochemical data than classical statistical procedures. The observed correlations of regional geochemical variation with underlying geology and of outlier values with known bedrock mineralization support the view that the EDA approach offers an alternative, viable, method of geochemical mapping in Irish terrains.

IMPROVED AUTOMATION SYSTEM FOR PROCESSING OF GEOCHEMICAL INFORMATION VIA THE METHOD OF MULTI-DIMENSIONAL FIELDS

V.N.Evdokimova, N.A.Kitaev, Institute of Geochemistry, Irkutsk, USSR

The final results of geochemical prospecting and mapping, depend both on the methods of prospecting and those of geochemical data processing, i.e. the efficiency of these methods in obtaining the information needed for forecast.

The contribution considers the grounds of the improved mathematical method for simulation of a complicated system based on the analysis of multi-dimensional data according to linear trends (wells, trenches), two-dimensional fields (different types of mapping) and three-dimensional space (volume models of ore fields and deposits).

The method is realized through the computerized system ASOI of multi-dimensional fields. The system is introduced in some industrial and scientific establishments of the Soviet Union and is used for processing of data of geochemical survey. Its application increased the efficiency of geochemical methods of prospecting. The method and the system are being at present improved, e.g. automatic classification, the classes-associations are distinguished without the background job. Suitable points of sampling and element contents in them are indicated on mono-element fields thus showing factual data and data of interpretation. Solution of special problems is being developed:

In calculating and making maps of productivity, the volume models provide the quantitative evaluation of geochemical fields of industrial concentration.

Summarising a large amount of problem solutions through multi-dimensional method for standard objects the geochemical formulae of metallogenic formations were derived from primary haloes and stream sediments. The solution of the inverse problem by method of anology is aimed at determination of formational type of the observed anomaly by computer, i.e. qualitative and quantitative composition of element associations in the anomaly and other evidence permit the type of mineralization and its genetic features to be recognized.

The method is applicable for processing of information obtained from sampling of any media (bedrock, secondary haloes, stream sediments, hydro-and biogeochemical survey and for ecological purposes) and scale (from the study of metallogenic belts to ore bodies).

The information processing via MF method is exemplified by materials of geochemical prospecting.

REGIONAL DATABASE ON GEOCHEMICAL ANOMALIES OF THE UKRAINE

(Experience of Realization and Use)

L.S.Galetsky, B.A. Gorlitsky

(Central Project Expedition of the Ukrainian Geological Survey "Ukrgeologia", Ministry of Geology of the USSR; Institute of Geochemistry and Physics of Minerals, Academy of Sciences of the Ukrainian SSR)

An array of relational geological-geochemical database of information - logic system "GEOMET" (geology, geochemistry, metallogeny) has been created. Division of results obtained from geochemical testing into data determining the geochemical background and data being a deviation from that background, so-called anomalies, is one of the function of "GEOMET". That function is provided with special procedures.

Geochemical anomalies carry information on the substance distribution processes determining the geochemical background. Considerable part of the anomalies-origination processes is potentially ore-generating one. So information on geochemical anomalies differs from the background one in logic and methods of application. Background information is used to determine average content or "supply" of those or other chemical elements into the objects to be characterized and compared. "Anomalous" information characterizes not so much supply of anomalous element as the confinement of potential-minerogenic events to one or another geological object (structural-substance complex, tectonic zone, etc.) or process (appearance of metasomatosis,silification, weathering, etc.), e.g., in terms of relative frequency of occurrence in the series of objects or processes under consideration.

The created database on geochemical anomalies contains today data on 20 those geochemical anomalies of the Ukrainian Shield. A structure for the description of a single anomaly is as follows:1. Number of anomaly in the database. 2. Coordinates. 3.Source of data (author, year). 4. Author's number of the anomaly. 5. Number of aiming point (outcrop, well). 6. Interval of sampling. 7. Name of the enclosing rock. 8. Petrolithotype of the enclosing rock. 9. Basic rock-forming minerals. 10. Accessory minerals. 11. Ore minerals. 12. Superimposed processes. 13. Structural-tectonic position (geoblock, interblock zone, zone of deep fault, etc.). 14. Stratigraphic nomenclature of the anomaly.enclosing rocks (series, complex, suite, rock mass). 15. Formational nomenclature of enclosing rocks (group of formations, formation, facies). 16. Type of analysis. 17. Laboratory source and its metrologic parameters. 18. Content of anomalous elements.

Technique and special software are developed in the course of creation of regional database on geochemical anomalies. they permit solving problems as to distinguish and typify associations of anomalous elements, to classify anomalies by the degree of their ore potentialities, to unite single anomalies into anomalous fields. Computer-aided creation of specialized catalogues anomalies, tables for construction of forecast functions, specialized diagrammatic maps of anomalies and values of forecast functions are eigenfunctions of anomalies base.

Database on anomalies within GEOMET is a part of common relational database and is used to analyze metallogenic conditions: confinement of anomalies to certain structural-substance complex, negative or positive fluctuations of the geochemical background, combinations of those or other geological properties. A series of the forecast-geochemical maps new in principle and specialized by according to the mineralization types is created on computer proceeding from analysis of the whole complex of data being in service of the GEOMET system and of developed methodic means.

ANOMALY RECOGNITION APPLIED TO LATERITE GEOCHEMISTRY, YILGARN BLOCK, WESTERN AUSTRALIA: APPLICATION OF DATA ANALYSIS AND STATISTICAL TECHNIQUES

E.C.Grunsky and R.E.Smith
Division of Exploration Geoscience CSIRO, Wembley, 6014, AUSTRALIA

The trace element compositions of lateritic materials are useful for determining the potential for precious and base metal deposits which can occur within the laterite itself as well as in the underlying bedrock. Anomalous multi-element geochemical signatures are generally associated with many ore deposits and a variety of numerical techniques are used in order to refine the characteristics of the anomalies.

Numerical methods have been successfully used to describe and discriminate background abundance levels from mineralized zones. These methods include principal components analysis, discriminant functions, non-hierarchical clustering and classification techniques. Many of the trace elements are non-normally distributed and many samples commonly contain abundance levels that are less than the detection limit of the procedure used to analyze for them. Where possible and appropriate, transformations are applied to the data in order to use parametric statistical procedures. Robust procedures are also used where standard parametric procedures fail.

Application of these techniques will be demonstrated with data from a regional laterite geochemical sampling programme together with orientation data within the Archean Yilgarn Block.

APPLICATION OF A NEW APPROACH TO PREDICT ORE DEPOSITS FROM ARCHIVE DATAS (BLOCK OF JESENÍK CASE STORY)

Hájek J., Grym V., Žáček M., Geoindustria Jihlava, Czechoslovakia

During geological survey, geological mapping and regional geological studies we obtain geological data sets of different information level. In its variability they have one common propriety - they represent manifestations of mass and energy fields, hierarchicaly ordered.

Informations, concerning mass field are contained in chemical, physico-chemical, petrological and mineralogical analyses, in geological maps and its legends. Informations concerning energy field we obtain from geophysical and tectonic maps.

Informations about geological age result from model calculations and classification of stratigraphy.

It is possible distinguish areas of disturbed geological field and not disturbed field by system analyses of geological data. Disturbed geological field represents potential ore -bearing areas.

Data treatment (with a view of prediction) is made in two stages. In the first one we convert all data into qualitative level and define single partial fields (mineralogical, chemical, geophysical and tectonical fields) and we obtain so called kinematic graph deliminating areas of maximum disturbances in geological field.

In the second stage, using models of known ore deposits we appreciate single anomalies from the viewpoint of ore potential. On the basis of these results we can define with more precision ideas about metallogenic systems in studied area and anomalies position in these systems.

By this process ore potential of several regions in Czechoslovakia, Cuba, Mosambique, Iran, Ethiopia and Mongolia was evaluated in last years. The latest evaluated region is eastern segment of European Variscides in Czechoslovakia - block of Jeseníky Mts. with significant polymetallic stratabound mineralizations in devonian volcanogenous formations of tholeiit-dacite-rhyolite facies.

Facies classification was made with more precision using statistical and heuristic evaluation of data sets of silicate analyses of rocks and creating geochemical models of basic and acid membres of volcanosedimentary series. Revaluating isotopic analyses of lead from Jeseník ore deposits using classification by Pasians method, natural groups and their model age were determined.

Processing of large geological data sets from Jeseníky block leads to creation of model of metallogenic active zones. Scheme marked metallogenic significance both Variscan volcanosedimentary series and shear and block dislocations.

Results of this work clearly show that above mentioned approach to data processing (respect to different quality of observations) can be effective in spite of archive data were used.

References:

Grym V., Kotovicová J. /v tisku/: Typologie izotopického složení olova ve vztahu k metalogenetickým systémům Českého masívu. - Mineralia slov. Bratislava

Hájek J., Žáček M., Grym V. /1989/: Analýza rudních formací a metodika prognózování v měřítku 1 : 200 000 až 1 : 50 000 (na příkladu jesenického bloku). - MS, Geoindustria Praha

Procházka Z., Žáček M. /1986/: Prognózování metodou KOMBI v měřítku 1 : 50 000 na příkladu Železných hor. - Sbor. Horn. Příbram ve vědě a technice, Konf. geol., 57 - 67. Příbram

STATISTICAL EVALUATION OF GEOCHEMICAL DATA ON WESTERN CARPATHIAN GRANITOIDS

Katarina Janakova
Geological Institute, Slovak Academy of Sciences, Bratislava, Czechoslovakia

Statistical evaluation of data on Western Carpathian granitoids was based on a data bank comprising major- and minor-element data on about 650 rock samples. Except basic statistics (mean, variance, standard deviation, roust parameters, histograms, box-plots etc.), multivariate methods were used as well - factor analysis and cluster analysis. The methods have shown relative uniformity in the composition of the studied rocks. However, cluster analysis indicated the existence of two groups of granitoid massifs in Western Carpathians, forming two belts - "outer" and "inner", in accordance with determinations based on the evaluation of multication diagrams by I. Petrik (oral communication).

The granitoids have been studied also from the viewpoint of their tectonic classification (P.D.Maniar-P.M.Piccoli, 1989, J.A.Pearce et al., 1984). Western Carpathian granitoids could be classed with Continental Arc (Volcanic Arc) Granitoids.

References:

Maniar P.D. - Piccoli P.M. (1989): Tectonic discrimination of granitoids. - Geol. Soc. Amer. Bull. 101, 635-643.
Pearce J.A. - Harris N.B.W. - Tindle A.G. (1984): Trace Element Discrimination Diagrams for the Tectonic Interpretation of Granitic Rocks. - Journal of Petrology 25, 4, 956-983.

THE ROLE OF SEMI-VARIOGRAMS IN GEOCHEMICAL PROSPECTING

U.Kramar
Institut für Petrographie & Geochemie
Universität Karlsruhe/Germany

Semi-variograms are a well known statistical tools used in the valuation of ore deposits (De Wijs, 1951/53; Matheron,1971; Krige 1978).

In geochemical exploration this method is rarely used. However it can be helpful to determine the minimum sampling distance. Hints on geological structures can be obtained and window size in moving average mapping determined.
The variance between paired sample is calculated as a function of distance

$$\text{GAMMA}(h) = \frac{\sum_{i=1}^{n-h} (x_{i+h} - x_i)^2}{2 * (n - h)}$$

GAMMA(h) plotted as a function of the distance between the sample pairs tends to a constant value at the range of influence e.g. of a vein type deposit (Fig 1). The diagram can be characterised by three values: Range a, Nugget effect C_0 and Sill C_1.
This is only exact for infinite size of the investigation area. For finite size areas periferical effects can lead to an further increase of the variance if the distance h exceeds 1/4 of the extension of the area.
This increase can be misinterpreted e.g as chemical trend.

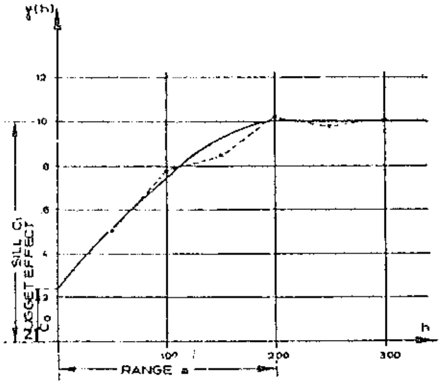


Fig1:Example of a Semi-variogram
(transitive type)
(after Welmer,1983)

The aim of this work is to present new methods which are able to deal with this problem. Models of semi-variogram for different geological situations will be calculated and compared to experimental ones e.g. different geological units within the area result in stepsized diagrams.

References

De Wijs, H.J.: Statistics of ore distribution. J.of the royal Netherland Geol. and Min. Soc. (1951/53).

Matheron, G.: The theory of regionalized variables and its applications. Les Cahiers du Centre de Morph. Mathématique de Fontainebleau.,1971, 211pp..

Krige. D.G: Lognormal - De Wijsian Geostatistics for Ore evaluation. Geostatisics 1,S.A. Inst. of Min.Met. Monogr. Ser., 1978,50pp.

Welmer,F.-W.: Klassifikation von Lagerstätten mit Hilfe der Geostatistik. Schriftenreihe der GDMB, Heft 39, Verlag Chemie, Weinheim, 1983, 164 pp.

ROBUST ANALYSIS OF CHEMICAL COMPOSITIONS OF TESCHENITE ASSOCIATION ROCKS

Pavel Machek - Dalibor Matýsek, Mining University Ostrava, Czechoslovakia

The hitherto published classifications of teschenite association rocks are very unequivocal. Due to complex mineral and chemical composition of rocks, great variability in structure and also due to high degree of secondary processes on rocks the classifications are difficult to compare and review. An attempt was made to establish a classification of these rocks based on their chemical compositions using multidimensional mathematic-statistical methods (MACHEK - MATÝSEK, in press).

The multidimensional methods provided reliable results: they made possible to define several petrochemical rock types, to present graphically the structure of the rocks' compositions and to reveal the basic trends of changes in teschenite association rocks chemism. The methods contributed to the construction of a new classification scheme and complemented the petrogenetic model of teschenite association rocks genesis.

Nevertheless, for the present the results must be considered only from the qualitative point of view. The quntitative outcomes are debatable. The mathematical apparatus used in the study involves methods derived on the basis of normal distributions of variables.

Real geochemical data are notoriously nonnormal. Their distribution are positively skewed, leptokurtic, they have heavy tails and contain outliers. The arithmetic mean and standard deviation commonly overestimate absolute values for both location and scale. The methods that include computation of these basic estimates may give bizarre results for geochemical data which are far from normally distributed.

A very promising, viable alternative to the classical "normal" methods are their robust modifications. Robust estimates are designed to be less sensitive to departures from normality. They can be employed to provide more reliable results. From over 70 robust estimates proposed till this time especially trimmed means, Hampel's estimates, Gastwirth median, trimean can be used in many geochemical situations. They can be quite easily included into clustering techniques forcing also the clustering process to be robust. The most accssible from hierarchical methods is the group average strategy. Substituting the trimean for the arithmetic mean in computing the distances between clusters clustering becomes no more sensitive to outliers, skewed distributions etc. Performances with Gastwirth median or trimmed means are even more safe.

The use of robust clustering methods is proved passing through all stages of processing of the teschenite association rock suite resulting in quantitative results.

Reference:

Machek P. - Matýsek D. (in press): The mathematic-statistical study of the teschenite association rocks based on their chemical compositions. - Sborník ÚÚG, Prague.

SOFTWARE FOR THE TECHNOLOGY OF METALLOGENIC FORECAST

Makedon I.D., Sadikov M.A.

All-Union Research Institute for Ocean Geology
and Mineral Resources ''VNIIOkeangeologiya'',
Leningrad, USSR

The system of processing of packages of geological data in operating system (PGD OS) is based on the module principle and realized on computers of single series (SS). PGD OS contains a large set of service programs (sorting, conversion, merging, selections, normalization and centering, tabulation); many of them can use matrix with a special program. Realized was a set of statistical programs staring from computation of elementary statistics (of means, dispersion, standard, coefficient of variation, asymmetry coefficient, kurtosis coefficient, range coefficient); criteria of evaluation of their difference (Pearson test of fit, Student's t-test, Fisher's variance ratio, Abbe number, Barlett and Rao tests and the like); pair, multifold (after Yu.K.Burkov) and partial correlation; appraisal of homogeneity of coefficients obtained; computation of regression, discriminant functions, different versions of regression factor analysis. A substantial group of programs, related to hierarchical and nonhierarchical clustering of initial data, including that with regard to geographical coordinate of sampling points, was also developed. Different estimates for successive data are to be obtained in the regime of 'sliding window'.

There is a group of programs which perform a large set of petrochemical conversions (of coefficients, atomic ratios, virtual composition, indexes of basicity of rocks and minerals). Programs, intended to study the structure of geophysical fields, differ from all the rest by using uniform rectangular grids. In addition, there is a program for conversion of any data into such a grid. Hence, geochemical data can also be processed with the aid of these programs. Naturally, all parameters obtained can be schematically represented and mapped.

The system envisages built-in programming aids allowing compilation of subprograms for a user by employing and algorithms, as well as all-purpose procedures whitch permit to vary some parameters of functional programs and include programs, prepared for computers SS without varying internal structure of the programs. Data can be transmitted to any system by both external representation and by the presence of system interface.

PGD OS was used as a basis for the development of schemes of tasks, to be solved with its aid, of processing or geochemical data, classification with regard to coordinates. All the schemes are realized as job batches, characterized by a certain sequence and priority. The scheme of processing provides organization of different conversions and accumulation of converted data for different means of their representation. Conversions can be associated with both separate objects (in particular, estimation of virtual composition of rocks, ratios, multiple indexes) and with their systems (contrast in rock types and groups; factors; filling up informational and local gaps). The formation itself of such systems (open and closed) allows us to turn to study of ordered sequences, considered as reflections of natural processes responsible for the formation of ore-magmatic systems. Syngenetic and epigenetic components are to be revealed for formed sequences; interrelations in them, as well as their variations in the process of system evolution, are to be evaluated; this allows mathematical-geochemical models of natural objects to be constructed. Diversity of representation of initial data determines variety of model reflecting various aspects of natural processes. Principles of actualism and uniqueness can be taken as a basis of agreement between the models and natural consistent patterns. The principle of uniqueness is realized by the authors in the form of the method of ''exclusiveness'' or, turning to terminology of the theory of pattern recognition, in the form of recognition without teaching; this permits its extensive application in areas where standards are absent and where it is difficult to collect representative samples. The proposed graph of processing widely employs classifications based on coordinates; this is a fundamentally new step in understanding of geochemical patterns, and if, furthermore, we take into consideration that first three converted factors of typomorphic elements of a given type of mineralization are assumed as purpose characters for classification, then a combination of field of classes with those of ''exclusiveness'' reflects a rather objective estimation of mineral resource potential of the area. The sequence of such an estimation is determined by the scheme of strategy of geochemical prognosis, all data for which are obtained from the scheme of processing, resulting in mapping of all necessary information and tabulation of basic data. Computer-aided construction of polyelemental geochemical maps by the procedure of extreme situations and concentrations, contrasts, contents (COCOC), worked out by the authors, also represents an important link in the scheme of metallogenic forecast; although its software will no doubt be improved, even its current state allows solution of problems raised.

PGD OS acts on computers SS within operating system OS SS. Under way are works at organization of exploitation of all the functional programs of the package in two other media, namely, systems of virtual machines (SAM SS)and MS DOS (IBM PC).

MODIFIED CELL METHOD - 3D GEOCHEMICAL MODELLING

Petr Obst, Center of Applied Geochemistry, Geoindustria Co., Jihlava

The specific modification of the cell method was developed at the Center of Applied Geochemistry, Geoindustria Co., for the processing of very variable geochemical data of some localities.

The cell method is based on division of a studied space into regular segments (cells). Every cell is characterized by the samples inside of it. According to the coincidence or the similarity of these characteristics it is possible to group the cells to larger units and to interpretate geochemical relations in a studied area.

The method developed by the CAG appoints no statistic parameters in cells (as it is usual in most of other similar methods used by many authors) but it calculates concrete percentages of studied characteristics. In this way widely known problems with the reliability of statistic parameters are eliminated.

The effectiveness of this method may be shown on two localities where this method was successfully used: the gold deposit Čelina and the polymetalic deposit Křižanovice. Both deposits are of complicated geological and geochemical situation. Geochemical data were very variable and the processing by classical methods gave no sensemaking results.

The Čelina deposit is attached to the contact of the Central Bohemian Pluton with the Jílové Belt. The Jílové belt consists of effusive rocks and tuffs metamorphosed into the greenstones facies and contactly altered by the granitoids of the Central Bohemian Pluton.

The dominant tectonic structure of the deposit area is the large WE mylonite zone strongly deeping to N. There exists a genetic relation between this zone and the paralell system of gold-bearing quartz veins up to 0.5 m in thickness with trace contents of sulphides and local accumulations of the younger genetic type of scheelite (the gold-bearing mineralization of the deposit).

The second genetic type of scheelite is a member of the second, older, significant mineralization type of the deposit - volcanogenic stratiform sulphide mineralization.

Geological situation of the deposit then can be characterized by fast changes of the lithological environment and by the interaction of two main types of mineralization.

For the evaluation the deposit was divided into 150 cubic cells arranged regarding the network of underground prospecting workings.

After filtering away of the disturbing geochemical signal of the rock environment the space distributions of studied elements were drawn. According to the space correlation the elements were divided into two associations:

1. the association of stratiform mineralization - Cu, Zn, Pb, Ag
2. the association of gold-bearing mineralization, which turned out to be zonal paralelly with the mylonite zone as follows: (As+Sb) → (Au+Bi) → (Mo) with B as a rim of the most intensively mineralized center of the deposit.

W is noted for the transient distribution between these associations.

Here the evaluation was temporarily interrupted till further data will be disposable.

The polymetalic deposit Křižanovice (barite, Zn, Cu, Pb) is situated near the border of two rock types of the Nasavrky Massif - tonalites and the Křižanovice granite. The deposit is developed in strongly deeping WE zone of dynamically and metasomaticaly altered rocks (porphyroides and various types of quartzites). Stratiform and lens-shaped orebodies themselves are considered to be the product of the final phase of metasomatism.

In the deposit center there are orebodies arranged to the discontinuous fold-like arc. This arc was interpreted as the strongly compressed anticlinal bend. But some facts did not support this interpretation.

The deposit space with 61 boreholes in 15 cross sections was divided into 56 cells prolongated paralelly with the course of the cross sections.

The most important result of data operations in cells is the model of the vertical zonality of the deposit. Downwards from the surface level these zones follow: ($BaSO_4 \pm Zn$) → → ($Zn+BaSO_4$) → ($Cu \pm Zn$) → (Cu). Pb is not included into this zonality because the major part of Pb pertains probably to one of post-ore mineralization periods.

This knowledge about the vertical zonality was the missing link for the interpretation of the deposit morphology. Now the fold-like shape of main orebody could be re-interpreted as the result of activity of a complicated system of paralell faults.

Except for here described 3D variety of the cell method there is disposable 2D variety at the CAG, too. It is used for the evaluation of a surface prospection. Both variets were successfully applicated in various mutations at a number of localities.

References:

Štícha R. (1987): Model vertikální zonálnosti aureoly ložiska Křižanovice a vyhodnocení litogeochemických dat zóny Křižanovice - Samařov. Závěrečná zpráva úkolu Křižanovice 01 83 3101. MS CAG archives, Jihlava

Štícha R. - Obst P. (1987): Etapová zpráva úkolu Geochemické modely Au ložisek a Au-W mineralizace - lokalita Čelina. MS CAG archives, Jihlava.

STRUCTURAL ANALYSIS OF GEOCHEMICAL DATA IN A LOCAL MINERAL PREDICTION

M.K.Ovsov and V.M.Pitulko, All-Union Geological Institute, Leningrad, USSR

Earths substance in the process of evolution is in continuous movement which results in "an order from a chaos". Convection is a predominanting mechanism of heat-and-mass transfer in the lithosphere; its traces are reflected in the features of geochemical fields. This mechanism is the basis of natural hierarchy of metallogenic units of various ranks.

Data proceeding discovers the natural structure of ore-forming system. Main hierarchial structures are: (1) the hierarchy of observable variables - concentrations of elements and (2) the hierarchy of objects both in relationship and in spacial-geometrical co-ordination. An algorythm of structural analysis of geochemical data consists in cyclic recurrences of stages of transformations of the same type, where the structure of variables and structure of objects have been analysed in succession. The following steps have been undertaken for every stage:

1. Cluster analysis of correlated matrix of the variables;
2. Revealing of levels in the structure of variables;
3. Selection of the most common level and definition of cluster centres as major correlated factors, obtaining of the oblique-angled factor decision;
4. Turning to outlining of the objects in space of the most common variables (calculation of values of major factors);
5. Transformation of space of major correlated factors into space of orthogonal variables with subsequent hierarchial cluster analysis of the objects;
6. The analysis of objects structure for the purpose of revealing of the levels of their organization.

This procedure is applied to every of distinquished data subsets. As a result the geochemical data are represented by hierarchial structure which progressively develops from the most general divisions to more detailed and specific.

On the geochemical fields of gold and rare metal objects it is shown, that a number of levels of description is revealing in intensity and relationships of the elements. These levels are suitable for mapping and estimation of various aureoles. Individualization of samples in the association of an ore complex is evidantly expressed at the zero level (maximum number of simple factors). At the first level Li, Ag, Tl become typomorphic; an association of Sr, Ba, Cr, Ni is distinquished at the second level. The high clarke petrogenic elements are among the factors at the las level. A jump in an increment of similarity serves as a measure of differentiation at a description of levels. Change in role of variables is observed between levels and many examples from the practice of prospecting confirms this.

QUANTITATIVE ASSESSMENT OF POTENTIAL METAL RESOURCES FROM STREAM SEDIMENTS

V.A.Romanov, Institute of Geochemistry, Irkutsk, USSR

One of the important problems in prospecting by geochemical methods is the quantitative assessment of mineralization from stream sediments (SS). In calculation procedures the estimation of erosional shear level of mineralization has a great significance (Solovov, 1985, Polikarpochkin, Belogolova, 1982). The method of quantitative estimation of potential metal resources is proposed for weakly eroded deposits.

This method is based on the model of formation of an ideal stream sediment according to A.P.Solovov (1985): $P'_x = S_x \cdot (C'_x - C'_b)$

where P'_x – apparent productivity, $m^2 \cdot \%$; S_x=the area of the denuded basin, m^2; C'_x, C'_b = subdued and background element concentrations, correspondingly,%.

The amounts of potential resources (Q'_D) for the reasonable mineralization depth (D) are estimated according the formula: $Q'_D = \frac{1}{c'c} \cdot \frac{1}{40} \cdot H \cdot \sum_{i=1}^{n} P_t$

where c'c = the local propotional coefficients; P_t = "true" productivity of SS, and the division by 40 corresponds to the transition from $m^2 \cdot \%$ to the potential resources of P_2 rate in tons.

The estimation of P'_t value is the most important parameter in the second equation. It may be derived by the formulae: $C'_t = \frac{P'_x}{S'_x} + C'_f$; $C'_R = \frac{C'_t - C'_x}{C'_t} \cdot 100$; $C'_t = \frac{C'_x}{100 - C'_R} \cdot 100$

$P'_t = S_x \cdot (C'_t - C'_f)$ where C'_t = the theoretical element concentration in the train of SS, confirming the statement; P'_x max =const; P'_x = the maximum value of apparent productivity in real true element concentration in P'_x =max point.

The value of a common proportion coefficient between potential resources and metal reserves in the deposit ($Q_{o.b.}$) is determined by standartization: $K = \frac{Q'_D}{Q_{o.b.}}$

The estimation of potential resources of lead, zinc, silver and gold is made for the reference sites, as well as probable mineralization within one of ore-bearing fields.

The ratios between potential resources and metal reserves on the test deposit, accepted as unit, amount to 1,02:1 - for lead, 0,98:1 - zinc, 0,67:1 - for silver, 1,02:1-gold.

The promising areas within the ore-bearing field (Fig.) are: the surroundings of the standard deposit for gold-silver mineralization (5,2:1 for Au; 4,9:1 for Ag) and the surroundings of the test deposit for polymetallic (2,32:1 for Pb; 5,73:1 for Zn).

The spatial distribution of potential resources of the metals considered is correlated with mineralogical-geochemical endogenic zonation.

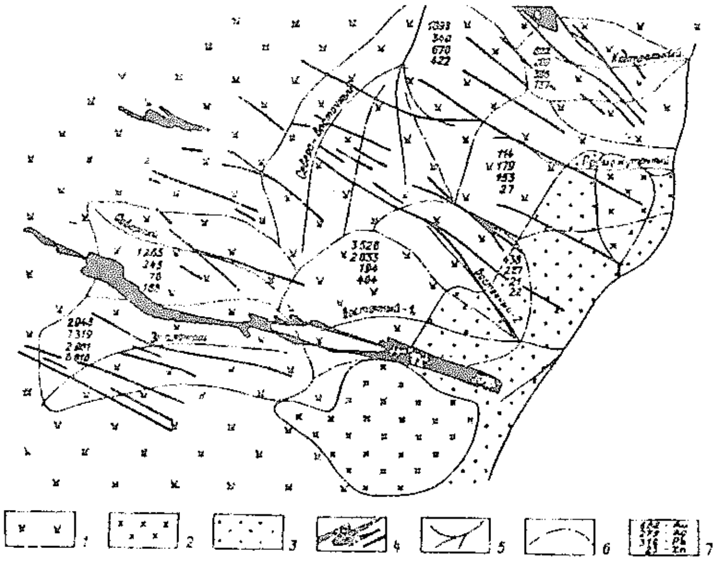


Fig. The potential metal resources (Q_D), estimated from the stream sediments of ore fields. 1 - Middle Upper-Mesozoic effusive rocks of basic-intermidiate composition; 2 - Upper Mesozoic granitoids; 3 - Jurassic sandstones; 4 - ore zones; 5 -stream beds; 6 - watershed lines ; 7-potential metal resources.

HIERARCHY OF SYSTEMS IN ORE-SEARCHING GEOCHEMISTRY

M. A. Sadikov
All-Union Research Institute of Ocean
Geology and Mineral Resources
"VNIIOkeangeologiya", Leningrad, USSR

A scheme of the structure of geochemical prognosis has been developed by the author; the scheme is based on metrological estimation of all stages of works from data acquisition to interpretation; the sequence of stages and combination of methods; hierarchy of the whole searching process; attention to methodology and ideology. Each cell of a scheme can be developed into a lower-level scheme. A set of such different-level schemes of: strategy of prognosis; data processing; tasks to be solved with the aid of processing of packages of geological data; classification with consideration for coordinates was constructed. Current with an hierarchy of schemes, as well as within their limits, an hierarchy of system, considered in them, can be evaluated. Of upper-level system, the systems of views, data acquisition, analysis and preparation for analysis, data processing and interpretation appear to be most important. All of them can be quantitatively characterized only through the system of quality estimation; this is indirectly expressed by results of analysis. Views determine the system of space, in which they are realized, and the system of methods with the aid of which they can be expressed. Of systems of the next level, systems of samples and indicators, which are closely interrelated, should be noted. All the systems are based on certain notions and principles which reflect their interrelations and combinations in a different-level space and determine the ways of their study, resulting in the construction of models of natural objects and schemes of their understanding. They are based on the principle of system approach, which consists in infinite divisibility of an object of study; this principle allows us to outline appropriate hierarchical levels according to sophistication of the system and their combination in independent, crossing and overlapping spaces. The interrelation of the systems of views and interpretation is determined by the means of data representation; this is reflected, according to redistribution of elements in entire matter, its portion or according to proportional variation of components in the process of formation of aureoles and fluxes, in the form of contents, concentrations, contrasts. Taking into account the fundamental role of this notion, the question of three ideologies of applied geochemistry as a missing link in the theory of geological knowledge is raised. Depending on data representation, models, based on them, can appear to be inadequate to natural process and can reflect different aspects of the processes. Lower-level systems from technologies and models from methods,principles, concepts. It should be noted that levels of organization of the system frequently are not in line with natural levels of organization of matter, thus causing a discrepancy between hypothetical models and natural regular patterns. Existing subjectivity of selection of firm data and the level of statement of problems often determines ambiguity of their solution. Since the properties of systems substantially determine a set off new qualities of the systems, thus resulting in their self-improvement, hence study of the hierarchy of systems as reflecting natural features should play in ore-searching geochemistry to ensure its further progress. Upper-level systems primarily need further investigations as their inadequate understanding is a serious handicap to purposeful and fruitful application of geochemical methods. Some ways of tackling these ripe problems are proposed.

THE EVALUATION OF LITOCHEMICAL DISSIPATION FLOWS

Yuri V. Shvarov, Moscow State University, U.S.S.R.

The quantitative evaluation of geochemical anomalies in stream sediments in units of the area productivity P (m^2 %) is economically very important as an objective criterion for revealing of commercial ore deposits at the earliest stage of geochemical prospecting. This paper is devoted to account a method for such evaluation based on the mathematical model of a dissipation flow.

The essential assumptions of the model are:

- contents of all chemical elements in friable stream sediments are stable: $C=C(x)$ changes along the stream bed but does not depend on time;
- variations of erosion are not taken into account, i.e. only mean values of parameters are considered;
- the stream transportation speeds of the ore elements and the chemical elements of country rock may differ.

Relying on these assumptions there was found an equation describing the connection between the superbackground contents of the ore element - the mean value in the cross section of the slope ($\bar{C}$) – and its content in the corresponding point of the dissipation flow (C):

$$\frac{u_o}{v}\,\sigma(S)\,\frac{dC(S)}{dS} + \frac{u_o-u_r}{v}\,C(S)\,\frac{d\sigma(S)}{dS} = \bar{C}(S) - C(S), \qquad (1)$$

where u_o and u_r are the migration speeds of the ore element and rock elements, v is the rate of erosion – the span of eroded layer per unit of time (m/s), S is the area of the drainage basin for the corresponding point in the stream bed, and $\sigma(S)$ is the area of the cross section of that part of the active stream that is occupied by the transported solid material; both values are in m^2.

Let us discuss two cases:

1. All the material entering from the slopes into the bed is completely carried away by the stream. In this case $\sigma=Sv/u_r$ and then (1) provides:

$$\frac{u_o}{u_r}\,d(CS) = \bar{C}dS, \qquad \text{or} \qquad P = \frac{u_o}{u_r}\,CS. \qquad (2)$$

The value u_r/u_o corresponds to the empiric parametre κ' broadly used in the formula $P=\frac{1}{\kappa'}CS$ that describes the "ideal" flows in first grade streams.

2. The stream is saturated i.e. according to the local hydrodinamical conditions it transports highest possible amount of matter. In this case $\sigma(S)=\omega S$ where ω is a proportionality coefficient. From (1) we reseive:

$$P = \int CdS + \beta\left[\frac{u_o}{u_r}\,CS - \int CdS\right], \qquad \text{where } \beta=\frac{u_r}{v}\omega. \qquad (3)$$

When $u_o=u_r$ the formula (3) changes into the equation of "non-ideal" dissipation flow, also broadly used in practice.

The evaluation of dissipation flows can be done using (3) by a method similar to the method used for FLOW computer program (Shvarov, 1984) if the value of κ' is known. This parametre can be determined, for example, by studying "ideal" dissipation flows in similar conditions.

Applied for complex anomalies this method allows to evaluate the productivity even of those elements which $u_o \approx 0$ (i.e. elements forming placers) because the coefficient β (the same for all elements of the anomaly) may be found by companion elements.

References:

Shvarov Yu.V. (1984): Computer evaluation of litochemical dissipation flows.– Moscow University Geology Bulletin, 2, Allerton Press Inc., New York.

THE IMITATION OF GEOCHEMICAL AND GEOPHYSICAL PROSPECTING ON A PERSONAL COMPUTER

G.S.Vakhromeyev
Polytechnical Institute, Irkutsk,

Y.G.Shestakov, P.N.Mulin
Nonferrous Metals Institute, Krasoyarsk, USSR

The imitation system permits to realize the search-prospecting process, preserving the succession of actions of a geologist and at the same time decreasing the duration of the process from several months or years to minutes and hours. The model territory perspectives can be evaluated irrespective of the size and orientation of the search net, with analytical data being accurate. Making use of this system a research is able to correct his hypotheses and optimize the search methods whereas a student or a production worker have the possibility to accumulate an experience in carrying out combined prospecting, to analyze and correct their mistakes.

The technical base of the system is a personal computer of IBM PC type. The information base is represented by the bank of the model territories perspective from the point of view of discovering minerals deposits of definite geological-commercial types.

The system includes the following subsystems:

1. Formation of model territories variants.
2. Imitation of prospecting on dispersion trains.
3. Imitation of prospecting by secondary dispersion halos.
4. Geophysical prospecting imitation.
5. Imitation of a geologist's actions in establishing the metallization contouring ore zones by pits and determining their depth by boreholes.
6. Data processing imitation.

The first subsystem on the basis of elaborated geological-mathematical model of the territory evaluated provides the variants that differ in number, size, location of the prospecting objects, in their erosion level as well as in the character of their reflection into geochemical and geophysical fields. The second subsystem enables to imitate the selection and analysis of alluvium samples from the stream flows of different order, the panning, geological examination of slopes - the places of possible transportation of the ore material in the river bed as well as sampling and analysis of eluvium-deluvium. The third subsystem ensures the imitation of sampling and analyzing of talus deposits in modification of secondary dispersion halos, geological examination of the discovered geochemical anomalies and panning of any part of area. The fourth subsystem is to imitate geophysical surveys by aeromagnetic, field magnetic, gravity and geoelectric methods. The fifth subsystem is to imitate mine-drilling works. The sixth subsystems is designed to evaluate the reliability of analytical data to establish background and anomalous contents of different elements, to smooth out the measured values of detecting weak anomalies and also to evaluate the prognosis of commercial resources of the object discovered.

The imitation of all prospecting stages takes not less then three days work including from 10 to 12 hours spent at the personal computer terminal. The game elements of the system are: projecting with the aim of carrying out geochemical and geophysical works at any stage, their realization, data processing and interpretation, making and defending accounts in accordance with the works done.

At present the models of polymetallic, gold-ore, skarn-magnetite deposits with corresponding geological situations, geochemical and geophysical fields have been worked out and are stored in the bank of model territories.

COMPUTER MODELLING OF MERCURY ORE-FORMING PROCESS.

Voitsekhovskaya M.B., Institute of geology and geophysics, Novosibirsk, Borisov M.V., Moscow University, Moscow, USSR.

The development of geochimical researching showes, that eloborating of genetic's models of different types of ore-forming processes is the base of systematic metallogenetic analyses and forecasting of ore deposits. The model's way to the revealing of combined factors of the forming ore deposit allowes to put investigations on more elevated level. One of the prospecting of ore-forming systems is the thermodynamic computer modelling.

The thermodynamic model of process of mercury ore-forming in zones of argillizations is suggested. Hydrothermal system of deposit may be described as model-system H,O,K,Na,Ca,Mg,Al,Si,Fe, C,Cl,S,Hg under $T=150^{\circ}C$, including 49 solidphases (minerals) and 70 particals of water's solution. The calculating is based on programmGIBBS.

The special method of quantitative appraisal of fluid's composition have been worked out in order to take account the degree of reaction's proceeding (ξ) between mineral and fluid.Fluid composition indicated kaolinite+quarts assemlege (mole/kg H2O): NaCl-2,0;H2CO3-0,1; CaCl2-0,5;KCl-0,1;HCl-10^{-4}; H2S-10^{-6}-10^{4};Hg-10^{-6}-$2\cdot10^{-5}$;for hydrosilica+quarts assemblege is (mole/kg H2O): NaCl-2,0;H2CO3-0,1; CaCl2-0,5; KCl-0,5; H2S-10^{-3}-10^{-1};Hg-10^{-6}-10^{-7}. The solubility of Hg sulfide in solution is determined by $HgCl_4^{2-}$ complex (mH2S$\geq 10^{-6}$) or by $Hg^{\circ}_{(aq)}$ species (mH2S-10^{-5}-10^{-3}), or by complex $Hg(HS)_2^{\circ}$ (mH2S$\geq 10^{-2}$). The precipitation of cinnabar cheked up by incongruential reactions between silicate minerals of wall-rock and fluid, endeed. The prevalence in hydrothermal solution of complex $HgCl_4^{2-}$ fixes the coditions for precipitatin of native mercury in zones of argillization or formation halo of mercury. The precipitation of cinnabar is determined by complex $Hg(HS)_2^{\circ}$ and there were no ore deposit if $Hg^{\circ}_{(aq)}$ species prevail over the hydrothermal fluid.

GEOSTATISTICS FOR THE INTERPRETATION OF GEOCHEMICAL ANOMALIES

Hans Wackernagel, Ecole des Mines de Paris, France

The well-known geostatistical technique of kriging (cokriging in its multivariate form) builds a moving average of data in a spatial neighborhood. The weights of the moving average are deduced from a probabilistic model.

From a geochemical/geological point of view the key question is to know whether it is profitable to use a technique which is based on a weighted average of several samples. Clearly the answer depends on whether there is a possibility for geological anomalies to have an influence on more than one sample in the region.

The poster presents an application to multivariate exploration data.

References:

Wackernagel H. /1988/: Geostatistical Techniques for Interpreting Multivariate Spatial Information. - In: C.F. Chung et al. (eds), Quantitative Analysis of Mineral and Energy Resources, 393 - 409, D. Reidel, Dordrecht, Holland

Wackernagel H. /1989/: Caractérisation d'Anomalies Géochimiques par la Géostatistique Multivariable. - In: S.E. Jenness et al. (eds), Geochemical Exploration 1987 - J. Geochem. Explor. 32, 437 - 444, Amsterdam.

ESIGE - THE EXPERT SYSTEM IN GEOCHEMICAL EXPLORATION

Wang Weirong (1), Luo Xiwen (2), Yang Zhuxi (1), Liu Yanging (1)

(1) Computer Section of Geochemical Exploration, Institute of Geophysical & Geochemical Exploration,
Langfang, Hebei 102849. P.R.China
(2) The Fourth Geological Survey, Jilin Bureau of Geology & Mineral Resources, Tonghua, Jilin 134001,
P.R.China

ESIGE, the expert system in geochemistry was cooperatively developed by the Institute of Geophysical and Geochemical Exploration and the Fourth Geological Survey, Jilin Bureau, of Geology & Mineral Resources. It was written in Turbo PROLOG language on IBM PC/XT microcomputer. It consists of four modules: (1) knowledge base and data base management module (2) reasoning machine module (3) data acquisition and expert consultance module (4) message explanation and graphic display module.

The system offers versatile management to the knowledge base and the data base, which enable the users to add, modify, delete, and list the rules and information in both bases. The knowledge base, data base, and the management module were designed to be reparable from the rest. Any of them can be edited, modified, and expanded individually. The inexact bidirectional reasoning with probability multiplication was employed to the system. The confidence level was introduced to indicate the contribution of the variables.

A user's surface which consists of a set of menus is easily handled. To be more conveninent to the users with different purposes, it provides two input modes. (1) data input interactively: The user may respond to the questions inquired by the system, referring to the explanation given by the system. The built-in prompts will help the user with next operation. (2) data input in file: skilled user may choose the second input mode. It would be more efficient to input the necessary information from a prepared data file.

An explanation to the message and graphic display module help the user to understand, to run the system. Users have access to a sophisticated graphics performance. With the visual explanation, users can understand the geochemical models of known areas and the model being consulted much better.

The main ideas of the knowledge base and the inference-frame were drawn from the geological and geochemical data of the gold mines in Jilin Province. More than 500 rules were included. More experiments should be done, so as to explore the applications of the ESIGE system to the field of geochemical exploration.

A COMPUTER FOR THE RAPID EVALUATION AND SORTING OF MULTI-ELEMENT GEOCHEMICAL ANOMALIES - RESMA

Xie Xuejing

Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849
People's Republic of China

A computer system for the rapid evaluation and sorting of multi-element geochemical anomalies (System RESMA) was developed. The system is able to:

1. Resolve the single-element data into a local and a regional component, and plot the single-element component maps of background surfaces and anomalies.
2. Calculate the normalized areal productivity (NAP) of each single-element anomaly.
3. Write down the "single-element anomaly series" by taking any one element anomaly as center and write down all other element anomalies overlapped to a certain extent with this central anomaly in a sequence arranged according to the magnitude of their NAP values.
4. Delete all the anomaly series in which the NAP value of the first element is less than the second one. The remainders are all the actual multi-element anomalies on the studied map. The computer will print out their "element association expression".
5. The significance of the multi-element anomalies can be ranked according to the magnitude of NAP values of the first element on the element association expression.
6. The multi-element anomaly map can be plotted by calculating the multi-element values MAV_1 and MAV_2.

The method is objective and the results can be reproducible by any worker using the same program. The results are normalized and can be compared between different map sheets.

The aim of the system is not to replace subjective interpretation of the geochemists. On the contrary, the system could display clearly large amount of information hidden in the multi-element data and render the subjective interpretation more effective.

PRINCIPLES OF STORAGE AND RETRIEVAL OF GEOCHEMICAL INFORMATION IN DATA BASES ON MINERAL DEPOSITS

Vladimir G. Zolotarev, VNII Zarubezhgeologia, USSR Ministry of Geology

The problem of storage, retrieval and usage of geochemical information received in the studies of chemical features of natural objects is one of the most important in improving the forecast and assessment of metal resources and, thus, in managing the prospecting and exploration at different stages of geological works.

The most common are the territorial data bases that contain analytical data supplied by a relatively simple description of a sample and a site of sampling. Further development usually lies in improving the algorithms of statistical data treatment, geochemical mapping and anomaly detection.

The data banks that contain information about the geological objects (ore deposits, ore occurences, etc.) were not used to solve the applied geochemical problems in exploration. Geochemical information in such data bases may be both of primary nature (concrete sampling data) and of secondary nature (compiled by a researcher).

The goal of the report is to demonstrate the perspectives in usage of geochemical information, that characterize a geological object, in geochemical forecast at different levels of exploration. The data bases AIRS-Ores and AIRS-Nonmetals (Industrial Minerals) of GEOINFORM System (CMEA countries) are supposed to contain various geochemical information on mineral deposits. It include chemical analyses for oxides and elements and physical-chemical (fluid inclusions, stable isotopes), indicatory (a set of geochemical indicators) and radiological data. These quantitative data characterize either a single rock or a mineral assemblage both of which has a certain spatial and time position, or an ore (mineral) body. Relational-hierarchial way in tying the parameters (both terminological and quantitative) opens the possibility to use the geochemical information not only with petrological-geochemical purposes for stratified and intrusive rock complexes or in studying the features of the mineralization but also in evaluating mineral resources.

At the medium-scale (1:50,000 - 1:100,000) and small-scale (1:200,000 - 1:500,000) studies a deposit (an occurence) may be represented as an elementary cell (a point) which can be described in the terms of geochemical spectrum of elements, reserves and metal grades, temperatures of formation of the concrete mineral assemblages, and stable isotope values. Each of them may be used to reveal a zonation or trend pattern for the whole territory under study. The zones with certain characteristics and with corresponding resources may thus be chosen.

The geochemical values for rock sequences and intrusive massifs may be used as some standard values to be compared with the changeable values of geochemival fields of a territory, whereas the geochemical pattern of a deposit - with the patterns of multielement fields. This information appears to be valuable in the anomaly selection comparatively with the known mineral deposits.

Geographic geochemical information interacts with the object-devoted information both at regional (when a concrete deposit is regarded as a point with definite coordinates) and local (when the geochemical zonning of a deposit is analysed in the purposes of exploration and exploitation) levels.

New perspectives will be open by a combined usage of geographic and object-devoted information and choosing the quantitative and qualitative data from a deposit description, as it is possible in the AIRS-GEOINFORM data bases while carrying out geochemical exploration, especially, for deep-seated deposits in well-studied countries. According to B.Skinner (1987) the search for them will reach its summit to 2015. At the present time regional analysis of object-devoted infotmation that describes mineral deposits and occurences may be carried out only for large territories, including the territories of the developing countries.

THRESHOLD OF ANOMALITY - BASE PROBLEM OF PROSPECTING GEOCHEMISTRY

Žáček M., Geoindustria Jihlava, Czechoslovakia
Procházka Z., Intergeo, Czechoslovakia

Discover of economically effective ore deposit is the main aim of the geological survey works and the mean how to reach this aim is realization of different observations - heavy mineral samples, stream sediment samples, soil and rock samples etc. Delimitation of ore provinces, zones, knots and ore bodies results from the data processing of these observations. Obtained data sets are divided in two base groups - the first, reflecting by some way the manifestations of mineralizations (anomalous values) and the second one, describing geological environment characteristics and their variability (so called background values). The limit, separating these two groups of values is commonly called threshold of anomality. Consequently threshold determination represents one of the base problems when estimating ore potential of the regions.

In this time several methods of determination of the threshold of anomality are used, issued from the base rules of parametric statistic. So called three standard deviation rule (sum of aritmetic or geometric mean and threefold of standard deviation value),established originaly for excluding outliers from data sets is the most frequent. (Sattran V., Soukup B., 1973). Then this limit value was decreased into sum of mean and one half - or twofold standard deviation, with the aim increase a number of anomalous samples in the data sets. Later, Lepeltier proposed a new method, (Lepeltier C., 1969), making possible quick and easy estimation of threshold of anomality on the basis of the graphical evaluation of cumulative frequency plot in logaritmic scale (probability graph). But using distribution models takes many of problems, discussed up to this time in the literature (see Žáček m., Křivánek Z., 1987).

Besides other ideas appears as for example Woodsworth one (Woodsworth in Sinclair, 1974), situating threshold of anomality in the point of maximal curvature of cumulative frequencly plot.

What have these approaches in common, is the fact there is no system view on problems: threshold of anomality is determined everytime for each variable separately, when presupposing independence of single variables. Resulting threshold of anomality, determined by this way is represented by fixed value, valid (accepted) in whole data set. Percent of anomalous values of each variable is practically unchangeable - 0,15 % in the case of three standard deviation and 2.5 % in two standard deviation cases.

Processes in the nature go according physical and chemical laws and single natural objects form owing to mass energy interactions of structural units of these objects. Then possibility determine threshold of anomality of given element in dependence on concentration of other elements in sample outlines. Data processing is optimal in the level of ordinal variable, optimal number of variables is three.

Data processing is made natural assamblage sets, these composed of positively correlating elements. Concentration values of single elements are converted in the ordinal scale.

Number of classes of each element is equivalent, interval span is made on the basis of real distribution plot estimation.

Threshold of anomality is determined step by step evaluating contingency tables in two and three-dimensional spaces. Thresholds of anomality separate single "high density" areas in these spaces (areas with relatively big number of points, whereas in surroundings points are rare). As result each element has several thresholds of anomality, depending on concentrations of the other elements in assamblage. The name of this method is Pasians.

When the number of variables is bigger than three, we are limited by human imagination. In these cases it is necesary to use the method of mode analyse of distribution function of multidimensional random vector which is very similar in approach.

The Pasians method was applied for the first time in geochemical data sets from south - east Iran region. Obtained results were very encouraging and seems to be better in comparison with above mentioned methods.

References:

Lepeltier C. /1969/:A simplified statistical tratment of geochemical data by graphical representation. Economic Geology, 64,p. 538 - 550, Amsterodam

Sinclair A.J. /1974/: Selection of threshold values in geochemical data using probalility graphs. Journal of Geochemical Exploration, 3/1974/, p. 129 - 149, Amsterodam

Žáček M. et al /1987/: Geochemical evaluation East Iran project Area No.2. Final Report

Žáček M., Křivánek Z. /1987/: Realita vztahu mezi geologickými objekty a matematickými objekty. Sborník sympozia "Hornická Příbram ve vědě a technice", sekce M, 1. díl, str. 71 - 79, Příbram

ASSESSMENT OF ORE POTENTIAL OF THE GOLD-BEARING REGION AT GEOCHEMICAL MAPPING

F.A.Akhmadulin, N.V.Sanina, Institute of Geochemistry, Siberian Br.USSR Ac.Sci.,Irkutsk

A large-scale (1:10000-1:500) geochemical mapping of endogenic geochemical fields of concentration (GFC) was performed for an old gold-bearing region of Kuznetsky Alatau. The region has a dissected topography, forested southern slopes, coarse-clastic tailings, taluses on the northern slopes and bedrock outcrops in the near-apical parts.

The main goal of mapping was the complex assessment of potentials for gold mineralization in the area under study. This required solution of the following problems: determination of elements-indicators of mineralization, levels of their concentrating and scales of development, establishment of geochemical criteria for interpretation of distinguished geochemical anomalies and forecast assessment of deep horizons and flanks of mined ore veins.

The region consists of volcanogenic-sedimentary sequence (diabase porphyrites, their tuffs, tuffschists) of PR age. The numerous quartz veins commonly have the sublatitudinal and north-eastern strike and steep (up to 70°) northward dipping. The mineralization consists of pyrite, arsenopyrite, pyrrhotite, sphalerite and galena in insignificant amount. A specific feature of mineralization is its telescopic nature together with presence of sites where the mineral associations of the early pyrite or late polymetallic stages are available.

The geochemical mapping resulted in construction of a series of mono- and polyelement different scale maps with diverse informational meaning.

The local and areal types of GFC are distinguished on geochemical maps. The areal GFCs are on the whole characterized by the area of a region differring in the element spectrum in the northern and southern parts of the territory. The element-indicators for them are Au, Ag, Pb, Cu, As, Bi, Mo, B with contrast coefficients 1-10 (CC normalized after background). Within the northern part of the area the geochemical zonation (from south to north) implies a replacement of element associations: Au, Ag, Cu, Pb, As, Bi → Au, As, → Ag, Cu, Bi, Au, Mo, → As, Mo, B, Li, Au → As, B, [Nb, Be], → Mo, Nb (the elements in associations are situated according to CC diminishing from 10 to 3). Within the southern part the geochemical zonation implies the CC values increase (from 2 to 8) B, Au, Ag, As, Mo towards the center of the region with coincidence of anomalies of these elements.

Within the areal GFC there are local complex anomalies confined to strongly fissured parts of rocks. The form of anomalies is oval, elongated in the north-eastern direction. The dimensions may achieve 1kmx1.5km. The element spectrum of local GFC is similar to the composition of areal geochemical fields but CC values vary from 5 to 30. The study of local GFC with regard for geologo-structural features of the region permitted the most promising for gold mineralization anomalies to be distinguished at depth.

The detailed geochemical mapping of two deposits stripped to 900 m depth and situated within the northern part of the region showed that their GFC have a complex composition and reflect the features of mineralization. Zonation of GFC of deposits is reflected in the presence of three levels of element-indicators accumulation with CC 10-1000 Au, Ag, Pb, Zn, As, Bi (upper) → Au, Ag, Pb, Zn, Cu, Sb, Bi, Cd (average) → Au, Ag, Zn, As, W, Mo (low horizons) and indicates the limited potential of deep horizons. On the whole the geochemical fields of deposits have a heterogeneous structure, presence of local isometric anomalies with domains of extraction and accumulation of elements within their limits reflecting development of ore columns of gold.

Thus, the large-scale geochemical mapping in the old mining region revealed new sites promising for gold mineralization within the whole area and on the flanks of known deposits.

UNFILTERED FORM OF TRACE ELEMENTS IN ATMOSPHERIC AIR - A NEW GEOCHEMICAL PROSPECTING TOOL.

E. L. Altman
Leningrad State University, Leningrad
B. Krcmar
Geofyzika s.e. Brno

Recently, a number of scientific and research institutes analyze emission of some metal elements from geological structures into soil or atmospheric air respectively. The elements in a molecular form can penetrate through even very thick overburden, or through sea and water. The method of the molecular form of elements can be applied even in localities where traditional geophysical and/or geochemical methods cannot be used (villages, large dwelling places, etc.).

Concentration of the emitted elements is able to detect hidden mineral deposits (Au, Zn, Cu, Co etc.) and burried geological fault structures. Possibilities of the methods are demonstrated by several case histories.

PECULIARITIES OF THE VOLUMETRIC MAPPING OF THE MASSIVE SULPHIDE ORE-BEARING AREA

A.N.Arkhangelsky, Vernadsky Institute of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR

Geochemical prospecting of buried massive sulphide deposits is a complicated tasc in spite of significant progress of their investigation. The stratiforme distribution of geochemical anomalies, polygenetic character of halos, convergence of flanking and overlying zones of halos are the real reasons of this. Increas of local geochemical forecasting reliability and geochemical prospecting efficiency may be realise by using volumetric geochemical mapping /1/. The base of the method is the formation of volumetric model for the geochemical field where its morphology and zonality are shown in three-dimentional extent.

Methodical peculiarities and the results of geochemical volumetric mapping of the Verkhneuralsky ore area in the Southern Ural are presented in the paper. The area is distinguished by the morphological variety of copper-rich massive sulphide deposits and by the detailed investigation with deep drill holes. Most deposits are buried. They are localized in the Middle Devonian acidic volcanic rocks, that are underlyed by basaltic unit and overlyed by volcano-sedimentary sequences of 150-600 m thick /2/. Endogenic geochemical halos of the deposits are characterized by the combination of extended stratiform zones, which are in accordance to ore bodies localisation level and submited cross-cutting chut zones in underlying and overlying rocks. The halos dimensions have an essential diversity, especially in the overlying sequences. On the bedrock surface most of the deposits are marked by geochemical anomalies similar to those in the fields without ore occurrences. So, surface geochemical mapping is not sufficient for the buried deposits forecasting.

The geochemical sampling data of the deep (up to 1-1.5 km length) drill holes cores have been used as the base of the volumetric mapping of the area. The prospecting drill holes network cells are 0.5*0.5-1 km dimensions. Sampls were analyzed by semiquantitative spectrographic method. Volumetric mapping was accomplished by drawing geochemical polyelemental cross sections disposed in 0.5-1 km to 1:5,000-1:10,000 scale and "volumetric" press-projection maps to 1:10,000-1:25,000 scale for the some units of rocks. Anomalies of Cu, Zn, Pb, Ba, Ag, As, Co, Mo, Mn concentration and Cu, Zn, Pb, Ba, Co, Mn depletion were shown on the maps and cross sections. The polyelemental anomalies were displayed on maps and cross sections using the method of fields of native geochemical assosiations of elements.

As the result of volumetric geochemical mapping the prevalence of depletion zones were established in the anomalius geochemical field structure of the area. They have a wide development in plan and front views. The concentric lateral zonality is clearly distinguished in the anomalius field structure. It's well mapped in the ore underlaing sequences and are characterized by the next general distribution of anomalies in the plan view: inner zone - corresponding to the ore bodies subjacent halo of Cu, Zn, Co, Mo, As accumulation, Cu, Co may be depleted there; intermidiate - with Zn, Cu depletion anomalies and Ba, Pb accumulation ones; external - formed by Ba, Pb depletion. The most extended (up to 1-2 km distence) are external zones, inner ones are more local (up to 0.5 km in diametr). There are several centres of lateral zonality, corresponding to the known and potential deposits and ore occurrences.

Determinated features of anomalius geochemical field of the area can be well explained by a convection model for the deposits formation /2/. The geochemical criteria improvement of massive sulphide deposits forecasting and prospection and direct of further prospection works are the result of this investigation.

References:

1. Baranov E.N./1987/: Endogeneous Geochemical Halos of Massive Sulphide Deposits. -Nauka, 296, Moscow (in Russian)

2. Baranov E.N. at al./1988/: A genetic model and exploration criteria for buried massive sulphide deposits of the Verkhneuralsky area, Southern Ural's, USSR. -Proc. of the VIIth IAGOD Symp., 449-460, Stuttgart

NEW APPROACH TO THE GEOCHEMICAL PREDICTION OF GOLD OCCURRENCES IN BLACK SHALES

An. A. Asadulin

Institute of Ore Deposit Geology, Petrography, Mineralogy
and Geochemistry of the USSR Acad. of Sci. (Moscow, USSR)

1. The gold occurrences of wide-spread black-shale formations are rather difficult ones for discovery. The disposition of gold mineralization in such formations is very irregular and the ores have shown usually no apparent differences from the surrounding rocks. Therefore it is useful to apply some indirect geochemical indications. Here, the geochemical data processing by traditional approach gives unreliable results due to the lack of trace-elements which are accumulated by gold deposition.

2. The examination of probability-statistic particularities of trace-element distribution in gold deposits and host O-S flyshoid formation (Uzbekistan) shows the following: the majority of trace-elements in the gold deposits have average contents commensurable with the local geochemical background. Nevertheless, the features of distribution of many elements in the ore-bearing zones and host rocks vary. It is due to the gold deposition process which transform the geochemical field of the host rock formation without significant gain or loss of many elements. Thereby some special zone of internal redistribution of trace-elements exists. We consider this zone a kind of multidimensional analogy of the so-called "subbackground halo" (after A.V. Cancel a.o.). The anomalous and subbackground haloes of elements compose the complex geochemical field of the gold occurrence. This field spread sufficiently beyond the outlines of ore bodies and deposits.

3. This phenomenon permit to increase the range of the geochemical indications being used and, hence, sensitivity and reliability of gold occurrence prediction. For determination of the complex geochemical field of ore deposition it is expedient to apply the Basin algorithm of pattern recognition. This method is favorable when the sampling network and the obtained geochemical data are discrete.

GEOCHEMICAL MODEL OF RARE-METAL ORE-GENESIS AND ITS APPLICATION TO ORE PROSPECTING AND PREDICTION

Ludmila F. Badanina-Syritso
Leningrad State University, USSR

1. The considered type of mineralization has spatial and genetic link to rare-metal peraluminous granites (RPG), which origin is related to the last stage of the specific ore-magmatic systems (OMS) formation. These systems characterize the geodynamic regime for the zones of tectonic magmatic activization (TMA) of the Phanerozoic. Chemical composition of OMS is presented by discrete-succession compositional series of rocks from alkali gabbroids to RPG (1). Basaltoid magma of shoshonite-latite composition is of petrogenetic importance in the origin of such systems.

2. Ore-bearing RPG (apogranites) have polygenic origin. The conditions of origin for concrete intrusive chamber involve the mechanism of interchamber crystallization, the ratio of magmatic and metasomatic processes as well. Within the same geodynamic regime the origin of the either RPG geochemical type and related metallogenic specialization depend on the time-space of degasing of the same type rest magma. Autometasomatic redistribution is the determinant factor in concentration of the ore material.

3. We consider the concentration levels of Rb and Sr in the rocks (2) to be the key geochemical tracer of the degree of OMS development and the extent of mobilization to the ore-genesis. The method of Rb-Sr typification of intrusive formations of TMA including leucogranites hardly distinguished by other methods was developed on the basis of RMS structure studies. The method renders the possibility of the reliable and express estimation of the potential ore content for granitoid complexes in the stage of prospecting and surveying works and delimination of the ore productive areas in the stage of predicting and valuating works.

4. The rubidium content in the rocks is the most effective indicator of tantalium content in lithium-fluoric type of RG (3). The strong Ta-Rb correlation serves as the basis for the development of express analytical method of indirect valuation of tantalium content versus the rubidium and strontium with value intervals invariable within the individual regions and can be considered as a universal indicator of ore productivity for the whole series of RG geochemical types.

References

1. Syritso L.F. et al., 1988. The evolution trend for ore generating intrusive systems of activizated folded regions. Dokl. AN SSSR, v. 343, No 4.
2. Syritso L.F. et al., 1988. Concentration levels of Rb and Sr as geochemical indicators of the development of nongeosyncline magmatism. Geochemia, No. 9.
3. Syritso L.F. et al., 1981. Rubidium as a criterion on tantalium content in rare-metal granites. Dokl. AN SSSR, v.259, No.3.

GEOCHEMICAL FORECAST OF MASSIVE SULPHIDE DEPOSITS BASED ON THE CONVECTIVE MODEL

Baranov E.N., Vernadsky Institute of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR

The genetic models for the ore deposits are the foundation for the scientific principals of local prospecting of buried deposits. So the genetic concepts review and the creation of new models for deposits improve the forecasting methods and increase the efficiency of deposits prospection.

The convective (recycling) model for the massive sulphide deposits (MSD) has become widely accepted. Convective oreforming systems combine flanking-descending branches, which are the ways of seawater filtration, and central ascending ones, corresponding to the ore-transporting channels. The oreforming components are leached from the rocks by seawater. So the flanking-descending branches are marked by zones of ore-elements depletion, what is a principally important for the creation of geochemical methods of MSD forecast.

Recently, geochemical forecast is based only on revealing and study of indicator-elements accumulations halos. We have carried out the special investigation of ore-elements depletion zones in rocks of MSD areas. The main one was the Verkhneuralsky area, Southern Ural which is well investigated with deep boreholes. It allowed to complete the volumetric (three-dimensional) geochemical mapping of the area.

Statistical analysis of indicator-elements distribution in the unaltered rocks (out of near-ore halos) showed up its heterogeneity. As a rule, there are two maximums of probability density of contents, which are distinguished in 1,5-5 times: the first is about clark contents, corresponding to syngenetic background dispersion of elements, the second one fixes their depletion from the rocks.

The volumetric geochemical mapping confirmed the vast distribution of depletion zones of Cu, Zn, Pb, Ba, Co. They have a concent stratiform distribution in sections and are extended for 2-3 km distance in lateral plan from the deposits and more than 2 km to the depth. In volumetric terms the depletion zones excel in several times the near-to-ore accumulation halos. It's determined the distinct lateral zoning of distribution of maximums of elements depletion in direction from flanking of the ore fields towards the deposits: Ba-Pb-Zn-Cu-Co. The mean level of elements depletion excel 50% of their background contents. In general the depletion zones are developed in the greenstone-altered volcanites and selectively situated in the fields of intensive albitization, hematitization, epidotization and carbonatization, only partly in the near-ore propylitic rocks and metasomatites.

The peculiarities of spatial distribution of the depletion zones, their close relation to altered rocks and lateral zoning prove that they are indicators of flanking-descending branches of the convective systems and have been formed as the result of seawater filtration. Seawater predominance in the oreforming fluids have proved by the H and O isotopic composition in sericites from underlying metasomatites of the deposits of the area. Oreforming convective systems belongs to shallow-seated.

The similar ore-elements depletion zones are established on MSD of the northen, middle Ural, Mali Caucasus and Rudniy Altai. We have many reasons to assume, that they are the characteristic features of geochemical fields of all MSD areas.

Revealing of vast underlying-flanking depletion zones, which fix the descending branches of convective systems, opens the new possibility for geochemical forecast of MSD: a) revealing of the perspective ore fields using more sparse prospecting system of observation; b) recognition of the flanking and underlying zones of ore fields in the absence of the anomalyes of the accumulation; c) increase of determination reliability of the spatial position of prospected deposits on the direction of gradient vectors - from the depletion zones towards the accumulation ones; d) the quantitative estimation of the forecasting resources of ores using the migrational balance (depletion-accumulation) of ore-elements. All this contributes to higher efficiency of geochemical methods of MSD prospectings.

GEOCHEMICAL MAPPING AND MODELING OF RUDNYI ALTAI ORE DISTRICTS

V. D. Baranov
Institute of Mineralogy, Geochemistry and
Crystallochemistry of Rare Elements, Moscow, USSR

Geochemical maps for Rudnyi Altai, 1:200,000 and 1:50,000 scales, as a basis for prognostic-metallogenic studies mainly employ approximate-qualitative spectral analysis data for country rocks and stream sediments, with sampling by a common grid. Results of analyses for rock and ore compositions by special precise methods are also much used for metallogenic modeling. Structural-formation zonation and geophysical data on the Earth's crust deep structure serve as a geological basis for metallogenic modeling.

Geochemical features for maps encompass contours of complex geochemical anomalies, their association with a certain formation, the composition and intensity. The map also demonstrates lateral geochemical zones and lithological-stratigraphical levels with peculiar petrochemical and geochemical features which emphasize the structure of the geochemical zonation for the province, ore districts and ore clusters.

The ore district is a structurally (tectonically and geochemically) isolated part of a metallogenic zone that formed in the geodynamic regime of island arcs on the continental crust. It is related to a volcanic-tectonic trough of a Devonian ore-bearing basalt-rhyolite formation which occupies an area of about 4,000 sq.km. Such troughs are controlled by deep faults that are commonly located across the strike of the province. The system of these troughs and faults feathers an elongated longitudinal zone of the deep fault, with the magmatism and hydrothermal metamorphism being essentially potassium.

The trough-depression that controls the ore district is semiclosed and has a single concentric centripetal structure of the geochemical zonation (petrochemical and ore geochemical).

Siderophile and chalcophile element associations (V, Cr, Mn, Ni, Co, Mo, Cu) are abundant mainly within peripheral zones of troughs, adjacent uplifts and separate anomalous fields - all with essentially sodium composition in magmatites and hydrothermolites. Geochemical associations of chalcophile, siderophile and lithophile sialic elements (An, Pb, Ba, Ag; As, Sb, Au; Fe, Mn; Sn, W, Mo; Nb, Ta, Be, Y) are predominantly located in the inner parts of depression and anomalous fields with sodium-potassium and potassium magmatism and hydrothermal metamorphism.

The K2O/Na2O ratio as well as ratios of other elements in different geochemical associations in volcanics, hydrothermalities and geochemical anomalies clearly reflect the structure of the formation-facies zonation of ore districts, ore clusters and fields.

The geochemical zonation of the ore province exhibits a single lateral level of ore contents, with the ratio of indicator-elements of the zonation being close to the background level. This level makes up 20-25% of the whole volume of the ore-bearing formation, yet it contains the majority of commercial massive sulfide base metal deposits and geochemical anomalies.

Within this level the ore-bearing anomalous geochemical fields show a higher thickness and multi-stage stratiform occurrence.

According to the composition of the ore-bearing basaltrhyolite formation, anomalous geochemical fields are displaced from the centre to the periphery of ore districts and ore clusters, and from bottom to top along the section, and are characterized by changes from essentially lead, gold-silver to complex massive copper sulfide mineralization. The direct rhythmical zonation is a feature of each ore-bearing lithological-stratigraphcial level.

The anomalous field for each ore-bearing lithological-straigraphical level has its own inner structure of the geochemical zonation with concentric and rhythmical elements, which extends laterally for several kilometers and only several tens to hundreds of meters thick.

The multi-stage formation of the ore-bearing basalts and rhyolites and further geological development of the province account for the varying degree of the tectonic deformation, intrusion and metamorphism of the anomalous geochemical field and ore bodies, with regeneration of the ore material including redeposition in overlying supra-ore geological units. The most active and long-lived zones with essential potassium magmatic manifestions are related to commercial epigenetic base metal and gold-silver concentrations.

Deformation, metamorphism and regeneration did not change the parameters of the geochemical zonation in the district which formed during the formation of ore-bearing basalts and rhyolites. This situation permits using data on the geochemical mapping for the reconstruction of the volcanic-tectonic ore-bearing structure and effective prognosis of mineralizations.

Ores in ore districts, ore clusters and fields and in some lithological-stratigraphical levels and geochemical zonation of the corresponding rank and are related to volcanics, hydrothermalites and geochemical anomalies.

15A

BEHAVIOR OF GOLD IN POSTMAGMATIC AND HYDROTHERMAL CONDITIONS AND NEW APPROACHES TO PREDICTION OF GOLD ORE DEPOSITS

V.L.Barsukov, N.N.Baranova, S.V.Kozerenko
Vernadsky Institute of Geochemistry and Analytical Chemistry
USSR, Moscow

The study of mechanisms of the ore elements transport and formation of endogene ore is a necessary condition for increasing its reliability in geochemical prospecting. The theoretical basis for the development of new physico-chemical approaches in applied geochemistry of gold deposits is the study of interconnection of the processes controlling: a) chemical state of gold in the high temperature magmatic fluids; b) complexing forms of gold existence in the hydrothermal solutions and their transformations when contacting the ions of arsenic, antimony, tellurium and sulphide ions presented in solutions in considerable amounts; c) subsequences of buffering action of various forms of the volatile components of the fluid [C,H,N,S] while mineralization of gold is formed.

Experiments of the transportation of gold by the high temperature magmatic fluids shows its presence in these conditions in the form of complex $AuCl_2^-$ [Zotov,Baranova, 1990]. At a hydrothermal stage of lower temperature,when in the solution there are higher concentration of sulfide ions and compounds of As,Sb,and Te. The complex $AuCl_2^-$ is turning into complexes like $Au(HS)_2^-$, $Au(AsS)^{2-}$, $Au(AsS)3^{2-}$, $Au(SbS)_4^-$, $AuTe_2^-$, $Au(Te_2)_2^{3-}$ [Seward, 1984; Nekrasov, Gamyanin, 1978; Nekrasov, Koniushok, 1982]. So, the change of activity of the ore-forming solution causes a decrease in concentration of sulphide ions and decomposition of the above complexes and change of the composition mineral association.

The available data on the contents of various volatile components of mineral forming fluids on gold deposits [from the fluid inclusion data] show that the permanent existence and considerable concentration of such pairs of compounds as CO_2 - CH_4, N_2 - NH_4^+, H_2S - HSO_4^- (SO_4^{2-}), determine by buffering the formation of the gold mineralization and may be called as the carbon,nitrogen and sulphate-sulphide buffers [Baranova, Koltzov, 1986]. Within the range of concentration of CO_2 and $CH_4 > p.10^{-2}$ M at total C= 2.5 M the pyrite-pyrrholite association and the minerals like arsenopyrite, chalcopyrite, antimonite, bismuthinite, argentite are stable. These mineral associations are common for the formations of gold-sulphide, gold-rare metal and gold-quartz type,which are mainly located in carbon-containing deposits. The equilibrium of N_2 - NH_4^+ at the contents of N_2 = 0.2.M and $NH_4^+ = 10^{-2} - 10^{-1}$ common for the hydrothermal fluids and pH values from 3 to 6 is within the carbon buffer influence. Therefore,its importance is more considerable than the nitrogen one in case of gold deposits. In the field of the transfer of H_2S into HSO_4^- (SO_4^-) or SO_2 [at high temperatures],pyrite is replaced by magnetite, auripigment, covellite, gypsum [anhydrite] are deposited, antimonite, argentite are stable and natural arsenic appears. These minerals are common for the near surface gold deposits. The ore bodies appearing on the sulphate barrier are often small, but the gold contents are high.

Reference:

Zotov A. V., Baranova N. N. [1990]: Thermodynamic Properties of the Aurochloride Solute Complex AuCl at 350 to 500°C and to 1500 Bar. - Science Geologiqueous,in press.

Seward T. M. [1984]: Gold'82: The Geology,Geochemistry and Genesis of Gold Deposits, 165-181.

Nekrasov I.Y., Gamyanin G.N.[1978]: As regards Ratio of Gold and Cobalt Mineralization in Arsinide Formations.- Doklady Akademii Nauk SSSR,243,N 3,752-755 [in Russian].

Nekrasov I.Y.,Kniushok A.A. [1982]: Geteropolynucleous Complexes of Gold in Antimony-Sulphide Solutions.- Doklady Akademii Nauk SSSR,N 6, 1463-1467 [in Russian].

Baranova N.N.,Koltzov A.B. [1986]: Influence of Ore and Volatile Ingredients of Hydrothermal Solution on Processes of Transfer and Deposition of Gold [After Results of Fluid Inclusion Study].- Geochimia,6,739-750 [in Russian].

INVESTIGATION TECHNIQUES AND NATURE OF AMMONIUM HALOES ON GOLD DEPOSITS

V.L.Barsukov, S.V.Kozerenko, N.N.Baranova, L.A.Bannikova

Vernadsky Institute of Geochemistry and Analytical
Chemistry, USSR

The assumption was said that reduction-oxidation reactions with participation of an organic matter at a level of Fo which corresponds to deposition of gold would be caused appearance of considerable amounts of NH_4^+ ion in hydrothermal solutions and the formation of ammonium haloes on gold deposits [Barsukov,1982]. The development of ammonium-bearing potassium feldspars and micas in the near to ore alteration zones on gold deposits [Barsukov and others 1985, Sterne, Zantop, Reynolds,1984],as well as the development of the ammonium haloes on gold deposits [Kydd, Levinson,1986; Barsukov, 1988] confirms that assumption. It seems to be reasonable to study the entire chain of the interconnected processes: appearance of the ammonium-bearing mineral phases, formation of the ammonium haloes, evaluation of the composition of hydrothermal solutions, changes of the organic matter of the ore-containing rocks. The study of distribution of ammonium in rocks,minerals and oreforming solutions is accompanied by considerable analytical difficulties due to a low content of ammonium and relatively high content of total nitrogen in the object of the study. This circumstance and the necessity of the determination of both the total content of nitrogen and its reduced form [NH] requires the use of a set of techniques which include spectrophotometric determination, IR-spectroscopic investigation,EPR technique and CHN determination.

The IR-spectra of micas are obtained by means of the 'Specord-75' instrument. An absorption band having a frequency of 1400 sm was used as an analytical one [Fig.1].The content of ammonium was evaluated in accordance with a graph plotted by means of standard pieces with ammonium content determined by spectrophotometric technique.

In order to detect the nitrogen-bearing groups in potassium feldspars the EPR technique was used,which provided for the determination of N^{2+},N^{2-}'NO_2 and NH_3^+ as well as other nitrogen-containing paramagnetic centres [NCPC] in minerals [Matyash,1982]. This technique has a considerable edge over the chemical one,because it facilitates a simultaneous determination of nitrogen at various degrees of oxidation and it is very sensible. The NCPC's appear in the feldspars due to the radiation of the ammonium groups within the mineral structure. The typical spectrum of the NCPC in feldspars is shown on fig.2.

The basic technique of routine analysis while studying ammonium haloes within ore zones is the CHN analysis. The determination in samples were conducted at 600 and 900°C. Nitrogen which gets fixed at a temperature of 600°C chiefly corresponds to nitrogen of an organic matter, but the 'higher temperature form', in general, corresponds to the NH_4^+ ion in the crystal lattice of mica and pottasium feldspars. The combination of the CHN analysis,spectrographic determination of the ion of ammonium,IR-spectrometry,EPR determination provides for obtaining maximal information regarding the distribution of ammonium within the oremetasomatic zones.

Data on the content of ammonium in the fluid inclusions in the quartz of ore bodies were obtained. Great variety of the values [np to 0.42 to 0.07 mol/kg H_2O] were detected. Maximum concentrations were found in the quartz of the main stage [mean value 0.26 mol/kg]. The contents of ammonium in the fluid inclusions in the quartz of the late stage were 2-3 times lower.

The organic matter of the hosted rocks, ore bodies and near to the ore altered rocks was subjected to the study. The bitumoids contents in the samples varies within up 0.1 to 0.04%. Hydrocarbons are the predominant fraction among bitumoids [73 to 87%]. Results of the elementary analysis show that hydrothermal changes were accompanied by considerable growth of the oxidation degree of the organic matter and disappearance of nitrogen from its content. Permanent nature of the mentioned phenomena makes possible to suppose that the basic source of the nitrogen of the hydrothermal solutions is the organic matter of the hosted rocks.

The distribution of the ammonium in the ore zones has been studied. It is confirmed that there are haloes of ammonium up to a length of 2-3 to 20-30 m around the ore zones with gold mineralization. Inside the haloes,the ammonium ion content grows from 3 to 10-15 times as compared with background values. The haloes are getting longer in the upper part of the ore bodies.

Thus, our study makes us believe that ammonium haloes found on gold deposits and located around the ore bodies are genetically linked with the transformation of the organic matter in a hydrothermal system. The presence of the NH ion disclosed in the minerals of wall-rock metasomatites [micas, feldspars, illites, montmorillonites] can be sufficiently reliable criterion of deep-seated intense oxidation of the organic matter that occurred in the redox potential range providing for the reduction and precipitation of gold, silver and number of ore elements.

References

Barsukov V.L. [1982] The development of the theory of ore genesis as a starting point of the progress in applied geochemistry, 'Geokhimia' N 8, pp.1059-1071 [in Russian]

Kydd R.A., Levinson A.A. [1986] Ammonium haloes in lithogeochemical exploration for gold at the Horse Canyon carbonate-hosted deposit. Applied geochemistry, 1, pp.407-417.

Barsukov V.L., Kosenko S.V., Ahmanova M.V., Zarembo J.G., Rusinova O.V. [1985] Ammonium-bearing micas in near to ore metasomatite on massive sulfide and gold sulfide deposits. Osnovnye problemy teoreticheskoi prykladnoi mineralogii, Moscow, pp.135-136

Sterne E.J., Zantop H., Reynolds R. [1984] Clay mineralogy and carbon-nitrogen geochemistry of the Lik and Competition Creek Zink-lead-silver deposits. Ec.geology, 79, pp.1406-1411

Matyash I.V., Bagmut N.N., Litovchenko A.S., Proshko V.J. [1982] Nitrogen containing paramagnetic centers in alkali feldspars. Miner. Zhournal, 4, N.5, pp. 13-20.

CONSTRUCTION OF GEOCHEMICAL MODELS OF DEPOSITS BASED ON PRINCIPLES OF THEIR POLYGENIC AND POLYCHRONIC FORMATION

V.I.Baumshtein, Trans-Baikal Research Institute, Chita city, USSR
L.D.Zorina, Institute of Geochemistry, Irkutsk, USSR

There is convincing evidence of multi-stage development of mineralization and its localization at several hypsometric levels. This is particularly common for ore-magmatic systems associated with ring-like volcano-plutonic structures. Normally, in the structures of this type because of repeated moving of fluids through changing ways of transportation the zonal mode of location of mineralization products and geochemical haloes is significantly complicated. Their interpretation is as a rule hindered since existing methods are aimed at the study of integral (summary) pattern of chemical element distribution in endogenic haloes and do not consider individual features of element distribution at each stage of mineral formation.

The method proposed is based on the historic reconstruction of geochemical fields considering redistribution of chemical elements in them. The main objective of studies is searching for indications providing the forecast of geochemical anomalies of different age and formations, as well as developing the criteria necessary for interpretation of these anomalies within spatial-temporal coordinates. At different stages of the substance study the three main approaches for interpretation of endogenic geochemical fields have been introduced: (i) differentiated sampling, (ii) differentiated scintillation spectral determination of element in the powder sample, (iii) typogenic analysis of geochemical fields.

The main approach at the initial stage of studies is mineralogo-geochemical mapping accompanied by step-by-step differentiated sampling of the substance. The material of a sample is visually observed as a product of the same stage of mineral formation. The number of samples must be correlated with types of observed mineralization.

At the second stage of study it is proposed to introduce the differentiated scintillation approximately-quantitative spectral method in order to determine in the sample the concentrations corresponding to a different origin of the elements in contrast to a conventional semi-quantitative spectral method which defines in the sample a summary amount of element with no regard for its polychronous-polygenic nature.

The typogenic analysis performed at the third stage by different procedures defines the limits of variations of numerical values of parametric characteristics of geochemical fields using distinctive features of composition and structure of mineral counterparts of elements producing these fields. The results of typogenic analysis conducted from reference selections show the changes in element composition in subsequent groups of ore mineralization varieties and lithological rock varieties.

The final goal is construction of models of distribution of polygenic-polychronic geochemical fields in the three-dimensional space of the ore knot. Such a construction is based on the compulsory interconnection of geochemical fields with appropriate geologo-structural conditions of mineralization localization and physico-chemical medium of ore formation.

The geochemical models constructed within the spatial-temporal coordinates for a number of objects of polychronic molibdenum-porphyry mineralization of Buryatia and Mongolia were applied for solution of many geological problems, in the local forecast of mineralization on the flanks, deep horizons and in inaccessible for observation and evaluation parts of ore knots.

THE USE OF STREAM SEDIMENTS FOR FORECAST GEOCHEMICAL MAPS

G.A.Belogolova, Institute of Geochemistry, Irkutsk, USSR

The geological survey from stream sediments was done in one of the Siberian ore regions over the area of 3000km^2 with the sampling density 1-2 samples per 1 km^2. The two alluvium varities, flood silts and fine-size matrix of gravel were sampled.The silt and clay material depositing after floods in near-shore parts of rivers may be used to reveal the pattern of localization of ore mineralization.

Monoelement and polyelement geochemical maps were compiled via the method of multi-dimensional field using survey data. The maps show the element combination in anomalies as geochemical classes, which reflect the primary composition of element associations.

The region under study is characterized by gold-sulphide veinlet-disseminated and quartz-veined mineralization, located in the Proterozoic black schists deposits. Gold mineralization is checked by regional fracture zones. All patterns of gold mineralization development, including previously unknown ones are clearly shown on the map of gold distribution(Fig.1).

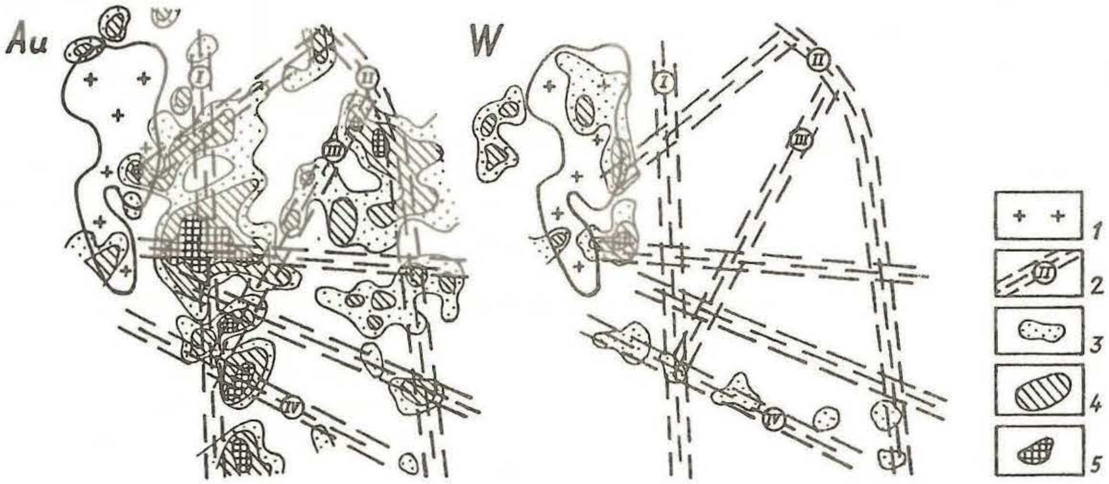


Fig.1. Element distribution in river silts: 1 - granitoids; 2 - tectonic zones; 3-5 - element concentrations in conventional units: 3 - low, 4 - average, 5 - high.

Gold anomalies are closely associated with tectonic dislocations. The polyelement maps display another specific feature of these zones. The gold stream sediments turned out to posses different element concentrations in various tectonic zones. The gold anomalies have high Mo,Ag,Cu concentrations within the Zone 1, while the Zone 2 is characterized by monoelement gold stream sediments with minor concentrations of other elements. In addition to gold,the Zone 3 is accompanied by As,Sb,Pb,Zn. The lithophyle elements B,Li, Cr and Mn produce here the steady anomalies. The mentioned differences in geochemical specialization are connected with various types of ore mineralization as well as different levels of the erosion shear of the entire gold system. There are indications that gold mineralization of this type may occur in the vertical section up to 3 km.

In the western part of the region around the granitoid massif the element composition significantly varies. The rare metal elements (W,Sn,Sc,Nb,etc.) are predominant here. It is evident from tungsten distribution (Fig.1). The W anomalies along Zone 4 seems to be connected with the concealed granitoid intrusion, that is particularly confirmed by geophysical data.

The maps of gold anomalies productivity was compiled via the computer using mathematical stream sediments model. This map permits the potential resources of ore objects from the stream sediments to be forecasted.

So, the forecast-geochemical maps compiled from stream sediments provide an extensive information both on the location and potential resources of ore objects and on the geochemical features of ore systems and geological patterns.

GEOLOGIC-GEOCHEMICAL MODEL OF THE UZBEK STRATIFORM GOLD DEPOSITS

E.B.Bertman
PGO "Samarkandgeologya", Tashkent, USSR

Gold deposits in the Kizil-Kum part of the South Tien Shan geosynclinal are considered as the stratiform. They are marked by a number of common features: time to tectonized parts of the sections and the olistostrome strata (the lithology-stratigraphic control) in spatial nearness to the deep displacement faults, the greenslate metamorphism of the rock, localization in zones of the tectonic tension with the predominant plicated deformations, considerable vertical range of the mineralization zones with the contrast geochemical zoning, the geochemical specialization of rock-contained strata on Au, As, W, Bi, Ag, C; mainly metasomatic way of the ore-forming.

Typification of the gold ore deposits is based on the idea of the productive mineral-geochemical paragenesis. Apportionment of paragenesis is confirmed by the statistical geochemical data, by the mineralogic analysis and by the indirect profiling type of the metasomatism along the edges of ore deposit, by the peculiarities of geochemical field structure. On the basis of this criterion in the region there were established the deposits of the rare metal-golden and golden-sulphid ore formations. The former are characterized by the multi-layer ore deposit of saddle and lens forms in the nucleus of anticlinies and in connection with the fleure line. Besides Au concentrations the ores and their nearest vicinity show W and Bi geochemical halo. Paragenesis connection between them is confirmed by correlative analysis. Element-indicators of sulphide associations (As, Pb, Ag,Cu) and first of all strongly marked early pyrite-arsenopyrite complex (As) show distinct tendency to accumulation of Au, Bi, W on all fronts of productive paragenesis spreading, especially in hanging sides of ore deposits. Against a background of the centrifugal-concentric zoning layer character of industrial mineral occurrence complicate geochemical field structure. It results in usually polymodal changes of the coefficient-index for crossing levels of the ore zones, that sometimes allow to draw a conclusion about "reverse" zoning. The mineral occurrence is accompanied by the guartz-biotite-chlorite-feldspar metasomatism, while on the parts with the sulphide paragenesis development latently metasomatic rock of the agrillic-beresite type becomes apparent. In accordance with the above mentioned the vertical geochemical zoning row looks as follows (from below upwards); (W1 - Co) - (W2 - Bi - Au) -(As - Ag1) - (Cu - Zn - Pb - Sb - Ni) - Ag2. The morphostructural mineralization of this type is presented by vein-stockwork bodies, where the stockwork component predominates sharply. The veins are situated at the periphery of the stockwork nucleus and are marked by the telescope structure of the mineral-geochemical paragenesis and heightended gold concentrations.

The deposits of the gold-sulphide ore formation are presented by the parallel-bedded ore deposits in connection with a screening surface of the combined type, by transversal ore flake-schistosity in zones of viscous faults. The ore accumulations are usually echelonment. Geochemically they are fixed in the Au and As intensive anomalous fields. Element-indicators of early (carbonate) -quartz paragenesis as local anomalous W and Co with not high contrast on the object are founded only on the deep horizon, on the others - in the limit of the productive blocks, but always, in spite of partial telescope, spatially separated from the nuclear parts of the As anomalies. The late sulphide-sulphosalt paragenesis is marked geochemically by the weak Cu, Zn, Ag, Ni, Sb anomalies, among which heigtened Cu and Sb concentration are the most stable. This element group show the tendency to accumulation in the head parts of the ore deposits and hanging sides of mineralized zones. As in the first case centrifugal-concentric zoning is complicated by the echelon accommodation of the ore bodies. Gold-pyrite-arsenopyrite vein-disseminated ores are accompanied by the listwanite (in the volcanogenic strata and reduced beresitelike (in the carbonaceos terrigenous strata) change of orecontaining. Hence mentioned facts and statistic treatment of the anomalous field allow to discrite the vertical geochemical zoning row as (from below to upwards): (W - Co) - (As - Au - Ag1) - (Cu - Zn - Sb1) - Ag2 - (Ni - Sb2).

Taking into account volumetrical character of mineral-geochemical zoning for the given ore formation, deposits, their parametric characteristics, investigated in vertical sections, it is easy to transform into longitudinal and transversal zoning coordinates. From this position it is convenient to produce prognosis estimation for the ore-formation belonging and ore resource of the parts with anomalous geochemical fields, marked by the geochemical search of surface.

A MODEL FOR FORMATION OF STREAM SEDIMENTS IN INTERMONTANE DEPRESSIONS

P.V.Bogatyrev, Earth Crust Institute, N.A.Kitayev, Geochemistry Institute, Irkutsk, USSR

The forms of existence of gold and accessory elements in fine fraction (<0,5mm) of fluvial deposits at the intermontane depression above concealed buried gold deposits, are studied. In stagnant reducing medium of lower horizons of alluvial deposits, gold and accessory elements are present in form of poorly soluble compounds or minerals. In the upper horizons under conditions of water circulation, well soluble forms of elements prevail. These conditions make it possible to transport these elements from lowel horizons into flood-plain silty fluvial deposits, surface waters and plants. The combined geochemical survey, showed that concealed deposit is clearly identified on the surface by haloes of ore elements in stream sediments of solid and liquid phases and by geochemical haloes.

Identity of elemental content of the ore body, of primary, secondary, hydrochemical, biogeochemical haloes and stray fluxes is confirmed by the correspondence coefficients calculated as a ratio of average elements contents in different media to the content of the same elements in an ore body (K_1) and to the content in primary halo (K_2). Values of correspondence coefficient vary for each element in different systems but sequence of elements position in all the systems is constant (Table).

In upper horizons of ore-enclosing rocks a superimposed polygenetic halo is formed from ore bodies and their primary haloes at the expense of diffusion, capillary rise, electrochemical reactions and other processes (Fig.). Pressure waters draining concealed deposits, their primary haloes and polygenetic haloes transport ore elements into loose deposits covering ore-enclosing rocks. As a result of physical and chemical reaction a salt halo is developed in alluvial deposits. In case, when ore-enclosing rocks are overlain by postmineral deposits which may serve as a screen for pressure waters, closed hydrochemical haloes might develop within postmineral and overlying alluvial deposits. As for the uppermost horizons of alluvial deposits, there is an exchange between the solid and liquid phases with enrichment of fine fraction on fluvial deposits, resulting from evaporating and biogenic accumulations.

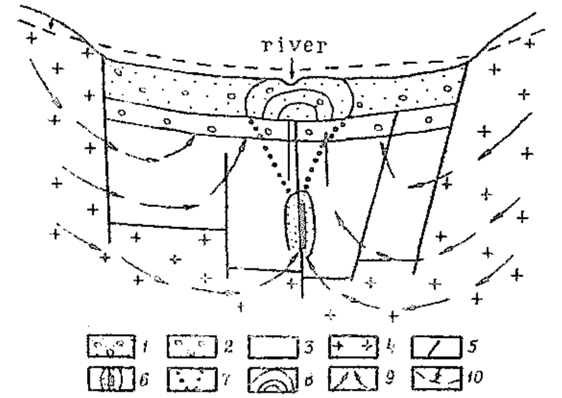


Fig. Scheme of development of anomalies in stream sediment of intermontane depressions. 1 - alluvial deposits; 2 - postmineral deposits; 3 - volcanogenic-sedimentary rocks; 4 - magmatic and metamorphic formation of basement and depression sides; 5 - faults; 6 - ore body and its primary halo; 7 - supra-ore polygenetic halo; 8 - superimposed salt halo; 9 - derection of subsurface drainage; 10 - piezometric level of subsurface waters.

Traditional geochemical stream sediment methods of prospecting in intermontane depressions are as informative as these in other geological structures.

Table. CORRESPONDENCE COFFICIENTS IN DIFFERENT MEDIA

Type of haloes	K_1				K_2			
	Au	Ag	Sb	As	Au	Ag	Sb	As
Primary	0,06(4)*	1,66(1)	0,14(3)	0,21(2)	-	-	-	-
Secondary	0,003(4)	0,6(1)	0,02(3)	0,05(2)	0,16(3)	0,36(1)	0,15(4)	0,21(2)
Stream sediment	0,01(4)	0,13(1)	0,02(3)	0,03(2)	0,21(3)	0,8(1)	0,18(4)	0,25(2)
Hydrochemical	0,06(1)	0,024(2)	-	-	0,06(1)	0,01(2)	-	-
Biogeochemical	0,12(1)	0,008(2)	-	-	0,12(1)	0,005(2)	-	-

* - in brackets - place of element in mobility succession

GEOCHEMICAL PROSPECTING IN STRATA-BOUND Pb-Zn ORE DEPOSITS FROM CANTABRIA (SPAIN)

Ignacio Bravo (*), Jesús García Iglesias (**) and Jorge Loredo (**)
(*) Dpto. Geología. Univ. Oviedo. c/Arias de Velasco s/n. 33005 Oviedo (España).
(**) Dpto. Explotación y Prospección de Minas. Univ. Oviedo. c/Independencia 13.
33004 Oviedo (España).

Strata-bound Pb-Zn sulfide deposits in carbonated rocks of Lower Cretaceous (Aptian-Albian age) from Cantabria (northern Spain) have been mined since the middle of the nineteenth century.

In four areas (La Florida, Novales, Reocín, Santander) included on the mining district, a total of 582 samples from drill holes and surface outcrops of carbonated rocks enclosing the Pb-Zn mineralization have been studied to know the geochemical and the microscopical characteristics of these rocks, and the aim of this paper is to study the dispersion and the distribution of some chemical elements in the rocks in order to try stablish some correlations between chemical elements, rocks petrology and the position of the rocks in relation to Pb-Zn ore deposits.

The samples were analysed for six chemical elements (Fe, Mn, Sr, Pb, Zn, Cu) by atomic absorption spectroscopy, and comparison between geochemical data in limestones and dolomites shows an important enrichment of Zn, Fe and Mn in dolomites in proximity the Pb-Zn mineralization. Otherwise, Sr and Pb contents in limestones are higher than they are in dolomites.

As results of statistical treatment of geochemical and microscopical data can be found a geochemical and textural characterization of mineralized domains where Fe-rich dolomites have high Zn content, anyway they have large porosity and favourable conditions to fluids circulation.

In relation with the application of these studies to the geochemical prospecting for these ore deposits, even if the dispersion of the analysed chemical elements in the rocks enclosing the Pb-Zn mineralization, can be little significant and little conclusive to its utilization as direct geochemical prospecting guide, the knowledge of these dispersions of chemical elements have enough interest to know some geochemical aspects of the mineralization, leading to a better comprehension of some metallogenetical aspects, and the results on geochemical data for these deposits are in agreement with a genetic model related to late processes where the enrichment of the enclosing rocks in Zn, Fe and Mn is later than dolomitization, and the source of these metals is away from the enclosed rocks. A consideration of "late diagenetic-epigenetic deposits" can be concluded for these deposits.

CONNECTION OF TIN ORES WITH GRANITES OF THE NEJDEK-MASSIF

K. Breiter
Geological Survey Prague

Geological and economic-geological evaluation of the representatives of all deposits types of tin-bearing ores found in the western part of the Krusne hory Mts., and a geochemical research into the evolution of the Nejdek massif have led to the construction of a model of granite massif differentiation and spatial distribution of tin deposits.

The Nejdek massif is the largest granite massif in the area. It is a complicated body composed of numerous individual intrusions of Upper Carboniferous to Permian age. It intruded along the system of NW-SE faults into a transverse depression of the Krusne hory anticlinorium. Is it a strongly differentiated massif of peraluminous granites with extreme Li, Rb, Cs, F, Sn enrichment in the youngest differentiates.

Four granite types represent the differentiation evolution of the massif:
-"mountain granite" - coarse to medium-grained biotitic monzogranite (Rb=200ppm, Sr=220ppm, Li$_2$O0.02%, Ce=100ppm, Sn=8ppm);
-"transitional granite" - mainly fine-grained, markedly porphyric two-mica monzogranite. (Rb=330ppm, Sr=60ppm, Li$_2$O=0.03%, Ce=60ppm, Sn=13ppm);
-"Krusne hory Mts. granite" - mostly coarse-grained biotitic syenogranite with the characteristic topaz content. This type includes great number of single intrusions of rather great differentiation. The relatively youngest intrusion of this type constitutes for instance the small body of Horni Blatna (Rb=700-1000ppm, Sr=10ppm, Li$_2$O=0.07%, Ce=20ppm, Sn=20ppm);
-"lithium granites" - the youngest, most strongly differentiated type of granites. Mostly fine-grained, less often medium-grained, albite-topaz-zinwaldite alkali feldspar granites (Rb=1400ppm, Sr=10ppm, Li$_2$O=0.2%, Ce=5- 10ppm, Sn=30-50ppm). They form stocks often rimmed by coarse-grained margin pegmatite - stockscheider.

All these granites are not in any case anorogenic (A-type), but postorgenic originated by the crust material reworking.

Three types of the tin deposits are characteristic of the Nejdek massif area:
-flat peri-contact greisens with wolframite and cassiterite and subordinate molybdenite abundances in lithium granites;
-so-called "vein greisens" - steep tectonically conditioned zones of greisenization with cassiterite in biotitic "Krusne hory Mts." type granites. They are not a product of these biotitic granites, but of deeper seated lithium granites stock. The biotitic granites are only their host rocks;
-zones of hydrothermal tourmalinization with cassiterite in phyllites close to the NE contact of the Horni Blatna body. Depending on the distance from the granite contact and on a decrease of temperature, zones developed with prevailing topazation, silicification, tourmalinization and albitization and chloritization.
All the types of mineralization are the product of a single mineralizing process, connected with the youngest differentiates of granite massives.

Tin is supposed to derive from lithium granites and their emanations or from hydrothermal solutions that immediately followed the intrusions of the lithium granites. Like other tin-bearing areas of NW Bohemia, the hidden lithium granite elevations may comprise economically valuable deposits of endocontact greisens. The mineralization of vein greisens and the phyllite mantle seems to be less economically significant.

Next exploration and prospecting are recommended to concentrate on detection of buried elevations and ridges of the lithium granite, especially beneath the largest so far known nodes of veins greisens. For that purpose lithogeochemistry at least on the scale of 1:10 000 should be used together with a detailed structural analysis.

CHOICE OF SAMPLING FRACTIONS IN THE SOLUTION OF PROSPECTING TASKS USING SECONDARY AUREOLES AND DISPERSION TRAINS

Victor A. Bugrov, VNIIZarubezhgeologia, USSR

1. An efficient and reliable solution of the geochemical prospecting tasks depends, to a greater extent, on dimensions and contrast of secondary aureoles and dispersion trains discovered in particular landscape-geochemical conditions. In the first place, it concerns regions with complicated conditions for geochemical exploration, that is, arid regions with eolian contamination of loose sediments under sampling and humid tropical and sub-tropical regions with clayey and lateritic weathering crusts.

2. The review of publications as regards this problem indicates that annualy there make great efforts in the World aimed at carrying out orientation work with a view of determining "optimal" sampling fraction. In this case often highly controversal recommendations are given even for regions of similar landscape-geochemical conditions. It is explaned by a number of objective and subjective reasons discussed as to many practical examples.

3. In arid regions a correct choice of sampling fraction is considered to be one of the significant component for a successful conducting of geochemical exploration by secondary aureoles and dispersion trains. Numerous experiments carried out in different deserts of the World related to the elimination of the deluting affect of eolian admixtures yield unambiguous information. However, the basis this problem solution is in the determination of a prevailing size of eolian particles transported by wind. Research-geographers have already long studying a granulometric composition of eolian material of deserts and have accumulated numerous data concerning this problem. It has been established that practically in all the deserts of the World (except for Atakama) from 70 to 100% of material transported by wind, is of less than 0.25 mm in size. Therefore, exploration geochemists should take into account such data.

4. In the 50-60-ies in order to discover deposits of a limited range of metals in humid tropical regions of Africa there was applied geochemical exploration by secondary aureoles and dispersion trains with sampling of -80 mesh fraction and usage of the colorimetric analyses for 5-7 chemical elements. This leads to methodical miscalculations and to the reduction of the efficiency of geochemical prospecting for mineral deposits.

5. When planning prospecting by secondary aureoles and dispersion trains and experimental work for the choice of sampling fraction it is necessary to take into consideration:

-targets of prospecting in close relation to a scale of operatios (detailed, regional, etc.);

-genetic types of deposits expected to the discovery and possible mineral forms of existence of ore-forming chemical elements and indicator-elements of the mineralization;

-character of a hypergene migration of chemical elements and of the creation of secondary aureoles and dispersion trains in specific landscape-geochemical conditions including the character of leaching and diluting of appropriate anomalies in paleo- and recent conditions;

-type of geochemical samples analyses which are scheduled to the usage in the process of conducting work.

The above approach to the choice of sampling fractions enables to raise a reliability of geochemical prospecting, their informativity and to avoid of baseless increase in the sampling density.

GEOCHEMICAL METHODS FOR QUANTITATIVE ESTIMATION OF MINERAL DEPOSITS IN PRIMORSKI KRAI; THE USSR

A.I. Burago, N.F.Kosterov
PGO "Primorgeologiya", USSR

The methods for quantitative estimation of mineralization used in the union "Primorgeologija" are based on the application of a mathematical model common for a large group of hydrothermal ore objects in Primorje. The formal basis for such a model is a linear combination of square-law exponents (Gauss-type), which satisfactorily describe distribution of ore elements concentrations in three-dimensional space.

On the basis of the received model and its adequate transformations, the methods and models were developed for local and area quantitative forecasting of mineralization according to primary and secondary lithochemical halos, that can be divided into the following three groups.

1. Methods of volumetric and flat modelling of anomalous geochemical field according to main ore- and halo-forming elements.

2. Methods of quantitative estimation by means of transformation of the concentration field of the elements into an isotropic model, which is adequate to that of the object under estimation according to its main characteristics.

3. One-dimensional methods of quantitative estimation by means of specific metal potential, linear and area productivity of ore bodies and their primary halos.

The above mentioned methods were presented as algorithms and realized in computer EC as complexes of programmes, which present a part of computer system of forecasting ASORD - 000, which operates in the Data-Processing center of the union from 1985.

The first group of methods is used in search for deep mineralization according to primary lithochemical halos, in prospecting and estimation, during preliminary and detail exploration. With these methods for the first time in practice of geochemical investigations the volumetric model of the primary tin halo was received for a part of the territory in one ore district of Primorje, on the area of 500 km2. The results of modelling allowed to estimate predicted resources of tin and to make their geometry in a three-dimensional space.

The methods of the 2nd and 3rd groups allow to solve the tasks of prospecting and prospecting estimation forecasting according to primary or secondary lithochemical halos both in area and profile variants. In this case one estimates: ore-formational belonging of the object, its possible sizes, depth of occurrence of commercial ores, predicted resources of the metal, degree of erosion. Special nomographs are "hand" made for estimation of the two last characteristics.

Several hundreds of ore occurrences and geochemical anomalies were estimated by these methods in Primorje during last years. According to the results of control works, the reliability of forecasting is 90%. The methods are applicable for estimation of hydrothermal deposits of tin, lead, zinc, tungsten, precious metals.

ON THE THEORY OF GEOCHEMICAL DIFFERENTIATION OF ELEMENTS IN PROCESSES OF HYDROTHERMAL METAMORPHISM AND ORE FORMING

E.K.Burenkov, I.Ja.Erukhomovich, B.S.Kogan
Institute of Mineralogy Geochemistry and Crystallochemistry
of Rare Elements, Moscow, USSR

Nowadays a new scientific branch - physical-chemical geomechanics - is being formed, which brings together concepts and methods of physics and chemistry of dispersive systems, geotectonics and geochemistry. The approach is based on the understanding of the fact, that the most general and essential sign of geological systems is their dispersity, i.e. developed boundary between mineral, fluid and gaseous phases constituting the systems. It is the character and degree of the dispersion, that determines together with chemical and mineral composition the behavior of the geological systems. Indeed, all the irreversible metamorphic processes occurring due to interaction of penetrating fluid and embedded rock include as a first step wetting and adsorption of most active molecules of ions of the fluid. It decreases essentially the surface energy and results in sharp changing of structural-mechanical properties of the rock. (Such phenomena of mechanical properties changes in rock are the "Rebinder effect" revealations in geological systems).

We have considered the self-consistent process of evolution of local stress (strain), porosity of embedded rock and flow of hydrothermal fluid penetrating the rock and we have derived a closed system of phenomenological equations describing the process, temperatures and compositions of both fluid and rock being taken into account the influence of active hydrothermal fluid on the structure (degree of dispersion) of porous medium. It provides a quantitative framework for consideration of geochemical differentiation of elements in large-scale hydrothermal metamorphic and ore forming processes as a component of the process of evaluation of originally unporous and homogeneous medium under joint influence of external tectonic stress and active abyssal fluids.

The set of equations of the physic-chemical mechanics is presented for some simple geochemical systems. General properties of solutions of these equations are considered. Under suitable conditions the solutions off the equations describe an appearance and evolution of dissipative structures. The conditions are obtained and geochemical meaning of the structures is discussed.

COMPARISON OF STREAM-SEDIMENT, SOIL, AND ROCK SAMPLING IN BASYURT YAYLA (GIRESUN -TURKEY)

Engin Cubukcu, Ayhan Erler, and Nurkan Karahanoglu

Middle East Technical University
Department of Geological Engineering
Ankara 06531, Turkey

The Basyurt anomaly, that resulted from a regional geochemical survey with stream-sediment samples, was studied in detail by stream-sediment, soil, and rock sampling. The studied area lies in northeast Anatolia, within the Pontids tectonic province. The rock units in the region include limestones, basalts, andesites, dacites, and agglomerates of Upper Cretaceous age; basalts of Paleocene-Eocene age; and granodioritic intrusives of Tertiary age.

The follow-up study resulted in two anomalies which totally cover an area of approximately 5sq km. Both of them are combined Cu-Pb-Zn anomalies. One is found to be related to the mineralization on the intersection of two fault systems crossing the granodiorites, and the other is related to the mineralization along the contact zones of granodiorites with andesites and basalts.

Background, threshold, and anomalous ranges for Cu, Pb, and Zn in stream-sediments, soils, and rocks, were estimated by several techniques, then optimum ranges were selected and utilized in preparation of isochemical maps. For stream-sediments, Cu and Pb appear to be better tracers then Zn, which has occasional anomalous values that do not correlate to either Cu and Pb or traces of mineralization. For soil samples, Cu displays a single, but wide anomaly, whereas Zn and Pb display two distinct anomalies. For rock samples Cu, Pb, and Zn display at least two distinct anomalies.

Trace element contents of stream-sediment, soil and rock samples were statistically analyzed using trend surfaces and multiple regression. Cu, Pb, and Zn in soil have southward dipping trends, whereas in rocks they have eastward dipping trends. Residual in both cases overlap with anomalous areas. Correlations between different leaching. Correlations between Cu, Pb, and Zn in the same sample type are generally significant indicating that they occur together in the mineralized zones.

GEOCHEMICAL CORRELATION AND COMPARISON BETWEEN LABRADOR AND GREENLAND

P.H. Davenport, Department of Mines and Energy, St. Johns, New Foundland
R.G. Garrett, Geological Survey of Canada, Ottawa, Canada
P.H. Green and P. Simpson, British Geological Survey, Keyworth, U.K.
A. Steenfelt, Geologial Survey of Greenland, Copenhagen, Denmark.

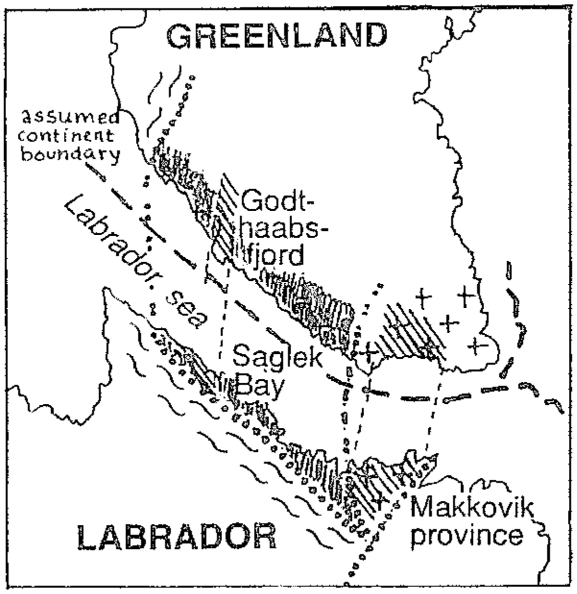
ABSTRACT

Continental reconstruction of the North Atlantic region (e.g. Gower and Owen 1984) indicates the approximate relative positions of Labrador and Greenland prior to the opening of the Labrador Sea. The reconstruction shown here takes into consideration features appearing in the Magnetic anomaly map of the Continental Margin of Eastern Canada (GSC 1988) thereby establishing the necessary geophysical and geological framework for a regional geochemical correlation study which traverses the common boundary between these terranes. The boundary is thought to correspond closely with modern coastlines in both south Greenland and Labrador as the reconstruction indicates.

Further geological and geochemical constraints on the fitting of the Labrador/Greenland terrane boundary are provided by Patchett and Bridgwater (1984) who showed that the Makkovik province in southern Labrador and the Ketilidian mobile belt in South Greenland were formed in the same crust forming event and by Armour-Brown et al. (1983) who suggested that uranium rich districts defined by stream sediment surveys in each of these two areas should be correlated.

Bridgwater and Collerson (1976) gave evidence to the close similarity between the early Archaean gneiss terrains at Saglek Bay in Labrador and Godthaabsfjord in Greenland. High uranium values associated with the gneisses in these two areas may therefore be correlated.

The intercomparison of regional geochemical datasets from surveys of Labrador and Greenland demonstrates that even though differing sample media, sampling density and analytical methods were used for each survey, robust geochemical patterns emerge which can be used for correlating geological terranes across national boundaries.



Correlation of uranium patterns from geochemical surveys in Labrador and Greenland

▩ Archaean block

〰 Reworked Archaean

+ Proterozoic crust

▨ Uranium highs

.... Geological boundary

References;

Armour-Brown, A., Kunzendorf, H. and Steenfelt, A. 1983: Uranium districts defined by reconnaissance geochemistry in South Greenland. J. geochem. Explor. 19, 127-145.

Bridgwater, D. and Collerson, K.D. 1976: The major petrological and geochemical characters of the 3,600 m.y. Uivak gneisses from Labrador. Contrib. Mineral. Petrol. 54, 43-59.

Geological Survey of Canada 1988: Magnetic anomaly map of the Continental Margin of Eastern Canada; Geological Survey of Canada, Map 1709A, scale 1:5 000 000.

Gower G.F. and Owen V. 1984: Pre-Grenvillian and Grenvillian lithotectonic regions in eastern Labrador- correlations with the Sveconorwegian Orogenic Belt in Sweden. Can. J. Earth Sci., 21, 678-693.

Patchett P.J. and Bridgwater D. 1984: Origin of continental crust of 1.9-1.7 Ga age defined by Nd isotopes in the Ketilidian terrain of South Greenland. Contrib. Mineral. Petrol, 87, 311-318.

IMAGE-PROCESSING OF GEOCHEMICAL DATA TO MAP GEOLOGICAL STRUCTURES AND ALTERATION ZONES

Peter H. Davenport and W. Lawrence Nolan
Geological Survey Branch, Newfounland Department of Mines and Energy, P.O. Box 8700, St. John's, NF
Canada, A1B 4J6.

Both geochemical and geophysical surveys map compositional variations in bedrock so techniques similar to those used to enhance spatial features in geophysical data can be applied to geochemical data. Although based on the geochemistry of surficial media, shaded-relief maps of drainage sediment geochemistry delineate linear and curvilinear features that are related to bedrock structures. Linear features arise in three main ways: 1) the juxtaposition of two geological units of contrasting composition (e.g. along an intrusive or faulted contact); 2) alteration along a linear zone (commonly fault-controlled); and 3) the offset of continuous geological units along a fault.

To apply image-processing techniques the geochemical data first must be transformed into a suitable format by processing through four main steps; primary gridding, secondary gridding, filtering and preparation of a shaded-relief image. The primary gridding interpolates the data from irregularly spaced sample sites to a square grid. Gridding parameters such as weighting factor and search radius are chosen to maintain as much original information (including noise) as possible during this initial step. An efficient grid-cell size is chosen such that the number of cells containing no data points, or two or more are minimized. Such a grid-cell size will be close to the initial sample site density for fairly evenly spaced data, and the grid file size will be close to the size of the original data set. Secondary gridding is done to fit the initial grid to the video display device such that the secondary grid-cell size is as small as possible to fill the pixel array of the screen without decimation. The image at this stage typically shows a good deal of small-scale variation, due largely to sampling and analytical noise, which detracts from the clear perception of broader, geologically significant patterns. The spatial signal is clarified by filtering this image; an adapted trimmed mean filter (a robust type of moving average filter that ignores outlying values) has been found to be effective. A shaded-relief image is then produced from the filtered image, either in grey shades or colour. The appearance of the shaded-relief image is used to determine whether the filtering parameters are acceptable; if the image contains too much high-frequency noise the size of the moving mean window is increased; if the image is too 'flat', it can be decreased. To obtain visually pleasing images it has been found that the window used in filtering should be on the order of 10-50 times the average sample-site density, and that even with this large window, quite narrow features can be resolved. Spatial features can be variably enhanced by changing the vertical scaling and the inclination angle of illumination, and particular structural orientations can be emphasised by varying the declination angle of illumination.

The distributions of elements such as Ni, Cr, Cu, and U in the regional lake sediment data for the island of Newfounland, Canada, are strongly controlled by lithology, and therefore clearly map major tectonostratigraphic units and their structure in much the same way as an aeromagnetic surveys does. Major boundaries between geological terrains and the intrusive contacts of large igneous intrusions are expressed as abrupt level changes in these elements which reflect corresponding changes in bedrock geochemistry. These elements also delineate more subtle offsets in the regional geology due to smaller-scale faulting or the influence of basement structures on near-surface geology. Elements such as As, Sb and Pb show less correspondence witn primary lithology, but delineate areas of hydrothermal alteration, which are commonly fault-controlled, linear zones. Although faults can be mapped both directly and using several other indirect approaches (from their topographic and aeromagnetic expressions, for example), geochemical mapping provides a way to distinguish faults associated with hydrothermal systems from those which are not. This unique information is particularly valuable in exploration for many types of hydrothermal mineral deposits, and on a regional scale it provides a broad overview of the location, extent and pattern of hydrothermal activity. These patterns are clarified when image-processing techniques are applied to the data.

Geophysically and geochemically defined linears are complementary in that they reflect different aspects of variations in bedrock composition, and they both in turn complement topographic linears which reflect variations in the mechanical properties of bedrock. The use of video display systems, especially those incorporating data overlay and analysis capabilities are useful in identifying the more significant of what can be a plethora of linears.

A SOIL GEOCHEMICAL STUDY OF THE KATO THERMES MINERALIZED ZONE, XANTHI PREFECTURE, N.E. GREECE

Alecos Demeteriades and Constantinos Zangouroglou

Institute of geology and mineral exploration, Greece

The mineralized zone of Kato Thermes is situated to the west of the homonymous village, and lies 50 km north of the town of Xanthi. The detailed soil geochemical survey covered an area of about 5 km^2 with an 80x20 meters sampling grid. The results of only the narrow zone of Kato Thermes of 0.4 km^2 area will be presented and discussed.

The Kato Thermes zone is made up from rocks of three different units. The oldest is the Intermediate Gneiss unit with leucocratic biotite gneiss, which is locally amphibolitic and banded; this is succeeded by the Upper Marble-amphibolite sub-series with amphibolite and graphitic marble, and the Upper Banded Gneiss sub-series with amphibole gneiss and banded biotite-amphibole gneiss (locally garnet bearing, graphitic and calcareous), which is intruded by pegmatite sills and, rarely, dykes.

The main mineralized zone has an overall N60E direction, with an observed length of 800 meters and a variable width from a few to 20-25 meters. Two types of mineralization have been identified: (a) vein Pb-Zn (+/- Py), which is the dominant type, and (b) ''metasomatic'' replacement occurring within the marble of the marble-amphobolite sub-series. It should be noted that in many cases the latter type is disputed due to the absence of skarn minerals. It is, in fact, space infilling at sites of least cohesion, such as heterogeneous contacts, open cavities, etc. The vein mineralization has qualitative and quantitative variations both in the horizontal and vertical sense.

The detailed soil geochemical survey was carried out with the aim to map the mineralized structures of the area. The soil sampling was executed along traverses of N40E direction, and the samples collected from the base of the developing B-soil horizon and the upper part of D. This sampling method proved to be effective, because no substantial displacement of the geochemical landscape was observed due to the intense relief. The soil samples after drying and disaggregation were sieved to the intense relief. The soil samples after drying and disaggregation were sieved to the -80 mesh (0.177 mm) soil fraction and analyzed by atomic absorption spectrophotometry for Cu, Pb, Zn, Co, Ni and Mn after digestion by a partial analytical method. The quantitative control of the analytical method was carried out by replicate determinations on 96 random chosen samples.

The soil geochemical survey mapped the main mineralized zone of Kato Thermes as well as other NW and NE trends. The presentation of trace element spatial distribution was done by a number of techniques, which aimed in their full interpretation. The positive residuals mapped precisely the Kato Thermes zone with a ratio of 1:2 to 1:4 over the mineralized zone, even over sections where there is a definite interruption of the single and multi-element geochemical anomalies with all the other treatments and presentations. The depth penetration of the soil geochemical method used has been ascertained by core-drilling, and is in the order of 100 to 120 meters from the surface.

This work shows that the combination of positive residual maps and other data presentation techniques were definitive factors in delineating the most promising sites for the occurrence of mineralization and the ones which give the most distinct patterns.

RESULTS OF GEOCHEMICAL PROSPECTION IN THE SLANSKE VRCHY MOUNTAINS, EASTERN SLOVAKIA

Lubomir Divinec - Peter Volko
Geologicky prieskum, Spisska Nova Ves, Czechoslovakia

The Slanske vrchy Mts. are formed by a range of andesite stratovolcanoes of the Neogene age. This range has north-south course and it is formed by stratovolcanoes as follows: the Zlata Bana stratovolcano, the Makovica stratovolcano, the Strechov stratovolcano, the Bogota stratovolcano and the Velky Milic stratovolcano. Each stratovolcano is regarded as a single metallogenic unit.

The above range of stratovolcanoes was investigated using geological, geophysical and geochemical prospecting methods, for the sake of prospecting of ores. Geochemical soil survey, lithogeochemistry and hydrogeochemistry were used.

Central volcanic zones of the above mentioned stratovolcanoes were investigated using geochemical soil survey. Soil was analyzed both semiquantitatively and quantitatively for Cu, Pb, Zn, Ni, Co, Sb, As, Ag, Mo, Sn, B, Bi, Hg. More than 15 000 samples were collected.

The most important results have been achieved in the area of the Zlata Bana stratovolcano. The deposit of precious and base metals is prospected there now. Very important anomalies of Zn and Pb have been identified here, they formed the secondary halo of this deposit. These anomalies have enabled to direct prospecting works on this deposit.

Anomalies ascertained in the other stratovolcanoes of the Slanske vrchy Mts. are not connected with ore mineralization, they reflect only lithological differences.

GEOCHEMISTRY OF SULFIDE-NICKEL ORE-MAGMATIC SYSTEMS AS A BASIS OF NEW APPROACH TO PROGNOSIS AND EXPLORATION OF DEEP-SEATED DEPOSITS

D.A.Dodin
All-Union Research Institute for Ocean Geology
and Mineral Resources "VNIIOkeangeologiya",
Leningrad, USSR

A new approach to prognosis and exploration of deep-seated deposits is developed on the basis of complex ore-magmatic model analysis for the largest nickel provinces of the world. The aim of the analysis in this case is prediction, based on anomalous mineral-geochemical fields of concentration (AGFC) and dispersion (AGFS), of sulfide-nickel ore-magmatic (SNOMS) or tectonomagmatic systems of different type and character by studying and modelling processes of their generation, formation, emplacement and development. The rank of such systems can vary from planetary, global (metallogenic belts) through superregional (provinces) and regional (structural-metallogenic regions and zones) to areal (ore areas) and local (ore fields, deposits and beds).

Outlined is a six-stage model of SNOMS formation: (i) premagmatic and pre-ore; (ii) volcanic; (iii) main intrusive and ore; (iv) main ore and intra-intrusive; (v) final intrusive and intra-ore; and (vi) post-intrusive and final ore stages. Main geochemical features of components of each stage of SNOMS development are recognized.

Data on chemistry of first-stage producers were obtained from calculation of weighted average compositions of different facies of some magmatic complexes of individual chambers, zones and provinces. Geochemical evolution of primary magma was determined in the result of study of trends on plot components diagrams. Considerable weighted average contents of mercury, copper, sulfur, water, chrome, platinoids, gold, and low nickel-copper, platinum-palladium and sodium-potassium ratios were established in the intrusive massifs (IM); specific features of geochemical rock types, which build up middle and lower horizons of IM were determined, and a particular trend was recognized in the latter and Bowen-like trend in the former and in the upper parts of IM. An increase in methane, hydrogen, water, fluorine, chlorine and heavy hydrocarbons was revealed for a commercial nickel-bearing contrasting antidrome volcanic association. A sharply reduction character of fluids, accompanied by the predominance of hydrogen over methane and higher nitrogen content, is typical of commercial nickel-bearing IM; methane dominates in low-nickeliferous IM.

As complex SNOMs develop, the content of copper, platinoids, gold, silver, mercury, potassium increases. As well as the presence of contrasting zonal AGFCs of these elements, as well as metasomatic aureoles of specific composition and structure, and shows of late ore formations (platinoid, polymettalic, antimony-arsenic, copper-zeolite and the like), suggest deep-seated SNOMSs containing rich ores. Loss of volatiles (mobile components) at the second stage of SNOMS development led to an increase in coefficient of explosiveness, inhibited magma layering into liquants of various composition and, first of all, excluded the appearance of high sulfur sulfide melt-separate ore intrusion in the case of the formation of large and unique deposits. It can be assumed that the higher the discrepancy between the given model of a particular SNOMS, the lower its nickel content.

Complexes of rhythmically layered pluton appear to be the most viable among major SNOMSs of the world; the pluton are related to ensialic and intercontinental rifting, exposing the deepest and unexhaustable mantle zones of magma formation and equivalent to them in composition and structure.

A global temporal trend of SNOMS development in expressed in an increase of the part of copper and palladium as compared to nickel and platinum.

GEOCHEMICAL MODELS OF ORE DISTRICTS AND FIELDS, AND PRINCIPLES OF THEIR CONSTRUCTION USING A NICKEL-BEARING PROVINCE AS AN EXAMPLE

D.A.Dodin, M.A.Sadikov and I.I. Sidorov
All-Union Research Institute for Ocean Geology
and Mineral Resources, Leningrad, USSR

Contrasting basalt series (picritic, comatiitic, ankarmitic-olivine-tholeiitic-andesitic) and comagmatic nickel-bearing differentiated intrusion with various ore contents are the characteristic magmatic features of the model for the province. Volcanics are treated as time-dependent primary flows of magmatic material concentrations, the antidrome character of which is an indicator of ore potential (the second temporal geochemical tendency). In the presence of copper-nickel deposits there will be an increase in ore element contents and a decrease in barium contents in similar rock types permits identifying ore types in the area under study. The proposed model uses heavy metal concentrations in magmatic sources that reflect the tendency for intrusive rocks to form later that extrusive rocks, which, together with gravity differentiations lead to an increase of metal contents in young basalts and formation of orebearing intrusive rocks during the final stage of the magmatic process. Along with an increase in minor element contents in the evolutionary process of basaltoid magmas, there are local ore element concentrations in upper levels of the tuff-lava unit, traced along disjunctive faults in underlying intrusions, which suggested an additional activation of ore materials during the Jurassic-Cretaceous tectono-magmatic cycle. This rejuvenation of primary haloes often results in their inverse zonation. Studies of primary flows of concentrations permit to know areas at depth and to outline them by types.

The recognition of these types is a basis for models assessing the ore-generating process and its effects on host rocks. The latter are significant only within deposits. The usage of factor diagrams enables us to identify geochemical types of differentiated intrusions by their exposures, i.e. to model them to depth. Ore-generating processes affect most dramatically only texitic and picritic gabbro-dolerites and also picritic basalts; while olivine and troktolite dolerites may also show a trend for ore-metasomatic transformations; this is a basis for assessing ore potential for the given area. To leave only the epigenetic component which is directly affected by ore-bearing fluids, all contents can be recalculated to median contrasts because of the weak dependence between medians and end members.

There are three basic variants for assessing system of relations by repeated correlations (after Yu. K.Burkov). The first variant:all trap elements (nickel, chrome, cobalt, titanium, zirconium) are separated from hydrothermal elements (gallium, molybdenum, lead, zinc, tin, yttrium, ytterbium); this type corresponds to natural associations practically unaffected by ore formation processes. The second variant: supraore halo elements (nickel, chromium, cobalt) are separated from supraintrusive halo elements (primarily titanium and zirconium), which reflects the effects of the ore-formation process when massive ores dominantly form. The third variant: chromium enters association, which only reflects changes of rock assemblages. Copper is more often related to nickel and cobalt associations and can transform to an opposite group, because of the weakness of this relationship. There can certainly be some variations in this principle scheme, which depends on the elements participating in the hydrothermal process as well as on the cover and bottom deposits due to the destruction of pre-trap rocks.

We have developed a model for a copper-nickel deposit using average parameters of truncations taken at an equal distance from the roof of intrusions and massive ores so as to remove the effects from rock varieties, and also using absolute depths. Two groups of elements have been recognized by supraore (copper, nickel, cobalt, chromium, vanadium, platinoids, mercury, barium) and supraintrusive (titanium, zirconium, strontium, lead, zinc) haloes, their discontinuity, the existence of inpoverishment in section of supraore and supraintrusive zones. Spatial-temporal relations within ore fields can be plotted as vectors for redistribution zones of average additive values, according to rock groups of typomorphic elements of supraore (group 1) and supraintrusive (group 2) haloes. Combinations of positive and negative vectors for the two groups determine the redistribution elements zones related to geochemical field disturbances.

Positive criteria for the discovery of copper-nickel deposits with massive sulfide ores include factor loading of the Talkhakh type. The situation, in fact, depends on the contrast between the supraore halo typomorphic elements and supraintrusive halo elements and also on the transition of chromium to the first association, i.e. we have a picture similar to the second variant of the repeated correlation. Therefore, classes identified by the first three factors (eight elements: copper, nickel, cobalt, chromium, vanadium, manganese, titanium, zirconium), also considering coordinates, are consistent with spatial structural patterns for primary haloes; they divide the geochemical field into uniform portions according to different levels of sulfide-nickel ore-magmatic systems. Most promising classes are consistent with fields of the third order "exclusiveness".

The proposed models identify ore districts, then zones, fields and ore deposits in provinces. A combination of regional and local approaches as well as methods of exploration at different depths permits to make reliable predictions of new disturbing objects at a considerable depth.

THE ORIGIN OF CONTACT ZONE BETWEEN SERPENTINITE AND GRANITE, JORDANOW, LOWER SILESIA, POLAND

Elzbieta Dubinska

Institute of Geochemistry, Mineralogy and Petrography,
Faculty of Geology, Warszaw University, al.Zwirki i Wirugy 93, 02-089 Warsaw, Poland

David Szafranek
Department of Geology, Institute of Earth Sciences, The Hebrew University of Jerusalem, Givat Ram,91904
Jerusalem, Israel

A highly tectonized contact zone between granite and serpentine is composed of different schists containing layer silicates (chlorite, vermiculite etc.) as well as tremolite as major phases. The minor, accessory phases (Ta-Nb+-Bi-phases and barite) indicate that the zone is formed due to penetration of an apophyse of Variscan Strzegom-Sobotka granite into the older Jordanow-Gogolow serpentinite.

Proposed model includes texture evolution of the schists and coeval changes of the granite fabric correlated with formation of various mineral assemblages and pathways of major elements.

GEOCHEMICAL MODELLING OF HIGH TEMPERATURE PROCESSES OF COPPER MOBILIZATION

N.A.Durasova, V.L.Barsukov, I.D.Ryabchikov, L.N.Kochnova, Vernadsky Institute of Geochemistry and Analytical Chemistry, Institute for Geology and Ore Deposits, USSR Academy of Sciences. Moscow

Cupriferous massive sulphid deposits in a number of regions of the world are noticed to have certain relationship with volcanogenic formations. The issue of cupper sources of the deposits is still a subject of debates.

The work based on an experimental modelling of the copper behaviour at magmatic parametrs and also during the further transfomation of the volcanic rocks with the changing temperature and oxidizing conditions. It permitted to evaluate an extent of the copper mobilization by magmatic fluids, its redistribution and forms of existence during the heating of the effusive formations under the oxidized conditions.

The factors facilitating the accumulation of copper in the residual melts during their solidification and copper mobilization into the fluid (i.e.increase in acidic state of the melts and concentration of chloride in a fluid, growth of oxygen partial pressure and pressure in magmatic systems) have been determined.

Thermodynamic calculations on the basis of the obtained experimental data confirmed that in natural magmatic systems, in the presence of sulphur, copper is mainly extracted by the sulphide phases which causes a decrease in its yield in the fluid.

The nature of copper redistribution during the heating the volcanic rocks under the oxidized conditions has been investigated. It has been shown that Cu is concentrated on the surfaces of minerals in an oxidized, easily mobilized form.

The obtained data permitted to establish favourable conditions, intervals of physico-chemical parameters which enhance the ore-generating capacities of volcanogenic formations with respect to copper.

GEOCHEMICAL EXPLORATION IN SELECTED AREAS OF SYRIAN ARAB REPUBLIC

Miloslav Ďuriš - Jaroslav Hak - Vladimír Majer - Vladimír Sáňka, Ústřední ústav geologický, Praha, Czechoslovakia

Regional geochemical survey on scale 1:50 000 was done in six areas of Syrian Arab Republic - Coastal Mts., Shoghour, Bassit, Kurd Dagh, Antilebanon and Southern Syria. Total 8640 sq.km were geochemically mapped using stream sediment and heavy mineral surveys as basic methods in search for base metals and diamonds. The density of sampling was roughly 4 stream sediment samples and 1 heavy mineral concentrate per sq. km in all areas. Stream sediments were analysed for Cu, Pb, Zn, Ni, Co, Cr and Mn using atomic absorption spectrometry. Every tenth sample was checked for Hg. All heavy mineral concentrates were mineralogically examined and selected tracer minerals (ilmenite, garnet, Cr-diopside) were analysed by electron microprobe and EDS. Fine fraction of heavy mineral concetrates was analysed by means of optical emission spectrometry. All field and laboratory data were computerised and resulting geochemical maps 1:50 000 and 1:200 000 were plotted using computer techniques. Geochemical maps show the distribution of chemical elements. Their content in individual samples is related to the statistical mean of corresponding geological unit. This is demonstrated on the maps by different value of standard deviation. The regional survey was supplemented by photogeological studies concentrated on exodynamic analysis of the areas with respect to tectonic predisposition of the relief and position of volcanic complexes. Detailed studies which followed regional survey were focused on search for diamond bearing rocks in Coastal Mts., gold in Al Ghab depression and Cu mineralization in Kurd Dagh. These investigations were based on close up geological mapping 1:5000 and 1:10 000 supplemented by soil sampling and other methods.

The area under consideration is located on the northern extreme closure of the African rift extending from Africa through Dead Sea to Lebanon and Syria. The most critical element which had been controlling the geological development of the western part of the Arabian platfrom since Jurassic until now, is a deep seated fracture zone related to the Rift. Regional geochemical exploration showed no prominent anomalies indicating an occurrence of base metal deposits. Only anomalies of base metals accompanied by mercury occurring in southern Coastal Mts. and in the Shoghour area are to be checked by a follow up program. They are related to fracture zones and may indicate some hydrothermal mineralization. No prominent concetrations of tracer minerals indicating the existence of diamonds or carbonatites were found in neither area. Detailed studies showed that economic concentrations of diamonds in Coastal Mts. are highly unlikely to occur there. Detrital gold in Al Ghab depression turned out to be of anthropogenic origin and of no economic value either. No economic mineralization of copper or other elements is expected to occur in Kurd Dagh because of small extent of ophiolite series and unconvenient geology. Out of all minerals which were looked for, only garnet may be used for jewerly, abrasives and filter production. This assumption is to be proved by processing tests, marketing and feasibility studies.

GEOCHEMICAL SOIL SURVEY IN KOZLU (TOKAT-TURKEY)

Ayhan Erler, Ender Atabey, and Caner Doganeli

Middle East Technical University,
Department of Geological Engineering,
Ankara 06531, Turkey

The Kozlu region lies in north-central Anatolia, within the Anatolids, near their boundary with the Pontids along the North Anatolian Fault Zone. The main rock units in the region are the Kececi phyllites and the Kozlu greenschists of probably Paleozoic age. The Kececi phyllite is green to dark gray and foliated; common mineral assemblage includes quartz, muscovite, calcite, epidote, and chlorite. The Kozlu greenschist is green and massive to foliated; common mineral assemblage includes quartz, epidote, chlorite, albite, and calcite.

Regional stream-sediment geochemical exploration indicated presence of copper anomalies at the southwest of Kozlu, and anomalous values for zinc and cobalt downslope from the major copper anomaly. Follow-up study was carried out by collecting soil samples at 250 m. Intervals over an area of approximately 6.5 sq. km to determine mineralized trends. The region is generally covered by soil, and outcrops are rare. Vegetation includes bushes and trees. Soils of the region are brown to green forest soils in which the horizons are not well defined. The soil samples were thus taken at a constant depth of about 30 cm. The samples were analyzed for Cu, Zn, Ni, and Co by AAS. The Cu values show appreciable correlation to the Zn values, but correlations between other elements are very low. The trace element values were higher in the fine fraction than those in the coarse fraction, indicating that they were associated with clays and sesquioxides rather than resistant minerals. The background, threshold, and anomalous ranges were estimated and utilized to interpret the isochemical maps. Trend surface technique was used to estimate the regional trends for the trace element contents.

A combined Cu-Zn anomaly was correlated to an area of ancient mining activity, whereas Ni and Co contents did not display distinct anomalies. Cu, Zn, and Ni values have northward dipping trends, however their trends do not parallel each other; in contrast, Co values have an eastward dipping anomalies, whereas those for Ni and Co are independent. The study points out that the Cu and Zn anomalies result from combined effects of dispersion and contamination, and the Ni and Co values are due to the background contents within original shales and mafic rocks of the region.

EVOLUTION OF MINERAL-FORMING MEDIUM DURING THE FORMATION OF QUARTZ-CASSITERITE IULTIN DEPOSIT.

A. Erokhin, V. I. Vernadsky Institute of Geochemistry, USSR.

Iultin deposit (USSR, Chukotka) is spatially and genetically associated with late Cretaceous granites, enriched in lithophilic elements. The deposit represents a series of subvertical ore veins in altereted carbonaceous schists and alevrolites, greisens are developed in the apical part of dome. Quartz (Q) is the major mineral of veins (up to 95%), other minerals - cassiterite (Cs), muscovite, wolframite, arsenopyrite, beryl (Be), calcite (Cc), fluorite (Fl) are in the minor abundences. Fluid inclusions (Fi) were studied in mineral assembleges defining the sequence of development of this deposit, using thermostage with an accuracy of ±2°C and cryostage with an accuracy of ±0.2°C. The temperature data for clasteres of one-type inlusions were used for calculations the fluid composition (in mole fractions) with our program. The evolution of mineral-forming medium have been considered in terms:

R1=XCO2/XCH4, R2=XH2O/XNaCl, R3=(XCO2+XCH4)/(XH2O+XNaCl) and Th - filling temperature.

1a. The Fi composition in preore quartz is H2O-NaCl-CO2-CH4, concentration of solution C =1.7-3.8 wt%, moreover Fi often contain organic bitumoids. Fluid are of reducing character - R1=1.1-3.8, Th=302-344°C, R3=0.16-0.52 (fig 1). Boiling of fluid was observed.

1b. The magmatic fluid in melt inclusions in granite and primary magmatic Fi is represented by H2O-NaCl solution, C=0.5-1.5 wt%, Th=230-300°C. Low Th of Fi are explained by high fluid pressure P=5-6 kbar, Th of melt inclusions is 780±20°C. Water contents in melt is 7-9%.

2. The composition of late magmatic fluid (Q-Fsp veins) is H2O-NaCl-CO2-CH4. C=3.7-10.5 wt%, R3=0.05-0.41 (fig.1), R1=2.3-10.0. Weak boiling of fluid occurred. Th=311-368°C.

3. Greisens contain the more oxidized fluid of such composition as H2O-NaCl-CO2-CH4 R1=15.1-22.5, C=8.7-10.4 wt%, Th=326-348°C, R3=0.25-0.35; the boiling is weak.

4. Ore veins. Three types of fluid were distinguished.

a) H2O-NaCl-CO2-CH4 composition. In (Q), (Cs), (Fl), (Be). Th=290-340°C, C=3.1-7.4 wt%, R1=2.3-4.8, R3=0.19-0.92. The influence of boiling on the changes in fluid composition is shown in the fig 2.

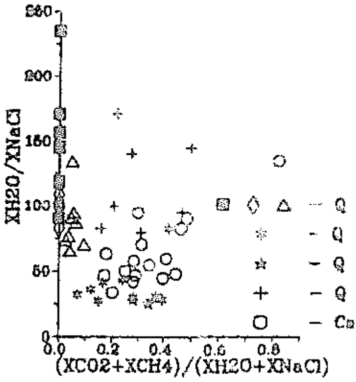
b) H2O-NaCl composition. In (Q). Th=220-280 °C, C=2.1-6.5 wt%. No boiling.

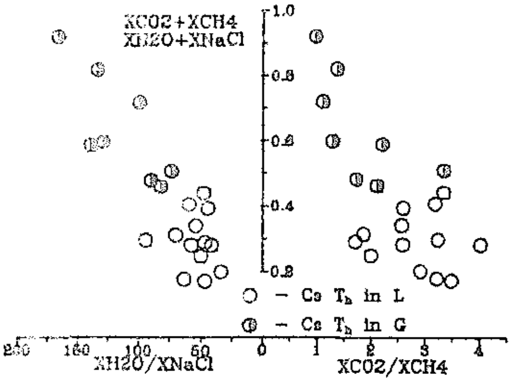
c) Carbonate-bicarbonate composition. In (Cc), (Fl). Th=90-210°C, C=0.6-2.9 wt%.

CONCLUSIONS:

1. Two different fluids are responsible for the formation of the Iultin Sn-W deposit: the first had water-chloride composition and was associated with granite, the second was a pore fluid of the heated wall rocks and was saturated in CO2 and CH4, which were the products of the interaction of this fluid with organic materials of wall rocks. At the stage of fractures formation the fluid mixing took place in the zone of mineral deposition, due to the drop of pressure. The mixing of the deep fluids with the infiltration solutions (of primary meteoric genesis) are confirmed by isotopic data of fluid water $\delta^{18}O$ [Устинов, et al 1989] and δD [Сущевская, et al 1990].

2. At the fractures filling stage fluid admixture enriched in volatiles, continued under decreasing temperature of wall rocks and pore pressure conditions. The great bulk of deep fluid was coming to the zone of mineral deposition from the intrinsic parts of crystallizing granite melt. Fluid boiling took place in the middle and upper parts of deposition zone. Fluids of bicarbonate composition, which are not directly related to ore formation, came last.





APPLICATION OF GEOCHEMICAL METHODS TO RESEARCH OF ACTIVE FAULTS

Jiang Fengliang, Xu Ping
Institute of Geology, State Seismological Bureau PRC, China

Strong tectonic movement may cause the medium to change its physicochemical nature and state, and result in abnomal variation of a series of geochemical parameters. While the rock body is compressed and deformed and finally ruptured, the transmission of energy and the exchange of substance among rock-water-gas systems bring about variation of some parameters of the fluids. On and in the vicinity of fault zones, the rock is broken and loose, and the porosity is high, so these places are good passageway for the upflowing of ground fluids. Therefore the gas composition of soil gas and water composition of ground fluids above the active faults and in the vicinity of active faults may show abnomal high value compared with those of soil gas and ground water in the area far away from the active faults.

1. Radioactive Rn Value

The ruptured rock leads to the increase of Rn-emanation area and the stress press out the Rn-gas of the active faults, and then it transmits into atmosphere. So that Rn value which is near the active fault and hidden fault is higher than that of neighbouring region.

2.Gas Value

De-gasing of deep earth on active faults is stronger and more evident than that on weak-active region. Gas is produced by the interaction of water and new rock surface which is formed by moving of the fault. The kind of gas is controlled by the petrochemical characteristics of the fault. Generally, sedimentary rock fault zones often produce CO_2 and igneous rock fault zones produce H_2. He, very active, can migrate along many kinds of permeation zones, e.g. rupture, crevice, large-deep fault. Therefore He value in the active fault is higher than that of neighbouring area.

3. Geochemical Composition

1) Hg: Hg, which mainly originates from deep crust and the upper mantle, has high-volatile and strong migrating and penetrating ability. These natures decide that it can migrate from the depth to the surface along the crevice. Hence, we can investigate the activity of fault and be certain about hidden faults and predict earthquakes by mearsuring gas-Hg of soil and soil Hg as well as groundwater Hg.

2) As: As,product of differentation of substance in deep earth, derives from deep site of earth. It and its compound have the traits of sublimation or changing into gas state while heated or functioned by gas stream, and finally can be discharged from rock-body. So As value of soil and spring water on the fault or in the vicinity of fault is higher than that of the far-away region. Therefore, As measuring of soil and groundwater is very important for the study of the strike and activity of faults.

3) Other Chemical Composition
The development of fissure causes the easy-volatile ions (e.g. Cl^-, SO_4^-, F^-) to upflow from the depth to the surface which is covered by Quaternary lay layer along the active faults is higher than that of the neighbouring area.

Theoretical and practical data have proved that these geochemical indicators may be used to study active faults, especially deep-covered hidden faults, and earthquake precursor and the stability of engineering structure as well as petroleum prospecting.

EXPERIENCE IN THE LOCAL GEOLOGIC-GEOCHEMICAL FORECASTING AND ESTIMATION OF ORE DEPOSITS OF MAIN GEOLOGIC-COMMERCIAL TYPES IN PRB

E.I.Filatov, G.Ya.Abramson, A.N.Ermolaev,
V.I.Motozov, A.Panajotov, V.Pyrvanov,
Institute of Mineralogy, Geochemistry and
Crystallochemistry of Rare Elements,
Moscow, USSR

The local geologic-geochemical forecasting and estimation of flanges and deep horizons of commercial deposits were carried out for Zidarovo and Madjarovo ore fields consolidating vein line gold-base metal deposits and for Chiprovo-Martinovo ore body, containing stratiform sideritic and silver-lead-zink deposits.

The investigation technique consisted of analysis of geologic position, conjugated geochemical standardization of primary and secondary halos of deposits and ore bodies and geologic-geochemical modelling.

The anomalous geochemical field in Zidarovo deposit is rather heterogeneous. In the veined bodies geochemical association of Au, Ag, Cu, Pb,Zn is changed with the depth to Au, Ag. Maximal total productivity of Cu, Pb, and Zn accounts for the mean-ore level, to which main Au-concentrations are confined.

The below-ore level of veins in Madjarovo ore body differs from the supra-ore veins in the decrease of Ag-content relative to Pb and Zn and in the absence of Ba.

The Chiprovo-Martinovo ore body is characterized by the change of geochemical associations from NW to SE: Bi, As, Ag, Sn, Zn, Mo - Ag, Pb, Zn, Sb, As, - Pb, Ag, Sb, Zn, Mo, Sn, Ba - Hg, Sb, Ag - Pb - Zn, Mo, thus reflecting decrease in the degree of contact metamorphism of stratiform ores in the marble horizon as moving away from granitoids of Svetinikolo massif.

GEOCHEMICAL MAP OF PRECAMBRIAN OF THE UKRAINIAN SHIELD

(Experience of Regional Geochemical Studies as Based on New Technologies)

Galetsky L.S., Gorlitsky B.A., Pochtarenko V.I.

Central Project Expedition of the Ukrainian Geological Survey "Ukrgeologia", Ministry of Geology of the USSR; Institute of Geochemistry and Physics of Minerals, Academy of Sciences of the Ukrainian SSR.

A polyelemental geochemical map of the Ukrainian Shield is compiled for the first time.

Regional information - logic system "GEOMET -Ukrainian Shield" (geology, geochemistry, metallogeny of the Ukrainian Shield) underlines new technology. That system consists of geological - geochemical data and means of their analysis including elements of the expert system (table). A hierarchical system of regional geochemical backgrounds of the complexity-increasing objects: petrolithic differences of rocks; rock association -stratigraphic subdivisions; complexes of rocks, geological formations; structural elements of the shield and, finally, region on the whole has been created. If necessary, potentialities of the system permit constructing and analyzing "agenetic" field of the substance composition distribution within the shield and in its separate parts. So, conditions necessary to characterize elements of the geological structure of the region in terms of the substance distribution and vice versa have been created.

Geochemical map of the Ukrainian Shield Precambrian compiled and bases on the above means is distinguished by the following peculiarities:

- geochemical zoning is carried out allowing for distribution of petrogenic elements (silicon, potassium, sodium, iron, etc.) in the geological formations, the above elements determining conditions of geochemical processes proceeded;
- geochemical background of superrock elements of the geological region structure (formations, structural-formational zones, geoblocks, etc.) are determined proceeding from average weights of contents of chemical elements in the lower-order objects, for example, in rocks as against their volume ratio in the higher-order object;
- both positive and negative specialization of geochemical formations is revealed and is, correspondingly, reflected on the map;
- confinement of geochemical anomalies and anomalous fields to elements of the geological region structure is reflected as a special type of geochemical information;
- analysis of "geochemical contrast range" for different systems of the shield division into structural-substance complex is carried out (precedes the geochemical map compilation), that permits a sound choosing of a geological basis for the geochemical map.

The map presented does not reach all the standards of new technology for information support of such works. Some mono- and polyelement geochemical, specialized forecast-metallogenic maps (diagrammatic maps) of the shield directed at the most promising potential-minerogenic elements and their associations have been compiled within this technology just now.

New quantitative methods and approaches to obtain generalized geochemical characteristics of the region territory are developed.

TABLE

Structure and Information Conjugacy of the Database System in the Information - Logic Systems "GEOMET - Ukrainian Shield"

The name of attribute	Legend	Map	Sample	Anomaly	Tectonics
1	2	3	4	5	6
1. The rock content in the volume of the stratigraphic subdivision or magmatic complex in %% (for each first-order block separately)	+				
2. Area of the stratigraphic subdivision distribution in each topographic sheet of 1:50000 scale (in%)		+			
3. Personal name of the object of analysis (sample, anomaly) in				+	+

the data bank					
4. A source of data (author,year,document)				+	+
5. Coordinates		+	+	+	+
6. Author's number of aiming point (well,outcrop,quarry)			+	+	
7. First- and second-order tectonblocks	+		+	+	
8. Stratigraphic subdivision	+	+	+	+	
9. Massif, area			+	+	
10. Formation			+	+	
11. Interval of sampling (from, to)			+	+	
12. Petrolithotype			+	+	
13. Name of the rock			+	+	
14. Essential rock-forming minerals			+		
15. Accessory and ore minerals (to 4)			+	+	
16. Superimposed processes (to 4)			+	+	
17. Texture of the rocks			+		
18. Structure of the rocks			+		
19. Type of analysis			+	+	
20. Laboratory source (laboratory, plant, method, year of the analysis)			+	+	

RATIONAL COMPLEXES OF GEOCHEMICAL METHODS IN SEDIMENTARY-COVERED AREAS AS EXEMPLIFIED BY THE UKRAINIAN SHIELD

L.S.Galetsky, E.I.Olshevskaya, T.M.Egorova

(Central Project Expedition of the Ukrainian Geological Survey "Ukrgeologia", Ministry of Geology of the USSR)

Some production and development works aimed at perfection of geochemical methods and their rational complexing have been recently performed in the territory of the Ukrainian Shield distinguished by the everywhere-occurring sedimentary-covered areas (1).

Widely used deep lithochemical searches by means of efficient drilling rigs KGK - 100 (300) premit sampling of crystalline basement rocks, their weathering crusts, basal levels and chemically active layers of the sedimentary cover, obtaining information on concealed and buried mineralization, data for geological-geochemical mapping and prospecting prediction. But efficiency of these works considerably increases due to qualitative, advanced geochemical and geophysical preparation of areas using surface methods high-sensitive in mantled regions.

Prospecting by superimposed haloes yields positive results. Intensity of those haloes is the highest in arid areas of the region where an increase in the fraction of salt component in the exogenous lithochemical haloes promotes their appearance on the surface even with the sedimentary cover thickness of 50 - 120 m (rare-metal pegmatites). The methods of mobile forms of elements (MMF): salt-acid and aqueous extracts, thermomagnetic separation are especially effectively used. A method for dry extraction of organic fraction of soils (DEOF) increasing three to five fold the contrasts range of anomalies of many ore elements (nickel, cobalt, molybdenum, gold, zirconium, etc.)(Boev, Klos,1988) is developed and introduced.

Halogenometric (fluoro-, iodo-, chlorometric) and pH-metric methods (Zhovinsky, 1988) used to prospect fluorite, rare-metal copper-nickel, polymetallic mineralization and to carry out geological-structural mapping yield high results in the mantled areas. The methods of mobile forms of elements and gas-mercury method are widely used to distinguish zones of tectono-magmatic activation, to prospect sulphide, rare-metal and rare-earth manifestations as well as other ore localizations.

Its combining with mercury-metric lithochemical sampling of soils gives reliable prospecting information even in complex landscapes characterized by high water content and loamy composition of soils.

Complexing of geochemical methods is performed with allowance for quantitative and qualitative efficiency indices under certain landscape-geochemical conditions. Criteria for estimating efficiency of the methods are as follows: their prospecting informativity, direct or indirect character of information, depth, efficiency and cost of reliable data.

Criteria of prospecting informativity is quantitatively expressed through a coefficient of the anomalous character of the prospected area and a coefficient of the anomalous character of the prospected area and a coefficient of the anomalous area minerogenicity. Their optimal values during mid-scale survey in the region amount to 0.1-0.2 and 0.3-0.6, respectively, while during large-scale survey when searches are concentrated in the promising areas they increase approximately twice.

The depth of the method efficiency is determined by facts, the greatest efficiency (by indirect informativity) is reached by the geochemical method (200 - 400 m while prospecting sulphide or fluorite mineralization), the MMF methods, pH-metry, gas-mercury searches in complex with lithochemical mercury-metric ones. The depth efficiency of lithochemical searches in the secondary haloes is 10-20 m under humid conditions of the forest zone, 10 m - in the forest-steppe one and much higher (50 - 120m) in the arid steppe zone (while sampling pelite-clayed fraction of soils).

Two rational complex (RC) are suggested for forest, forest-steppe, steppe landscape zones apiece. One of them is for landscapes with a thin (10-20 m) barrier-free sedimentary cover on the rock-debris hydromica weathering crust or on crystalline rocks (RC-1, RC-3, RC-5), the other is for landscapes with a thick (from 20 m and more) barrier sedimentary cover on caolinite weathering crust (RC-2, RC-4, RC-6).

So, RC-1 in the forest zone with advanced preparation of areas includes such basic searches as those in stray flows including concentrate-geochemical ones, searches as deep lithochemical ones; the method of DEOF can be an auxiliary one.

Searches in primary haloes (deep or surface), searches in secondary haloes or DEOF are recommended for accompanying works. Geophysical methods in combination with deep lithochemical searches serve as basic ones in RC-2 in advanced works, hydrochemical method being an additional one. During accompanying works the deep lithochemical searches are considered to be basic ones, biochemical searches - additional ones, hydrochemical searches (in underground waters) - auxiliary ones.

The composition of RC in the forest-steppe and steppe zones somewhat differs from that in the forest zone. The method of searches in superimposed haloes, halogenometric and atmochemical searches are more widely used there.

Geophysical methods such as electropolarization and electromagnetic, magnetometric, gravimetric, piezoelectric, acoustic and microseismic ones parallel with geochemical methods are of great significance in prospecting.

Recent prospecting is accompanied by ecological-geochemical research almost everywhere.

Rational complexes of geochemical methods developed for the Ukrainian Shield can be used for mantled areas of the USSR and other countries of the world.

References

1. Galetsky L.S., Boev N.I., Olshevskaya E.I. Stage Character and Complexing of the Prospecting Geochemistry Methods. In collected book: "Theory and Practice of Geochemical Searches under Modern Conditions", issue 1. Theses of Reports to the 4th All-Union Conference. Uzhgorod, October 10-12,1988 Moscow, 1988.

2. Boev N.I., Klos V.R. A Method for Detection of Secondary Superimposed Dispersion Haloes on Organic Fraction of Soils. In collected book: "Theory and Practice of Geochemical Searches under Modern Conditions", issue 1, Theses of Reports to the 4th All-Union Conference. Uzhgorod, October 10-12, 1988 Moscow,1988.

3. Zhovinsky E. Ya. Superimposed Haloes of Fluorine (Theory and Practice of Geochemical Searches). In collected book: "Theory and Practice of Geochemical Searches under Modern Conditions", issue 1. These of Reports to the 4th All- Union Conference. Uzhgorod, October 10-12, 1988 Moscow, 1988.

COMPLEX GEOCHEM⊕CAL MAPPING IN GOLD-BEARING REGIONS

[1]A.E.Gapon, S.I.Prokopchuk, I.S.Lomonosov, [2]A.A.Shimansky, [1]Institute of Geochemistry, [2]Polytechnical Institute, Irkutsk, USSR

The experience of exploration and assessment shows that despite an efficient use of associate elements accompanying gold in primary ores as indicators of gold mineralization there is every ground to consider that these elements are not efficient enough. This particularly concerns small-scale geochemical studies where associate elements are not indicators of gold deposits. Gold is in fact the only indicator of gold deposits.

In different geological formations gold produces complicated geochemical fields of concentrational heterogeneity of metal, the mapping and analysis of which increases the efficiency of exploration.

As an example of geochemical mapping of gold concentrations, the results of comprehensive geochemical studies are considered for one of gold deposits in East Siberia. The deposit represents the gold-sulphide veinlet-phenocryst type occuring in volcanogenic-sedimentary and sedimentary-metamorphic sequences of miogesyncline type and Precambrian age. Its formation is caused by gold-sulphide mineralization syngenetic for host sequences and the subsequent processes of metamorphism and granitization which contributed to the local redistribution of syngenetic sulphides and gold and their new formations due to supply of gold ,sulphur, carbon oxide, water and other components in ore-localizing low-T zones of metamorphism from the areas of high-T metamorphism and granitization where syngenetic mineralization was decomposed. In the periphery, the ore bodies are accompanied by zones of quartz-calcite veins with gold, and the ore bodies proper consist of quartz veins and veinlet-sulphide gold mineralization.

The analysis of mapped geochemical gold fields at the deposit studied indicated various efficiency of prospecting methods. Thus, the hydrogeochemical gold fields displayed numerous aqueous haloes with metal content over 0.002 mkg/l thus showing the potential of the region (Fig.1). The geochemical field from silts localized the anomalous domains around the ore body (Fig.2). The panning method was successfully replaced by scintillation method aimed at mapping of the secondary dispersion field totally occupying the area of the body (Fig.1) according to a number of gold particles (from 10 to 100) and their dimensions (10-25μ).

The efficiency of geochemical mapping was favoured by the development of new methods and improvement of existing prospecting methods, e.g. scintillation, selective sorption of gold from water through a solid extragent and employment of recent analytical methods (atomic absorption) which allow to outline promising areas and to define the most probable position of gold-bearing objects. The proposed set of geochemical prospecting methods significantly increase the efficiency of exploration in gold-bearing regions.

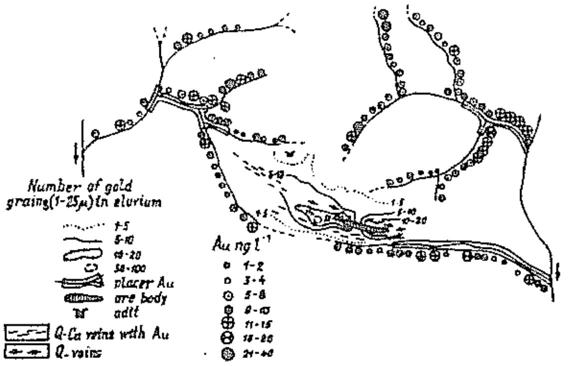


Fig.1. Au distribution in hydrogeochemical and secondary haloes stream sediments

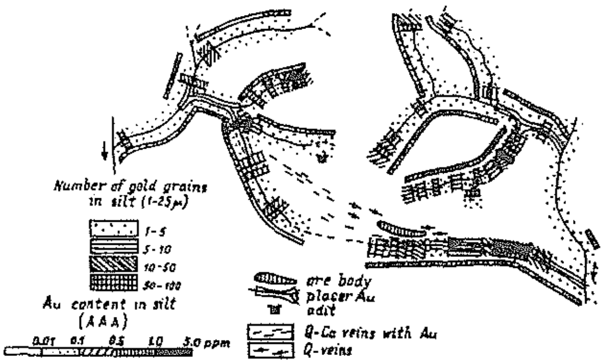


Fig.2. Au distribution in lithochemical stream sediments

THE RELATIONSHIP BETWEEN GEOCHEMICAL PROVINCES AND THE MAJOR TECTONIC DIVISION OF THE EASTERN CANADIAN SHIELD

R.G.Garrett (1), M. Beaumier (2) and P.H,Davenport (3)
(1) Geological Survey of Canada, 601 Booth St., Ottawa, Canada
(2) Ministere de l'Energie et des Ressources, Charlesbourg, Quebec, Canada
(3) Department of Mines and Energy, St. John's, Newfounland, Canada

Regional geochemical surveys employing organic-rich, profundal lake sediment cover a contiguous area of about 800 000 km^2 of the Canadian Shield in Quebec and Labrador. The results permit an evaluation of the relationship between broad-scale geochemical distribution patterns and the major tectonic provinces over part of a Precambrian Shield three times the size of that covered by the Nordkalott project area in northern Fennoscandia, and further demonstrate the role of global geochemical mapping in international geological correlation. Geologically, the region is significant in that it contains the southern terminus of the Trans-Hudson Orogen against the Grenville Province, and parts of the Archaean cratons that bound the Orogen - the Superior Province on the west and the Nain Province on the east.

The surveys were designed primarily for reconnaissance mineral resource appraisal, and were conducted in Quebec by the Quebec Ministry of Energy and Resources between 1982 and 1988, and in Labrador by the Geological Survey of Canada between 1977 and 1986. The sample medium was similar in each province, and sample density was generally consistent at 1 site per 13 km^2, although some surveys in Quebec were at a much higher density (1 site per 2.5 km^2). Analytical techniques differed: the Quebec samples were analyzed for between 32 and 44 elements, mainly by ICP spectrometry, whereas between 13 to 22 elements were determined on the Labrador samples, mainly by atomic absorption spectrophotometry. The two data sets have in common 11 elements (Ag, As, Co, Cu, Fe, Mn, Ni, Pb, Zn and U) as well as loss-on-ignition. Although for several of these elements the two data sets join seamlessly, level changes are evident between the Quebec and Labrador data for others. Data levelling tests have been performed for some of these elements by comparing, on a percentile-equivalent basis, values within a corridor along the Quebec-Labrador border. For some elements this levelling can be accomplished over their entire concentration range, whereas for others, eg. Pb, the values in each data set are truncated to a different extent by different analytical detection limits.

Element distribution maps of the levelled and merged data for the entire region reveal geochemical variation at scales ranging from local to sub-continental. The definition of large geochemical features is clarified by grouping the individual site data into cells of varying size (100 to 4000 km^2), and mapping cell medians. The effect of decreasing sampling density is modelled by sampling the original data to simulate different survey densities, and comparing the resulting maps with those for the corresponding cell medians of the full dataset. The data sampling is carried out using a structured sampling design based on analysis-of-variance principles so that the variability at different spatial levels can be estimated.

The results presented illustrate the value of geochemical mapping to broad-scale geological correlation in Precambrian shield terrains. Existing survey data contain a wealth of useful information, but greater standardization of sampling and analytical methods would increase the usefulness of the data even more. The compilation of these data has shown that additional analyses of the archived sample material are required to improve survey compatibility, and that modelling low-density surveys from archival data is a useful step in planning further reconnaissance surveys to complete initial geochemical mapping of Canada.

2A

GOV-UGTAAL TIN-POLYMETALLIC ORE-MAGMATIC SYSTEM, CENTRAL MONGOLIA

O.Gerel and E.Batsaikhan

Mongolia Polytechnical Institute, Ulan-Bator, Mongolia

The tin-polymetallic ore-magmatic system recognized in the North Gobi (Central Mongolia) is controlled by the volcanic domal structure 120 km across, observed in the magnetic field as a sub-ring negative anomaly. In space images it is interpreted as a highly fractured zone and is characterized by a high geochemical background of some chalcophile and lithophile elements which produce compositionally complicated anomalies.

The volcanic domal unit has zonal structure, its core is composed of Permian volcanics, Paleozoic and Mesozoic magmatic rocks. Externally, it is surrounded by the Cretaceous depressions filled by volcanogenic and terrigenous formations.

The Pre-Paleozoic basement made up of the carbonate-schist complexes crops out only in marginal parts.

The complex rare-metal polymetallic mineralization is associated with emplacement of the Early Mesozoic subalkaline syenite-alaskite volcano-plutonic association. It unites small-depth massifs of quartz syenites, alaskites, leucogranites of the regular-grained and porphyric structure with numerous varieties of monzonite composition and chilled facies of rhyodacite porphyres. The two phases are distinguished in its composition. The first phase involves quartz syenites, alaskites, monospar leucogranites, endocontact facies; monzonites, quartz monzonites, quart-bearing syenites and their porphyric analogs. The second phase contains leucogranites, rarely alaskites and their porphyric facies. The veined series consists of quartz syenite-porphyries - rhyodacite-porphyries, trachydacite-porphyries, aplite-like leucogranites.

The association belongs to the subalkaline K-Na series with a high potassic alkalinity and highly siliceous final members of the series. It is characterized by clark contents of Rb, F and higher concentrations of Zr, Sn, W, Mo, lower concentrations of Fe group, i.e. Cr, Ni, Co as well as B and Ta, low Ba, Sr and Li. With regard to these characteristics this association is close to the geochemical type of rare-metal granitoids of alkaline series (Tauson,1977).

The ore districts are localized in the nodes of intersection of ring structures with linear ones. The time of scarn formation corresponds to that of the main stage of crystallization of the main phase granites. Three stages of mineralization are known. At the first high temperature stage the scarns are formed. The second stage is associated with development of greisen-generating processes superimposed on scarns and accompanied by production of cassiterite, scheelite, etc. The third stage is remarkable for the sulphide mineralization superimposed on scarns and greisens which contains arsenopyrite, pyrite, sphalerite, chalcopyrite, etc.

The presence of two stages superimposed on scarns is substantiated by the distribution of ore-forming elements on separate ore districts and ore zones. The two main ore associations are recognized: i) polymetallic with elements-indicators - Pb, Zn, Cd, Au, and ii) tin-sulphide with indicator-elements - Sn, As, Ge, Bi, both combined in the zone of pyroxene-garnet scarns. The ore districts are characterized by classical vertical and horizontal zonation expressed in replacement of rare-metal mineralization by polymetallic one: Sn - CuBi - Zn Cd Pb - Ag or Mo, W - Cu Bi Zn Cd - Pb - Ag. The vertical and horizontal series coincide.

The ore forming elements are distributed in the zones within the structure. The districts confined to the uplifted eroded parts of blocks display an enhanced anomalous background of Sn, W, Mo, Zn, Pb, Bi, Ag. The central parts of the structure show the rare-metal W-Mo and polymetallic mineralization, while the peripheral ones have the tin-polymetallic mineralization.

The studies allowed evaluation of the type of mineralization, levels of erosional section and forecast of mineralization.

ORE PROSPECTING ACCORDING TO ANOMALY SUBTRACTION

I.S.Goldberg

NPO "RUDGEOFIZIKA", Leningrad, USSR

1. In many ore districts there were stated vast regions of lower concentrations of ore elements (negative anomalies) spaciously conjugated with positive anomalies involving ore deposits. Specifically such regions are revealed in spacious connection with copper-porphyry deposits and copper sandstone deposits, with polymetallic deposits of Rudny Altai, tin ore deposits of the Far East, pyrite deposits of the Ural, etc.

2. In the regions of lowered metal concentrations the deficiency of ore elements (corresponding to metallogenic district specialization) constitutes 20-50% and some reaches 80%. The deficiency of ore element mass in such regions is commensurable with the extension of mineralization and primary haloes. The spacious conjugation of these regions with positive anomalies has as a rule a dipole, polar nature. The revealed regularities of spacious distribution of positive and negative anomalies, their quantity relations allow to analyze the formation of such geochemical systems as a result of in time conjugated processes of addition - subtraction.

The anomalies of subtraction of ore elements are manifested in the extension of ore districts, deposits, individual ore bodies.

3. The analysis of the structure of geochemical fields, the peculiarities of the behaviour of separate elements in various forms of occurrence give reason to suppose the participation of the redistribution if natural electrical field ore energy takes part in these processes. Applying the revealed quantity dependences between the concentrations of ore elements in the areas of addition and subtraction, based on the given model of electrochemical transformation of rocks, new criteria of regional and local prognostication of ore deposits has been developed.

MINOR ELEMENTS DISTRIBUTION IN OOLITIC IRON ORES IN THE KERCH DEPOSITS.

E.V. Golubovskaya
Geological Institute, USSR Academy of Sciences, Moscow

An essentially new facies have been established for "tobacco", "brown" and "caviare" ore varieties in the Kerch deposits, which have the typical genetic properties and mineral associations. Differential analysis has been performed indicating the chemical minor elements distribution in different facies types. Geochemical specification of major components has been defined. In all the above types, phosphorus, arsenic, lead and zinc have been shown to directly correlate with iron and cobalt - with manganese.

The matrix in all ore types shown as average contents of all elements which is approaching the clarke value. "Tobacco" ores forming in silt basins show higher phosphorus, arsenic, lead and cobalt contents; "caviare" and "brown" ores accumulating in the nearshore (beaches, sandy fields and beachrocks) contain more nickel, manganese and rare earth elements (yttrium, ytterbium).

All types of ores feature oolites enriched by phosphorus, arsenic, lead, zinc, molybdenum and poor in vanadium, chrome and nickel. The clarkes of concentration of titanium and gallium are always less than 1; their average value is 0,4. However, the oolites contained in brown and caviare ores are generally enriched by manganese and ferrum, while in fragments of clay-ferrugineus rock these ores are enriched by vanadium, titanium and gallium.

Hence, the geochemical characteristics may be applied the facies-genetic environments with help the above-cites ore contents and specific distributional properties. Essential difference existing in geochemical specialization of brown and caviare ores do not naturally allow to agree with the wide spreaded view-point of their formation and to treat them as the products of tobacco ores alteration to accompany their oxidation.

GEOCHEMICAL MODELS OF ORE-MAGMATIC SYSTEMS IN VOLCANIC REGIONS

I.N.Golynko,
All-Union Scientific-Research Geological
Institute, Leningrad, USSR

Ore-magmatic systems of volcanic regions are represented by ore-bearing volcano-tectonic structures. By the geochemical model of the ore-magmatic system (OMS) it is meant the reflection of the ore-bearing geologic system structure in geochemical fields of dispersion and concentration. Dispersion fields are associated with processes of magmatism and regional metasomatism not resulting in significant accumulation of ore elements, fields of concentration are associated with hydrothermal ore-generating processes. The structure results from the following factors: geochemical types of magmatic complexes (according to Z.V.Tauston), evolution magmatism during structure development, its tectonic-morphological type. As far as these factors highly predetermine the composition of ore-bearing solutions and zones of their circulation, they also influence the structure and localization of fields of concentration.

The most promising there are ring polyformational OMS, corresponding to long-living magmatic centres with stable fluid-magmatic regime. One can distinguish central-cupola and caldera-depression ring structures. The first type is characterized by subconcentric geochemical zoning, usually with basification complexes around the periphery. Concentration fields and mineralization have a bent for the central part (roof bench of the intrusive massif) and thus this type of zoning can be called centripetal. Sometimes, mineralization zones appear around the periphery in connection with the complex of subvolcanic bodies and dikes with high basicity. The model of two-camera differentiation by Z.V.Tauson can be applied for this type of structures. Mineralization is lithophile and litho-chalcophile (Sn, Mo, Au).

Caldera-depressive structures with central uplift are characterized by centrifugal zoning: predominantly chalcophile mineralization (Cu, Zn, Pb) is associated with highly basic complexes and is concentrated around the periphery in the zone of ring faults. Local fields of concentration in the centre of the structure have a lithophile profile, but they do not give commercial concentrations. The genetic association with magmatism is more problematic than for the first model.

Purely depressive volcanogenic structures are the least productive. Local fields of concentration and ore occurrences are, as a rule, associated with excentric extrusive bodies, stocks, explosion breccias and have a bent for the borders of volcanic structures.

Studies of geochemical zonality of volcano-tectonic structures significantly refine the known model of transition from plutogenic mineralization to the volcanogenic one depending on the depth of he erosion level (Sillitoe, 1973, Vlasov and oth., 1984). The decisive factor (in the author's opinion) for forecasting of mineralization is a matter type of magmatic complexes and a tectono-morphological type of the structure but not the depth of the erosion level.

When constructing the genetic models it should be marked that some peculiarities of geochemical fields in OMS volcanic belts can't be explained only by degasation on account of formation of intrusion and their intracamera differentiation. Mixed crust-mantle geochemical characteristics of rocks and ores forces to suppose intensive mass-exchanges between mantle magmas and fluids and the crust.

RESEARCHING ON MICRO-PROSPECTING MINERAL MARKS AND GEOCHEMICAL PROSPECTING AT HATU GOLD DEPOSIT IN WEST JUNGERL BASIN, CHINA

Wang Gongque Tian Jianguo

P. R. China

Recently, the researches on geochemical prospecting in China are developing rapidly. On the way of prospecting mineralogy - quantum mineralogy research, spectrum analysis, isotope determination, mineral inclosure analysis and test , with systematology and information theory, we put forward a new method of geochemical prospecting -mineral geochemical surveying firstly in China. The purpose is to synthesize the mineralogy prospecting research, modern laboratory methods and mathematical geology with computer processing, to make geochemical prospecting to step into the field of plural microcosmic information, to make it more lively and creative.

Satisfactory results have been obtained through the new method on resources assessment, locating target-area and forecasting deposits buried deeply.

Hatu gold deposit is one of the largest and most valuable gold deposits in XinJiang. It is located at the north slope of Zaril-Daraboot synclinorium and north side of Daraboot abyssal fault, in west Jungerl zone of fold. It is located between two NE directed faults, Hatu and Anqi. The direction being NE 70°, the length about 60 km, Anqi gold metallogenic belt extends along and between these two faults. Qiqiu No.1 is the most perspective and typical deposit in Anqi belt. The ore bodies occurred in the proximate faults at north-side of Anqi fault. Nearby Qiqiu No.1, sedimentary rocks which belong to Tailergular and Baoguto formation are abnormally thick layers of intermediate basic volcanic and pyroclastic rocks, Qiqiu No.1 is in upper Tailergular formation which belongs to mid-upper Carboniferous. The wall rocks are dark grey tuffaceous siltstone, siliceous-argrilaceous siltstone, medium-grained feldspatic sandstone with calcareous, altered basanitoid, purplish-red ferruginous jasper rock. The main types of ore are altered basanitoid occurring in fracture zone and quartz vein occurring in faults.

With investigating the background data of regional structure and geochemistry and utilizing the data of geochemical prospecting mapping (scale 1:200,000), we studied the typomorphic characteristics of quartz and pyrite, thermoluminescence of quartz composition and temperature of enclosure, characteristics of trace elements distribution in pyrite and quartz, characteristics of isotope (H, O, S, C) in pyrite, infra-red spectrum, reflective power and microhardness of pyrite. Through these researches, we set up a microcosmic prospecting marks system in Qiqiu No.1, and combine it with the results of geochemical prospecting (scale 1:50,000) in Qiqiu area.

Investigating the distributive characteristics of elements in this district, we found that the distribution types of elements are affected on the excitation of variation and activeness by the system which elements were in through geological action. From these, we set up Mineralization Mature Index, it will reflect the effects that mineralization made to elements. We regarded it as effective marks of geochemical prospecting. Through statistic distributive type of Au-grade, the intensity of gold mineralization has been calculated. Plural peaks of the satistic curves have pointed out the overlapping activities of plural gold mineralization stages. Qiqiu No.1's characteristics of position and time have been made clear.

To study the thermoluminescence of quartz quantitatively, we measured the width at half-peaks of thermoliminescent curve. We attempt to make prospecting marks quantitative, and the results were satisfactory.

Systematology has been introduced into gold geological researches; from low structure level to high, the data were extended gradually in proper order, and were calculated the average with sliding-statistic-window. The sort of calculation can avoid the background noise which the ordinary ways cannot avoid, so the effects of geochemical prospecting data are obvious.

With GM (1,1) model of Grey-System theory, the quantitative estimation, including Au-grade, scale of vein with gold, and reserves in depth of Qiqiu No.1 have been made, and the result have been tested primarily.

Through the researches at Qiqiu No.1, Hatu district, we come to the conclusion: to combine and synthesize the data of geochemical prospecting with mineralogy of prospecting, modern laboratory methods, and mathematical geology, together with ample information from mineral geochemical surveying, we will get immense progress on resources assessment, locating target-areas, depth forecasting and forecasting perspective areas.

Our research suggested that the prospect of the Hatu district will be more optimistic.

ORE-GEOCHEMICAL MODELS FOR THE PORPHYRY-COPPER DEPOSITS OF URAL

A.I.Grabezhev, A.P.Bachtina
Institute of Geology and Geochemistry Academy of Sciences,
Sverdlovsk

Many aspects of the ore-geochemical zonality in porphyry-copper deposits are described well enough in the world geological literature. So we focus attention on new fascinating elaborations gained from the exploration of the Urals deposits.

Large-sized metasomatic aureoles (up to 2-15 km along strike and 0,2 km wide), which suggest the large-scaled processes of the substance migration are known to provide much information if carrying out geochemical researches. To date there are available new data on the behavior of carbon dioxide, sulfur and sodium.

For most of the Uralian deposits of the of the hypabyssal facies, it is found that the metasomatic carbonization is restricted to the hanging walls of the aureoles - the upper part of the sericitization - chloritization zone (at its boundary with propylites) or the upper part of the aureole. This allows to evaluate the erosion level of the aureoles and hence position of the ore bodies. At the subvolcanic level, the metasomatic carbonatization generally covers the whole of the phyllizite zone.

It is discovered for the first time, that Na substracted from the interior of the phyllizite zone is not fully disseminated, but is reprecipitated partially in the outer hanging wall of the phyllizite zone or in fracture zones. Large bodies of the albitized rocks, quartz-albites and humbeites are generated, which contain 5,5-7,5 mass % Na_2O.

The Micheevsky deposit, taken as an example, illustrates a direct relationship between a copper content in the ore bodies and a proportion of sulfur in the overlying "pyrite cover" of the aureole hanging wall. This allows to prognose that position of the blind ore bodies.

Data presented here, suggest that the evolution of the fluid upwards is followed by an increase in its alkalinity and activities of sodium, carbon dioxide and sulfur. A decrease in ferruginity of minerals in a direction to the center of aureoles (and as a degree of the rock transformation increases) and deltaS34 decrease to the periphery of the aureoles suggest most likely, that the oxidizing potential is increasing in the central and outlying parts of the aureoles, which appears to be related with the effects of the oxidized juvenile and vadose waters, respectively.

5A

GEOCHEMICAL CLASSIFICATION OF ENDOGENIC GOLD DEPOSITS FROM THE MODE OF SULPHUR, SELENIUM AND TELLURIUM DISTRIBUTION

V.I.Grebenschikova, Institute of Geochemistry, Irkutsk, USSR

Some gold deposits of Siberia were formed under different geodynamic settings, are hosted in rocks of different composition and age and refer to gold-quartz, gold-sulphide-quartz, gold-sulphide and gold-silver formations.

The geochemical classification of gold deposits is based on the ratios of three elements:S,Se,Te and Au/Ag. Sulphur, selenium and tellurium are associate elements of gold. Selenium is commonly dispersed in sulphide minerals, replacing sulphur. Its increased contents are observed in sulphosalts of silver. The tellurium, more than selenium is able to derive its own minerals,including gold tellurides. According to geochemical characteristics, selenium is well correlated with silver, while tellurium with gold. An active division of selenium and tellurium in the crust and mantle Te/Se=1,6 in mantle and Te/Se=0,013 in the crust) allows to use these elements for geochemical classification of rocks and ores of gold-bearing provinces. Four geochemical types of deposits have been distinguished.

The first,gold geochemical type represents predominantly gold-quartz sulphide ores with high Au/Ag ratio(>10), low Se and Te concentrations and Te/Se=1 ration. The Te and Se own minerals are not available. This type of endogenic gold deposits(Communar, Kuznetsky Alatau) is spatially and genetically related to the Proterozoic toleiitic basalts characteristsc of the initial stages of island arc development.

The second,gold-tellurian geochemical type represents the gold-sulphide-quartz ores with Au/Ag ratio which is over or equal to 1, with a hightened tellurium content and with a high Te/Se ratio (>10). The appearance of own Te minerals,including gold tellurides, is characteristc of this type. This type of gold deposits (Ust-Kara, East Trans-Baikal area) are rather numerous in activized marginal continental areas. The gold deposits are spatially confined to zones of high permeability of rocks with widespread granitoid magmatism primarily of andesitic geochemical type.

The third, gold-sulphur-selenium geochemical type is common for gold-bearing copper-nickel sulphide deposits spatially and genetically related to the trappean magmatism of the platform stage of the region development(Talnakh,Norilsk region).The Au/Ag ratio in these ores is smaller or equal to 0.1. This type is known for maximal concentrations of Se(up to 100 ppm) and low Te/Se ratio equal to 0.1-0.01. The selenium and tellurium may be present as own minerals and dispersed in sulphides replacing sulphur.

The fourth, gold-silver-selenium geochemical type unites near-surface gold-silver deposits of Mesozoic volcanic belts of the North-East(Dalnee,Okhotsk-Chukotsky volcanic belt). The Au/Ag ratio in the ores of such deposits is smaller than 0.01, Te/Se<0.1. The low concentrations of tellurium and high contents of Se are observed in ores. Selenium produces its own minerals and replaces sulphur in sulphosalts of silver. The positive correlation between selenium and silver is common.

The regional comparative analysis of distribution in Siberia gold deposits of S,Se, and Te together with Au/Ag ratio allows the different sources of ore substance to be proposed for deposits of this region. In some cases,the magmatic rocks hosting deposits could be the source for gold and associate elements (silver, selenium and tellurium),in others one may assume an additional supply of ore substance from the deep mantle source.

ON THE ORE POTENTIALITY OF GRANITIC ROCKS IN THE DUMBIER ZONE OF THE NIZKE TATRY MTS. IN THE CONTEXT OF THEIR CRUSTAL ORIGIN

Jozef Gubac

The Dumbier zone of the Nizke Tatry Mts. (central Slovakia), termed by V. Zoubek in the year 1935, is the crystalline complex of the Nizke Tatry Mts. western part. This zone belongs to the so called Tatride units of the West Carpathians. In its structure a batholith of deep-seated granitoid and tonalite rocks as well as the metamorphosed volcanic-sedimentary formation is taking part.

In the work by J. Gubac (1989) the crustal origin of the mentioned deep-seated rocks is analyzed. It is pointed out that in this petrogenesis certain material dependence between rocks of the deep-seated body and material composition of rocks from the metamorphosed complex may be proved. As in this area with rocks of the deep-seated body also manifestations of epigenetic ore mineralization should be put into connection, in the presented contribution we shall take notice of these facts, which will help to clear up their ore potentiality as manifestation of the mentioned origin. A relevant valuation is concerned, because so the possibility to clear up these facts, which are specific for the given tectonic unit and which impress their particularities on ore potentiality of the deep-seated rocks, is offered.

In the work quoted above the petrogenetic character of deep-seated rocks is interpreted from the viewpoint of their development in two deep-seated facies. Material composition of the more shallow facies of these rocks is derived from metamorphosed mixed rocks of the volcanic-sedimentary formation with more distinct portion of acid volcanism. The deeper facies contains higher portion of basic volcanism. It is necessary to put manifestation of ore mineralization into connection with both the mentioned deep-seated facies. The manifestation of ore mineralization occur in rocks of the metamorphosed complex as well as in deep-seated rocks themselves, mainly in rocks of the shallower facies. In deep-seated rocks there is a mineralized tectonic system, which resulted from tectonic relation of both these facies. The mineralized tectonic system in rocks of the metamorphosed complex is the result of general tectonic relation of deep-seated rocks and their metamorphic envelope as a consequence of intrusion.

From deposit viewpoint the manifestations of Au and Sb mineralizations are the most interesting. At present also the deposit importance of the scheelite mineralization is valued. In the past certain attention was also paid to galena-mineralization. Besides W, Au, Pb, Sb, also the elements As, Zn, Cu, Bi and sporadically also Mo, and Sn showed mineralization activity. This mineralization activity shows zonal distribution not only in the individual ore structures but also in the whole region with several centres. Zonal distribution from the centre to periphery may be expressed by this succession: W, Au, As, Cu, Zn, Pb, Sb. The first three elements as well as sporadic Mo and Sn are mainly manifested in the inner zone, Sb and partly also Pd in the external, and Cu, Bi, Zn as well as Pb in the transitional zone. This is obviously a reflection of the change in physical-chemical conditions of the ore mineralization process in space as well as time. The characterized zonal distribution of ore elements in this process may be proved by whichever type of the ore mineralization mentioned above and whether we want to put the given mineralization into connection with more shallow or deeper facies of deep-seated rocks. The ore-bearing solutions have preserved their general material framework at each degree of their material development.

Certain differences in manifestation of ore mineralization are a result of different physico-chemical conditions according to the place of the crustal origin of the deep-seated rocks. Owing to this we can observe certain dependence of concentration of the individual metallic elements in the process of ore mineralization on regional extension of petrographic rock types of the metamorphosed envelope. We want to prove this regional dependence by a geochemical map of the valuated area, compiled for its prognostic estimation. We can say that whereas rocks of acid volcanism contributed to more active manifestations of W, Au, As, or also Mo and Sn mineralization, rocks in the complex in which members of basic volcanism occur mainly contributed to more active manifestations of ore mineralization with Sb, Pb, Zn. This is only a general statement as also in the frame of this division more detailed dependences of this kind may be recorded. So, for instance, with mineralization activity of Pb and Zn in the area under study certain spatial difference may be observed, which is necessary to put into connection with the material character of rocks occurring in this complex.

It is evident that among the factors of ore mineralization linked with the formation of deep-seated rocks are also factors, which are resulting from the general geological structure of the given area. Regarding fully this fact we cannot be satisfied with evaluation of the tectonic position of the mineralized structures only, but it is necessary also to take into account material particularities of one or other tectonic unit.

References:

Gubac,J. 1989: Petrochemicke znaky koroveho povodu granitoidnych hornin dumbierskej zony Nizkych Tatier. - Mineralia slov., 3, 21.

CARBON ISOTOPE FRACTIONATION IN CARBONATE SYSTEM AND METHANE DURING PHASE TRANSITION OF THERMAL FLUID

L.K. Gutsalo. Branch for Physico-chemistry and Technology of Fossil Fuels. Institute for Physical Chemistry, Academy of Sciences of the Ukrainian SSR, Lvov; A.M. Plotnikov, Institute for Geology and Geochemistry of Fossil Fuels, Academy of Sciences of the Ukrainian SSR, Lvov

Today it is clear that the main mechanism which leads to the changes in temperature field, to the redistribution of gases and their isotope fractionation is simply due to separation by water and vapour phases and certain leakage of gases with escaping vapour (Gutsalo and Plotnikov, 1987). The processes are attendant to the forming, existing and exploitation of contemporaneous hydrotherms.

Under "water-gas" phase transitions in carbonate system of hydrothermal area springs the equilibrium distribution of the isotopes of carbon ($^{13}C/^{12}C$) between water and steam are the most frequent. The carbon isotope equilibrium fractionation factors in carbonate system of water-gas depend on temperature (T, °K) from 0°C up to 340°C as follows:

$$10^3 \ln\alpha^{eq}_{H_2CO_3-CO_{2(g)}} = -0,0172\ T + 5,206 \qquad (1)$$

and

$$10^3 \ln\alpha^{eq}_{HCO_3^--CO_{2(g)}} = -0,0691\ T + 27,956 \qquad (2)$$

During vaporization at hydrothermal reservoir which accompanies with partial loss of gases a kinetic fractionation of gas isotopes is highly normal process. An isotope fractionation is approved by dependance of the isotope composition on gas concentrations as well as on reservoir temperature. The carbon isotope kinetic fractionation factors in carbonate system during phase transition "water-gas" depend on temperature (T, °K) within interval from 0 up to 320°C as follows:

$$10^3 \ln\alpha^{k}_{H_2CO_3-CO_{2(g)}} = -4,665(10^6T^{-2}) + 15,629(10^3T^{-1}) - 14,085 \qquad (3)$$

and

$$10^3 \ln\alpha^{k}_{HCO_3^--CO_{2(g)}} = -0,139\left(\frac{T}{10^3-1,545\ T}\right)^2 + 7,105\left(\frac{T}{10^3-1,545\ T}\right) - 8,849 \qquad (4)$$

Following equation is more suitable for interval of 60°C up to 240°C:

$$10^3 \ln\alpha^{k}_{HCO_3^--CO_{2(g)}} = 195,6(10^{-6}T^2) - 107,2(10^{-3}T) + 10,28 \qquad (5)$$

where T, °K.

The kinetic distribution factor of carbon isotope ($^{13}C/^{12}C$) for methane dissolved in water referencing to that of the gas phase is linked within interval of 0 up to 320°C with temperature value (T, °K) by next equation:

$$10^3 \ln\alpha^{k}_{CH_{4(w)}-CH_{4(g)}} = -\ 0,249(10^6T^{-2}) + 0,173(10^3T^{-1}) + 0,279 \qquad (6)$$

References:

Gutsalo L.K. and Plotnikov A.M. /1987/: On the fractionation of isotopes of gases in contemporaneous hydrotherms. Doklady AN SSR. V. 292. N° 6. 1468-1472 (in russian).

HEAVY METALS IN DEEP-WATER SEDIMENTS OF THE SOUTHERN BAIKAL DEPRESSION

A.N.Gvozdkov, I.V.Sandimirov, Institute of Geochemistry, Irkutsk, USSR

At present, the southern basin of Lake Baikal occurs in the zone polluted by effluents from the industrial enterprises of Irkutsk city. The bottom sediments can be used for monitoring pollution of the Lake Baikal ecological system, since they well reflect the level of the ecosystem pollution and show its development throughout 15-20 years. However, great depth, significant facies variations of bottom sediments over the area do not allow the traditional scheme of monitoring to be applied.

The pattern of monitoring based on determination of heavy metal stream and estimation of technogenic component is proposed as alternative. Sampling of bottom sediments is made from standard horizons with a sampling interval 0.5 cm. The heavy metals flux onto the bottom is determined through recent rates of sedimentation and mass rates of sedimentation based on the method of unequilibrated Pb-210.

The distribution of heavy metals throughout the profile of bottom sediments is mainly controlled by distribution of Mn and Fe hydroxides which is due to processes of sediment diagenesis. The upper layer (1.0-1.5 cm) of bottom sediments is actually not changed and displays quantitative relationships of elements in time of deposition onto the bottom. The two upper layers of unaltered sediments each being 0.5 cm thick are sampled and the heavy metals flux on the "water-sediment" interface is determined for these sediments over a time span appropriate for each layer deposition.

The heavy metal flux into bottom sediments of the southern Baikal basin was found to increase during 8-10 years. Since variation of sedimentation velocity and chemical composition of the depositing substance during the last 20 years is hardly probable for an aquatic system of Baikal, the difference in the amount of flows reflect an increase of technogenic component of the heavy metal flow on the bottom during the last 8-10 years.

Table. Heavy metals flux on the "water-sediment" interface ($g \cdot 10^{-9}$ cm^{-2}, $year^{-1}$)

Sampling site	S $cm \cdot year^{-1}$	S $g \cdot cm^{-2}$, $year^{-1}$	T years	Hg	Ag	Pb	Zn	Cu	Ni	Co	Mo	Sb	Cr	V
S.Baikal 282	0.065	0.015	8	$\frac{0.2}{0.2}$	$\frac{4.5}{1.3}$	$\frac{60}{14}$	$\frac{900}{130}$	$\frac{1500}{180}$	$\frac{300}{150}$	$\frac{120}{11}$	$\frac{75}{28}$	$\frac{3}{1.5}$	$\frac{750}{170}$	$\frac{900}{0}$
C.Baikal 288	0.045	0.031	11	-	$\frac{0.22}{0}$	$\frac{22}{0}$	$\frac{550}{110}$	$\frac{1100}{220}$	$\frac{220}{0}$	$\frac{110}{33}$	$\frac{22}{11}$	$\frac{5.5}{2.2}$	$\frac{605}{55}$	$\frac{660}{330}$
N.Baikal 295	0.0071	0.001	70	-	-	$\frac{2}{0}$	$\frac{60}{30}$	$\frac{40}{0}$	$\frac{10}{0}$	$\frac{4}{0}$	$\frac{3}{0}$	-	$\frac{35}{15}$	$\frac{20}{0}$

The numerator-heavy metals flux; denominator-the technogenic part of the flux; "-"-no data; S-linear rate of sedimentation; S_M-total velocity of sedimentation, T-time of deposition of 0.5 cm sediment layer.

Sharp differences in the amount of heavy metals flux in bottom sediments in different parts of Lake Baikal are caused by the differences in the medium of sedimentation. In the southern and central parts of Baikal the flow of the sedimentary substance on the bottom predominantly consists of terrigenous material, while in the northern one it is diatomic material.

The absence of technogenic flow into the bottom sediments of the Northern Baikal is due a much smaller level of technogenic impact in this part of the Baikal aquatorium.

THE APPLICATION OF GEOCHEMICAL MODELS OF GOLD DEPOSITS IN THE PROCESS OF FORECAST AND PROSPECTING.

Chetvertkov Yu.I.,VNIIZarubezhgeologia,USSR.

1. The construction and subsequent usage of geochemical models for ore deposits in practice of a large-scale prospecting is of great applied importance. The elaboration of a geochemical model for a stockwork deposit of gold-sulphide-quartz formation, the study of regularities in the relation of its structure with features of geochemical anomalies structure of the gold field can serve as a gold example. Discovered regularities can be successfully used in solving forecast and prospecting tasks for appropriate types of mineralization.

2. Primary aureoles of gold, arsenic, bismuth, silver, molybdenum, copper, lead, potassium, barium, sodium, cobalt and vanadium have been developed within gold mineralization systems which are being studied. Anomalies of the first eight elements are characterized by their concentration and accompany known zones of ore localization, whereas anomalies of the last five elements are characterized by the subtraction as compared to the background.

Asymmetric vertical geochemical zonality of elements-indicators of gold mineralization is distinctly traceable in the level of deposit and ore bodies; symmetric horizontal concentric zonality is recorded in the level of ore field, deposit and ore bodies.

3. According to geological and geochemical features three main zones, that is, central, intermediate and peripheral can be distringuished within the limits of deposit.

Central zone is characterized by the development of contrast isometric and elongated aureoles with a leading role of gold-arsenic-bismuth geochemical association. The zone corresponds to the richest parts of the deposit, i.e., to the area of ore shoot development.

In the intermediate zone primary aureoles of the linear and elongated shape, of a small thickness, moderate contrast are noted; they accompany the vein-type gold ore bodies. Here a leading geochemical association is a gold-arsenic-silver-copper (or lead) one. Within a peripheral zone one can notice weakly contrast spotted-type aureole concentrations characterizing a small impregnated type of mineralization of no commercial importance. Gold-molybdenum-wolfram is a leading geochemical association.

4. The above features of the geochemical structure of a deposit are distinctly recurrent within ore field and ore body. In particular, in ore field around a deposit (with gold-arsenic-bismuth association being a leading one and with an isometric type of aureoles) one can notice the area of gold-silver-copper-arsenic or gold-silver-lead-arsenic association (depending on the composition of enclosing rocks) with aureoles of a linear type which is replaced, at the periphery of ore field, by the area of gold-molybdenum-beryllium association with a prevailing development of spotted-type aureoles. Within the listed areas in a favourable geological and srtuctural environment mineralization is developing, which, as regards geochemical features and morphology, is identical to the mineralization of a similar deposit zone.

5. The discovered features of the geochemical structure of the ore field and deposit can be utilized when working out of the strategy of the prospecting within ore fields, that is: concentration of main volumes of prospecting at flanks and in deep horizons of a deposit and within the limits of separate anomalies of the intermediate zone. Features of the geochemical model for a deposit and multiplicative coefficients of the zonality and intensity elaborated within the limits of a deposit on the known ore bodies can be applied as criteria for the assessement of geochemical anomalies.

SYNGENETIC ANOMALIES IN AN ALLOCHTHON AS AN EVIDENCE OF CRYPTO-BURIED MINERALIZATION

Chuchupalov V.N., Chulanov E.I.

Centrgeofizika, Moscow, USSR

Theoretic efforts and field lithochemical prospection have been made to test a new, more promising method based on geochemical analysis of argillaceous sediments in an allochthon complex, that would permit to determine syngenetic accumulations (anomalies) there and thus to forecast crypto-buried ore deposits.

A mineralized region of the Far East has been used as a standard area for field studies. Deposits and indices of tin, polymetals, fluorite, tungsten, gold as well as promising terrains of an ancient folded basement with linear and areal crusts of weathering underline thick (10 to 100 m) unconsolidated Meso-Cenozoic series. They formed as lacustro-alluvial deposits. Big masses of terrigenous material, composed mainly of products of rewashing in kaolinite crusts of weathering (Ivashinnikov, 1978; Korotky, 1983) were supplied during many consecutive periods in water areas of the late depression structures. Periodic appearance of great but shallow lakes in the intercontinental depression and consecutive regressive erosion provided for certain lithochemical aureoles forming around the ore deposits. We call them subaqueous defluxional dispersion fields (or aureoles). Formation of these fields is closely associated with aqueous transit and with areas of clastic material carried there from sources of mineralization. The word area (not current!) is just what we need to describe the picture of mechanical dispersion there. Syngenetic nature of subaqueous defluxional aureoles and of enclosing allochthon deposits is undubious and confirmed by a number of special (mineralogical, phase analysis etc.) studies.

Subaqueous aureoles are rich in information because their areas are much greater than those of primary and secondary (residual) aureoles in all of the ore-bearing hierarchical levels: deposits-ore fields-mineralized regions. Below we present comparative data table for various genetic types of buried aureoles in an ore field containing two deposits and seven indices of fluorite-rare metals, one tin deposit and a buried cassiterite placer:

Element	tin	fluor	tungst.	berillium	lead	silver
aureole type	numerator : length x width (km) denominator : area (km)					
primary	9x2.5 23	9.5x3 29	7x1.8 13	8.5x3 26	8x1.5 12	5x2.5 13
residual in the crust of weathering	14x3.5 49	15x4 60	11x2.5 28	12x3.5 42	10x4 40	7.5x4 30
subaqueous defluxional	17x6.5 111	18x7 126	14x5.5 77	14x5.5 73	16x6.5 104	15x6.5 98

It is evident that subaqueous aureoles have 5 to 6 times greater areas than the primary aureoles and 2 to 3 times greater than those of residual dispersions.

Summary:

1. New directions in theory and practice of lithochemical prospection (subaqueous defluxional aureoles) permit to reduce drilling efforts, at least at first stages of the search for ore and thus to provide for high efficiency of prospection work.

2. New information determines geologic efficiency that manifest itself in the following:
   - various types of commercial solid state minerals may be predicted within the subaqueous aureoles, including Cenosoic dated stratiform deposits of gold, tin, tungsten etc. with argillaceous rock as concentrators;
   - it becomes possible to calculate, at least approximately, ore material balance and to reconstruct the picture of the eroded parts of deposits to have more liberty in managing data on predictable reserves;
   - reliability of detection of crypto-buried deposit anomalies becomes greater.

We have been going on in our studies.

GEOCHEMICAL SYSTEMS OF OPEN ORE-CONCENTRATING LINEAMENTS

Ya.V.Ilyinsky

All-Union Scientific-Research Geological Institute, Leningrad, USSR

Many researchers such as Ya.Kutina, I.N.Tomson, M.A.Favoskaya and others have studied open ore-concentrating lineaments (OOL) from positions of metallogeny. Geological, space airborne geological and geophysical methods for mapping these lineaments have been developed. The main goal of geochemistry is to recognize among numerous systems of faults and lineaments those which can be referred to ore-concentrating ones.

Geochemical indications of OOL have been formulated in the process of compilation and analysis of geochemical maps: a map of the territory of the USSR, 1:10 000 000 scale, and a map of southern Siberia, 1:1 500 000 scale:

1. Development of geological units with definite geochemical features: metal-bearing volcanics that fill in lineaments of graben-, rift-types etc., dike belts and minor intrusions of basic, ultrabasic rocks, rare-metal granites commonly with an alkali tendency, etc.

   Geochemical features for many sediments are also determined by endogenic supply of materials by hydrothermal springs which are located along faults in a depositional basin. Geochemical associations of endogenic type are common in such environments.

2. Geochemical asymmetry of geological objects (intrusive massifs, sedimentogenic and volcanogenic structures) that is attributable either to inherited geochemical features of host rocks or to an additional supply of chemical elements as a result of the activation of faults.

3. A relatively high dispersion of the distribution and break of correlation relations between chemical elements (ore and rock-forming) resulting from hydrothermal-metasomatic transformations.

4. The endogenic type of indicator relations of elements which possess variable migration abilities in the hypogenesis and hypergenesis.

Points of intersection for OOL of different orientations, which are most favourable for ore formation have matched geochemical characteristics of intersecting lineaments, an increase in the number of spatially contiguous mineralizations of different types and ages and in the number of geochemical anomalies, and not infrequently, the substraction of elements and anomalous low geochemical background.

The geochemical evolution of OOL is determined by the interaction of inherited processes and new formation. The latter are recognized by an increase in contents of less abundant elements in later epochs: siderophile and chalcophile elements (cobalt, silver, bismuth, antimony etc.) in crustal stretching zones; dominantly lithophile elements (rare metals and rare earths) in zones of compression and granite formation. There is a tendency for a lithophile type associations to become more important, which is consistent with the directed lithification of the Earth's crust.

The data obtained should be considered in interpreting geochemical prospecting results.

GEOCHEMICAL PROSPECTING FOR GOLD IN THE BOHEMIAN MASSIF

J. Janatka
Geoindustria, Komunardu 6, Praha 7, Czechoslovakia

Rising prices of gold and changes in the theories of gold metallogeny in the early seventies started a new period of gold prospecting in Czechoslovakia. Extensive research program of re-evaluation of the gold potential of the Bohemian Massif resulted in collecting the data of nearly 1,500 gold occurrences. Paralelly, grassroots gold exploration was performed.

Almost 70% of the area of the Bohemian Massif was covered by regional panning prospecting with average density of 1 sample per sq. km, which detected large gold anomalies both in old known districts and in new areas. Results of the panning prospecting for gold are enhanced by analysing the -0.15 mm fraction of the heavy concentrates.

Soil prospecting in areas of favorable geological structure and/or Au anomalies revealed by the panning prospecting was used as the most frequent method on both regional and detailed scales of exploration. Up to the present time, soil prospecting helped to find several important gold deposits. The -200 mesh fraction of soil samples proved to be sufficient in detecting anomalies of most trace elements, including gold. The method is amended by analyses of heavy mineral concentrates of soil samples (e. g. in prospecting for gold-scheelite mineralization in high-grade metamorphic complexes of the Moldanubicum).

Gold itself represents the best indicator of mineralization. Gold districts are characterized by background values of tens of ppb, ore outcrops are indicated by concentrations up to several ppm. Halos of gold mineralization are larger, higher and more regular in granitic rocks than in areas of volcanic and metamorpic rocks.

Gold mineralization of the Bohemian Massif shows common zoning. W (scheelite) and Mo concentrations increase downwards, mostly with simultaneous decrease in Au grades. Arsenic, concentrated generally in the upper parts of mineralized structures, represents together with Bi the most useful pathfinders for gold. The spatial relationship of As and Au anomalies is sometimes not unambiquous (sstratiform mineralizations, e. g.). The suite of the most frequent pathfinders comprises occasional Ag, Hg, Pb, Sb.

9A

PÍSEK - VRCOVICE AU, AG DISTRICT: PROBABLE OCCURRENCE OF GOLD-BEARING SHEAR ZONES IN THE MOLDANUBICUM OF THE BOHEMIAN MASSIF

J. Janatka and T. Váňa
Geoindustria Praha, Komunardu 6, 170 04 Praha 7
Czechoslovakia

Target area is situated at the contact of Moldanubian gneiss with granodiorite of the Central Bohemian Pluton. The contact zone exhibits combined intrusive-tectonic character. Geologic structure of the studied area has been extensively affected by tectonics showing prevailing NW direction. In addition, numerous pennate structures are present.

Regional paning prospecting detected anomalies of mineralogical gold and scheelite associated with increased concentrations of Ag, As, and Pb in the -80 mesh fraction of heavy concentrates. In the most prospective area, soil and rock sampling, reconnaissance drilling and trenching were performed.

The results confirmed hitherto unknown gold mineralization with several quartz generations. The early, rather dark quartz forms veins and lenses located in zones of ductile deformation over 10 m thick, accompanied by extensive hydrothermal alteration and mylonitization. The quartz is characterized by common presence of fine-grained arsenopyrite pigment and occasional pyrite, marcasite, and chalcopyrite. Late rather light quartz forms veinlets and veins up to 1 m thick filling mainly the pennate structures. Gold contents reach up to 15 g/t. They are accompanied by increased concentrations of Ag, As, Bi, Cu, Pb, and Sb. The Au/Ag ratio falls into the 1 - 1/10 range.

Regarding the geological and geochemical features, gold mineralization of the Písek - Vrcovice district exhibits similarities to the gold-bearing shear zones of the Hercynian basement of France.

GOLD-BEARING PYRITE IN QUARTZ-SERICITE-CHLORITE SCHISTS WITH GRAPHITE NEAR NIELESTNO (LOWER SILESIA)

Andrzej Klosiewicz
State Geological Institute in Warsaw, Poland

Geochemical investigations have shown different contents of gold in quartz-sericite-chlorite schists with graphite in dependence on their type. Quartz lenses and quartz laminae schists with big amount of pyrite contain 0.021 g/t of gold on the average (maximum - 0.043 g/t). Schists without quartz lenses and quartz laminae and including small quantity of pyrite contain 0.006 g/t of gold on the average.

Microscopic investigations performed up to now have not shown the presence of native gold. Pyrite is the main ore-mineral of quartz-sericite-chlorite schists with graphite. This pyrite often shows organic textures. Electron microscope investigations have shown that pyrite is gold-bearing. Admixtures of the following elements: As, Pb, Bi, U have been also confirmed in this pyrite.

THE MAIN RESULTS OF THE GEOCHEMICAL EXPLORATION ON GOLD WITHIN THE CENTRALSLOVAC NEOVOLCANIC AREA

Juraj Knésl, Geological Survey, st. ent, Spišská Nová Ves, Czechoslovakia

Since the oldest times, the Centralslovac neovolcanic area represents the most important source of gold at Slovakia. The history of the gold mining here is at least 1.000 years old. They are the two best known Centralslovac deposits - Banská Štiavnica /base metals bearing veins with gold and silver content/ and Kremnica /gold bearing quarz veins with some silver content/. The gold mining here has been ceased in 1970 /Kremnica/, because of low prices of gold at that time. At present, the base metals from Banská Štiavnica ore district are mined and the small scale surface mining of the Šturec gold deposit at Kremnica is prepared.

Since 1965, the geochemical exploration has been carried out within the whole area /heavy mineral survey, stream sediments, soil and rock surveys/. As regards of the new knowledge about gold mineralization, besides the new information about the traditional gold bearing veins and occurrences, the very important information have been obtained here about the presence of the disseminated Au mineralization at sedimentary carbonate group of beds of mesozoic age, at the margins of the area, at vicinity of the neovolcanic formations.

The distinguished anomalies /Hg, As, Sb, Tl/ have been found out here, which indicate the probable presence of the gold mineralization within the secondary silicificated zones at the carbonate sediments /so called Carlin type - localities Remata at western margin of the Kremnica ore district, Bukovec at northern part of the Banská Štiavnica ore district, Sokolec at NE part of the Tríbeč ore district/.

By means of the geochemical prospecting /including of geochemical shallow bore-holes/, the primary gold mineralization near surface has been discovered /occurrence Uderiná by Lučenec/. So far the question of the type of this mineralization has been not solved yet, nevertheless, the average Au content /about 5 gt^{-1}/ is very interesting from economic point of view.

The main results of the geochemical prospecting, as regards of the disseminated gold mineralization at carbonate silicificated rocks from Remata, will be given at this report /used methods, distribution of the indicator elements within the secondary and primary geochemical field, the preliminary information about distribution of gold mineralization/. Further, there will be given the results of the geochemical prospecting from the Uderiná locality /used methods, distribution of the indicators within the secondary geochemical field, distribution of gold at primary rocks/. The final part of the report deals with the prognosis of the gold mineralization /so called Carlin type/ at the Centralslovac neovolcanic area and at Slovakia on the whole.

References:

Knésl J., Knéslová A., Maťová V. /1989/: K možnostiam výskytu Au rúd typu Carlin na území SSR. - Geologický pruzkum č. 12, 358 - 361, Praha

THE WEATHERING ZONE OF THE COCTENCOL DEPOSIT OF RARE METALS IN THE CENTRAL KAZAKHSTAN: GEOCHEMISTRY OF Mo, W, Bi IN WEATHERING PRODUCTS OF ORE-BEARING ROCKS

Sergey A. Kniazev, Institute Geology and Geophisic Siberian Branch Academy of Sciences of USSR, Novosibirsk, USSR

The weathering zone of the Coctencol deposit was formed in Triassic after the penetration of the granite intrusion of Permian age (P_1) in Devonian extrusive sedimentary layer (D_3fr-fm), accompanied by the formation of stockwork of rare metals /Мазуров и др.,I98I/. The weathering zone settles down in graben, within which limits native rocks are represented by ore-bearing garnet scarns, hornstones, decite porphyries; in quartz and quartz - K-feldspathic veins of these rocks pyrite, wolframite, scheelite, molibdenite, Bi-sulphosalts are found. In the central part of graben the thickness of hypergene formations reaches 200 metres.

Geochemistry of Mo, W, Bi in the weathering zone of the deposit is characterized with the aid of the analytical data (quantitative spectrum, atomic absorption, X-ray structural and other types of analysises) together with the results of phisico-chemical computer modelling with the help of a programme complex "Selector" /Казьмин и др.,I975/ of the weathering process of ore-bearing rocks.

Phisico-chemical conditions of hypergene mineral formation, a material composition of the weathering products, forms of migration of Mo, W, Bi in hypergene solutions, forms of these elements presence in the weathering substrates belong to the factors, which influence geochemistry of rare metals in the weathering products of the deposit's rocks.

Kaolinite and hypergene minerals of Fe, Mn (goethite, pyrolusite) get extensive development in upper horrizons of hypergene profiles during formation of a clay zone by weak acid (close to neutral) reactions of water solution. In this part of the weathering crust it is registered a considerable increase of consentration of Mo and W. The data of phisico-chemical modelling together with the results of X-ray structural analysises showed a possibility of formation of hypergene minerals of W and Bi - tungstite, russellite, bismite - in all the interval of the clay zone.

Forms of migration of Mo, W, Bi in hypergene solutions do not change essentially in transition from weak acid mineral formation medium to weak alkaline conditions (during formation of montmorillonite-illite paragenesis in lower parts of the wethering crust). In solutions ions of MoO_4^{2-}, WO_4^{2-}, $Bi(OH)_3^0$ predominate. The forms of migration of rare metals make it possible to suppose accumulation of Mo and W jointly with positive charged colloid - hydrooxide of Fe(III) /Чухров,1955/ - in the result of ion sorbtion.

In the disintegration zones of the weathering profiles it is registered a slight concentration of the weathering products by rare metals, connected with stability to the weathering of quartz and quartz - K-feldspathic ore veins.

So, the factors, checking the behaviour of Mo, W, Bi in the weathering zone of the Coctencol deposit, led to a considerable accumulation of hypergene rocks by rare metals. Maximum coefficient of concentration (K) for these elements have the following data in the weathering profiles in the central part of the Coctencol graben: K(W)=45,3; K(Bi)=4,7; K(Mo)=3,8. The peculiarities of geologic structure, main features of geochemistry of Mo, W, Bi for the weathering zone of the Coctencol deposit allow to value its rocks as an extremely perspective raw material of rare metals.

References:

Казьмин Л.А., Халиуллина О.А., Карпов И.К. Расчет химических равновесий поликомпонентных гетерогенных систем, когда число фаз превышает число независимых компонентов в исходных условиях, методом минимизации свободной энергии (Программа"Селектор")//Алгоритмы и программы. Информ. бюлл. №3. - М.:ВИНИТИ, I975. - С.I8-I9.

Мазуров А.К., Бакуров Г.С., Козловская З.А. Рудоносность коры выветривания на одном из вольфрам-молибденовых месторождений Центрального Казахстана//Изв. АН КазССР, сер. геолог.. - I98I. - №5. - С.20-28.

Чухров Ф.В. Коллоиды в земной коре. - М.: изд-во АН СССР, I955. - 67I с.

11A

USE OF ELEMENT METASTABILITY FOR APPLIED PURPOSES BY PHYTOHYDROGEOCHEMICAL METHOD

B.A.Kolotov, V.Z.Rubeikin, E.A.Kiseleva
All-Union Research Institute of Hydrogeology
and Engineering Geology, MOscow, USSR

Any natural or technogenic source of excessively concentrated chemical elements forms dispersion haloes in all geochemical spheres. This phenomenon is widely used in prospecting for mineral deposits and in environmental control.

State transformation (or forms of stay) of defusing elements in various media of litho-, hydro-, atmo- and biospheres is the main specific feature of dispersion process, which provides potential possibilities to use it for applied purposes.

Element dispersion mainly tends to ever growing probable stabilization with time. The stable state of elements may be specific for each particular medium or object and represents, thus, the information about the source of elements and the environment in which these elements migrate. Just this serves a potential for using this phenomenon for applied purposes. Here, of the greatest importance is the starting period of dispersion-halo formation when a metastable state is particularly contrast on minimum background and therefore most exactly reflects major specific features of elements as indicators of the source. With time the state becomes stable and is transformed in accordance with characteristics of an enclosing medium.

While carrying out analytical works to detect a dispersion halo in a medium, elements of metastable state and, thus, poorly connected with the medium substrate may be easily extracted using extragents of various composition and concentration. For example, they are extracted from samples of loose sediments, plants and zoo-organisms, using aqueous, acid, alkaline extracts and organic solvents.

The important advantages of the proposed methodical approach to geochemical studies are that it is simple, reliable and quick in completion. In particular, of high efficiency in indicating dispersion haloes for metals is the method of preparing short-term aqueous and hydrochloric extracts from plants (leaves) and the subsequent analysis of solution obtained.

The principle possibility is shown to use the present method in prospecting for ore deposits, oil- and gas-bearing structures, as well as in environmental control along motor highways and within urban agglomerations.

GEOCHEMICAL-MATHEMATICAL MODELLING OF STRATIFORM POLYMETALLIC DEPOSITS IN KAZAKHSTAN

V.K.Koshelev, M.S.Tonkopii,"Yuzhkazgeologia", Alma-Ata,
USSR

Construction of geochemical-mathematical models of mineral deposits with any genetic type, including stratiform polymetallic one, suggests their description in the form of equation or set of equations. Such expression of mineral deposit models have resulted from regressive analysis.

The basis of methodics is to reveal the optimal dependence between geochemical, geophysical and other features observed on mineral deposit, and the studied quantity, e.g. prospected reserves.

The mineral deposit models of Atasu type and separately of Mirgalimsai, plotted on electronic computer as polymetal reserves in above-mentioned mineral deposits versus chemical elements distribution in primary haloes, enables one to choose the informative complex of prospecting mineralization signs, to describe characteristics of these signs quantitatively, and to single out the rational methods for exploration of these mineral deposits.

The paper gives both the analysis of informative signs choice in regression of total zinc and lead reserves on Atasu mineral deposit and on Mirgalimsai, and their geological interpretation with possible correlation of various steps in industrial-worth ore formation.

The plotted models are used in practice for quantitative assessment of prognostic zinc and plumbum resources according to geochemical and geophysical data in Kazakhstan.

12A

PROBLEMS OF GEOCHEMICAL EXPLORATION FOR DEEP-SEATED COPPER-NICKEL SULPHIDE DEPOSITS

E.S.Kravtchenko and V.V.Ryabov

Institute of mineralogy ,geochemistry and crystal chemistry of rare elements
Mingeo and Academy of Sciences, Moscow, USSR

Primary halos of massive sulphide copper-nickel deposits, e.g. those of Petchenga, Allaretchka and Norilsk regions, were formed in different geological and structural settings: host rocks vary in age, composition and formation conditions. Nevertheless, the facts concerning distribution of chemical elements within ore-bodies, differentiated intrusive and primary halos give rise to a general hypothesis of their origin. Using the hypothesis it is possible to find a new approach to problems of prospecting for concealed copper-nickel sulphide mineralization.

It can be assumed that ore-producing magmatic activization along with intruding and forming of ore-bearing basic-ultrabasic complexes included abundant influx of deep solutions.

The main source of ore elements were intruding magma as well as deep solutions. The activity of the latter factor was more lasting, what resulted in partial re-distribution of ore and typochemical elements within host rocks.

Petrological and structural setting can be named as key ore-controlling factors.

The results of halo-ore body interrelations are applicable in prospecting and estimation of copper-nickel sulphide deposits including blind and deep-seated ones. This fact is of major practical importance.

Nowadays, the information on primary halos of copper-nickel sulphide deposits includes analytical results for ca 150 000 geochemical samples. On the average, the content of 15 elements was determined by semi-quantitative spectral analysis in each sample. For some deposits up to 20 elements content was determined by quantitative methods.

The following items are based upon the results of studying of geochemical maps of ore fields (scale 1:25.000), ore zones (scale 1:10.000 and 1:5.000) level plans of ore deposits (scale 1:5.000 - 1:1.000) and standard sections of intrusive and ore deposits.

1. Primary halos of copper-nickel sulphide mineralization obtain complex multielement compositions. Along with relatively limited suite of ore elements. (ca 6-10) there is also a large group of "satellite" elements (up to 20) which can be used for geochemical criteria for prediction and estimation of ore mineralization.
2. Primary halos were traced at a distance of several kilometers upward the inclination of ore-containing zones. Halo dimensions significantly exceed not only those of ore deposits as well.

   Practically, at least three hierarchical levels can be defined within halos structure:
   - i) primary halos of ore bodies;
   - ii) primary halos of ore deposits;
   - iii) primary halos of ore fields.
3. Complex zoning composition is inherent in primary halos of copper-nickel sulphide deposits. This is induced firstly by duplicity of ore-controlling factors, which is especially clearly revealed within large differentiated basic-ultrabasic massifs, e.g. Petchenga and Norilsk. There are two clearly defined trends in spatial destribution of indicator elements. The first of them is directed from upper differentiates towards the bottom ones while another one is subperpendicular to it and corresponds to the direction of deep solutions movement, i.e. up the inclination from root parts of an intrusive body towards its frontal parts.

There is evidence that the origin of geochemical pattern for ore bodies is generally the same.

The second major factor responsible for structural complexities of the halos is the mult -level hierarchy of their structure, as it has already been mentioned above. Each of the levels represents zoning pattern of its own.

Geochemical peculiarities that are revealed now for halos, ore bodies and differentiated intrusive bodies permit to define reliable criteria for prospecting and assessment of halo zones of a given ore formation type at the depth not less than 1,000 - 1,500m as well as to grade erosion level of ore bodies (instrusives) and direction of zoning vector. Using the results of geochemical investigations it is possible to adjust planning operations.

The facts given above confirm effectiveness of geochemical methods application for any stage of prospecting for hidden copper-nickel sulphide mineralization.

13

ON HYDROGEOCHEMISTRY IN ORE EXPLORATION IN FINLAND

P.W. Lahermo, Geological Survey of Finland, SF-02150 Espoo, Finland
V. Peuraniemi, University of Oulu, SF-90570 Oulu, Finland

Chemical analyses of groundwaters and/or surface waters have only exceptionally been used as an aid to geochemical exploration in this country. The Nordkalott Project, jointly carried out by the Geological Surveys of Finland, Norway and Sweden and covering northern Fennoscandia (above 66° latitude), collected and studied till, stream sediment and heavy mineral samples, and c. 6400 stream water samples. Although collected in summer, a season characterized by alternating rainy and dry spells, the electrical conductance and main cation concentrations (Ca, Mg, Sr) in the samples appeared to be controlled by the bedrock composition, i.e. the distribution of mafic, ultramafic and carbonate components in relation to felsic ones. In this respect, stream water seems to be as useful a material as till and even better than heterogeneous stream sediments. The most important ore elements generally used as pathfinders, such as Zn, Cu, Cr, Co and As, occur in natural waters in very low concentrations and are extremely vulnerable to contamination rendering the hydrogeochemical method more difficult.

In a more detailed study in the Sattanen area, central Finnish Lapland, water samples were collected from streams and springs. The Sattanen area is largely composed of sedimentary and volcanic mafic and ultramafic rock associations, such as amphibolites, gabbros and komatiites. These rocks are characteristically rich in Ni and Cr, as is also seen in their elevated concentrations in spring and stream water. The granite areas and the old basement composed of granite gneisses are reflected in very low concentrations of dissolved elements, including heavy metals.

The groundwater samples collected from some springs and wells in the granite gneiss area at Suomussalmi, eastern Finland, showed elevated F values. These could be attributed to the occurrence of early Proterozoic K-rich granites. Till samples from the same area contained anomalous F, Li and Sn concentrations. On the basis of geochemistry the K-granite is of the rapakivi type and has conspicuous ore potential.

Some groundwater samples were taken from springs and wells to decipher the sulphide ore potential of the Proterozoic Kiiminki schist area in northern Finland. Several high Zn concentrations showed that the volcanic sedimentary sequences of the area are potential for Zn ores. This was confirmed by the Zn ore boulders and the high Zn abundances of till.

During a nationwide hydrogeochemical mapping of groundwater, about 5900 samples from springs and wells dug into overburden and drilled into bedrock were also analysed for some heavy metals. Particularly in dug and drilled wells, contamination due to water utilization (pumps, pipes, containers, etc.), sampling procedure and preparation of samples is omnipresent and difficult to distinguish from values caused by natural heavy metal sources, such as chemical disintegration of sulphide minerals.

Some tens of deep small-diameter explorational drill holes were sampled for water (without pumping). As most of the holes were drilled in sulphide-ore potential areas, they often intersect ore mineralizations. Saline Na-Ca-Cl or Ca-Na-Cl dominant waters were encountered. Because of the strongly reducing environment and high pH level (pH 8-10), heavy metal concentrations (e.g. Zn, Cu, and Ni) were generally very low. Only Fe and Mn, readily soluble in a low Eh environment, sometimes reached levels of several tens of mg/l. Hence, drill hole waters in an ore environment do not always show strong positive anomalies. However, under favourable conditions drill hole water may give information about more distant mineralizations not intersected by the hole. This is particularly true of the fairly mobile U.

THE DISPERSION OF ORE ELEMENTS WITHIN THE WEATHERING PROFILE AT HANNAH SOUTH GOLD MINE; WESTERN AUSTRALIA

L.M.Lawrance and C.R.M.Butt

Division of Exploration Geoscience, C.S.I.R.O., Floreat Park 6014
Western Australia

The Hannah South gold deposit is located 15 km SSE of Kalgoorlie, in the Norseman-Wiluna belt of the Archaean Yilgarn Block, Western Australia. The deposit is situated beneath a playa that forms part of a ephemeral lake system. The original lateritic weathering profile has been partially truncated by the migration of this system and ferruginous gypsiferous lacustrine sediments have been deposited, leaving no outcrop. In winter, water temporarily accumulates in the lake saturating the profile. However, for most of the year, the watertable is at 20 - 30 m depth within the profile creating a redox front. Below this interface gray-green saprolitic rock is saturated with highly saline groundwater in a reducing environment. Above the redox interface, highly leached white clay is stained by red-brown iron oxyhydroxides in an oxidizing environment.

The mineralization is hosted by a highly altered basaltic unit, now a granular and semi-massive siliceous epidote-ankerite rock. A tuffaceous sediment and an andesite porphyry bound this unit. These rocks have been dissected by numerous fault which have promoted weathering to a depth of 65-75 m, where major faulting has truncated the host unit. Between this weathering front and the redox interface, gold is confined to the host unit, associated with sulphides, dominantly pyrite; it has an average grade of 17 ppm Au, with local concentrations of up to 180 ppm. Cobaltite, galenobismuthite, bismuthite and wittichenite also occur, either within pyrite or as free grains. Primary gold is mainly associated with the bismuth-sulphide minerals and rarely as inclusions in pyrite. Higher in this zone, as weathering increases the pyrite becomes increasingly porous and finely fractured. Groundwater flow is limited in this zone and the weathering of pyrite produces pH values of 4.0 - 5.5 in the host unit, in contrast, with the wall rocks which produce a pH environment of 7.5 - 8.5. Micron-sized secondary gold begins to occur as isolated grains and clusters within the kaolinite matrix and as fine fracture fillings in epidote surrounding the semi-weathered sulphides, but remain confined to the host unit.

At the redox interface, the pyrite is completely oxidized and replaced by iron oxyhydroxide pseudomorphs. Just above this interface in a moderately acid environment (pH 5.5 - 6.5), a flat lying zone of secondary gold enrichment has formed, which spreads into the adjacent weathered country rocks, resulting in a mushroom shaped gold distribution pattern for the deposit. The zone has an average grade of 20 ppm Au with localised areas at grades of 50 - 110 ppm. The supergene gold in this zone occurs predominantly as octahedral and hexagonal crystals of high fineness, deposited in voids within iron-rich clay. Secondary gold also occurs in iron-oxide veins within the host unit and along faults in the adjacent country rocks. Above this zone of secondary enrichment, the upper highly leached saprolite is strongly depleted in gold and as a result the mineralization cannot be detected by surface soil sampling or shallow drilling.

Silver, As, Bi, Co, Cu, Mo, Pb, Sb, W and Zn are associated with the primary mineralization, and their mobilities have also been affected by weathering. The relative mobilities and dispersion patterns of gold and these associated ore elements will be discussed in the context of weathering profile evolution under changing environmental conditions.

METALLIC ANOMALIES OCCURRENCE ACCORDING TO THE NATURE OF CONSTITUENTS IN THE WEATHERING PROFILE OF THE MINERALIZED MBORGUENE AREA (EAST CAMEROUN)

Paul Lecomte

BRGM, BP 6009, 45060 Orleans Cedex 2, France

The Mborguene area forms a part of the Betare Oya gold district situated in east Cameroun and contains Au mineralizations associated with sulphides [pyrite] in partly brecciated quartz facies. The mineralizations are scattered in a Lower Proterozoic volcano-sedimentary series consisting of two main units of black schist and sericite schist, close to a monzosyenitic intrusion.

On surface, the secondary gold halo is developed in the various horizons of a 25 m thick lateritic weathering profile, up to the surficial soil, in association with several pathfinders such as Pb, Bi, Mo, W, and As. The different exploration steps [BRGM, unpublished reports] led to the discovery of some orebodies in spite of the lack of outcrops and the thick weathering mantle concealing the bedrock.

In a previous methodological study (Freyssinet et al., 1989), an attempt was made to evaluate and compare the size and type of the geochemical dispersion haloes in the different horizons of the lateritic profile and to define an order for halo size among the different pathfinders of the mineralization, including gold.

A specific sampling of different constituents and at different levels of the weathering profile was undertaken to determine the most efficient metal-bearing phases directly concerned by the primary mineralized environment. The data of this study are presented in this paper.

Sharing out along two traverses cross-cutting two mineralized structures, 14 sampling sites were chosen according to the type of weathering profile and their location in relation to the orebodies. On each site, the various horizons of the lateritic profile were sampled, from the saprolite to the surficial soil. The different constituents were separated generally in five main phases, before the chemical analysis: the fine argillaceous matrix, the ferruginous crust remnants, the ferruginous globular [or pisolitic] nodules, the lithorelics and the quartz.

All these constituents were analyzed for 34 major and trace elements by ICP and for Au by AAS. The data were processed using the classical multivariate statistical analysis as, for instance, the principal component factor analysis, and more specifically the plot of metal variations in the different two-dimension factorial spaces.

At the scale of the prospect area and for whole samples, the metals occurring together in the primary orebody, obviously remain rather well correlated in the weathering profile, with a similar dispersion pattern but different halo sizes. Conversely, partitioning the samples into several constituents, we showed that the best expression of the anomaly is not located in the same phase for each element. The different metals are therefore distributed in increasingly evolved constituents (see table 1) in a rather comparable order to that of the dispersion scale defined in the previous regional study; from one side, Au or W are more specifically associated with the fine argillaceous fraction and the lithorelics and, to the other side, As or Ag are exclusively related to the lateritic material (crust or nodules).

Considering the fine argillaceous matrix only, it can be observed that the image of the haloes is not dependent on the type of weathering horizon or on the sampling depth. In the same way, the contents of quartz or ferruginous material in the matrix do not significantly change from one horizon to other. Conversely, the specific geochemical signature of the geochemical setting around the mineralizations is clearly marked in the fine fraction of the different horizons and, in this case, appears different for each of the two structures.

These results indicate that in this case of lateritic weathering, the more efficient sampled material to define a surface anomalous halo is not necessarily the same for each metal (or pathfinder) of the primary mineralization. In fact, the ferruginous lateritic constituents for As, Ag, Mo and Bi, and the fine argillaceous matrix for Au, W, Pb give the best geochemical response on surface, which corresponds rather well to the specific behaviour of these elements towards iron. Furthermore, the fine matrix seems to correspond to a homogeneous environment, independent of variations in depth or horizon type; the fine matrix would therefore be the more reliable sampling material, particularly for gold.

Table 1: The best image of the anomalous halo in the weathering profile according to the nature of the samples.

Sample type	Au	W	Pb	Bi	Mo	As	Ag
Crust						XX	XXX
Nodules		X	X	XX	XXX	XX	XX
Lithorelics	XX	XX	XX	XX	X	X	X
Fine matrix	XXX	XX	XX				
Quartz							

References:
Freyssinet Ph., Lecomte P., Edimo A., 1989. Dispersion of gold and base metals in the Mborguene lateritic profile, east Cameroun. J. of Geoch. Expl., 32, 99-116.

SURFICIAL URANIUM DEPOSITS - AN ALTERNATIVE SOURCE IN THE NUCLEAR FUEL CYCLE

S.D. Lepky, Institute of Geochemistry and Physics of Minerals, Academy of Sciences of the Ukrainian SSR,
Kiev, SSSR

The analysis of uranium deposits shows that uranium for nuclear power industry is mined from conglomerates, pegmatoid granites, metasomatites and sandstones of the Proterozoic to Phanerozoic age. Mining of these deposits is closely connected with ecological damage due to blasting, stripping, mine sinking and rock handling. Tailings occupying great areas are constant radioactive pollutants of the air and hydrological basins. Gaseous product Rn and UF6 escape into the atmosphere. The personnel is exposed to gamma and beta emitters.

Nowadays there is a trend to search for new sources of nuclear energy fuel that eliminate environmental hazards. Surficial deposits in the cover of the Ukrainian Shield that formed from the Upper Tertiary to Recent age meet some ecological demands. the main advantages of these deposits over conventional types are as follows:

1. Host rock is near or on the surface, and the deposit is mined by open-pit technique or uranium is exacted by in-situ leaching.
2. Due to less voluminous infrastructures surface disturbance is negligible, and the bulk of pollutive waste is small.
3. Physical properties and geochemical background of the surrounding are not significantly altered.
4. Low-level radioactivity of the deposits (radioactive equilibrium ranges within 2 - 8%) makes a less hazardous influence of gamma-radiation upon the staff.

Surficial uranium deposits may be considered a quite promising source for nuclear fuel.

GEOCHEMICAL MODEL OF AURIARGENFEROUS DEPOSIT

Litvinenko Yu. S.
Moscow State University,USSR

1. The geochemical model presented is a generalized graphical or analytical image of a deposit (ore body) where distribution of chemical elements actually existing in a geological medium is replaced by geochemical values (contents and productivities of elements exceeding background values, factors of zonality, similarity, etc.). The latter are presented as respective graphs, maps of isolines, tables, etc. providing new information on a given object.

2. The results of investigating near-surface auriargentiferous deposits localized in paleogene volcanic formations are considered. Ore bodies are composed of chlorite-sulfide-quartz and kaolinite-sulfide-quartz veins and vein zones with steep incidence which are accompanied by primary aureoles of gold, silver and up to a dozen of accessory elements.

3. Vertical zonality of elements distribution formed in the process of ore deposition is accepted as basis when constructing a geochemical model of a deposit. Similarity of particular series of vertical geochemical zonality constructed for main ore zones was helpful at deriving a generalized zonality series for deposits (in upward direction): Mn-Zn-Cu-Sn-Pb-Bi-Mo-Ag-As-Au-Ba-Sb-Hg. Relationships between average over-background contents or linear productivities of elements decreasing constantly with depth reliably indicate mineralization horizons. The relationships are presented as follows V_z:

$$V_1 = Sb.Ag/Mn.Zn,\ V_2 = Sb.Ag/Cu.Zn,\ V_3 = Ag.Pb/Mn.Zn,\ V_4 = Sb.As/Mn.Zn,$$

$$V_5 = Au.Sb/Cu.Zn,\ V_6 = Sb.As/Bi.Zn,\ V_7 = Pb/Zn$$

4. Numerical values of these indicators for different mineralization levels were studied at the cross-section of thoroughly prospected (referential) ore body. The total scale of ore mineralization of a referential body in a conventional metrics is $Z=0,0 \div 1.0$.

5. The obtained V_z graphs provide valuation of all discovered cross-sections of ore veins and vein zones with confidence interval estimation $\pm S/\sqrt{n}$ where n is the number of factors V; S is standard deviation of their values. This resulted in estimating the level of erosion section of ore bodies and separate tectonic blocks as the average of particular estimations over 5-8 factors. Isolines of factors V_z are plotted at longitudinal vertical projections of ore veins and vein zones. They correspond to contour of commercial mineralization to the lower ($Z>0,2$) and upper ($Z<0,8$).

6. Estimates of prognostic resources of ore bodies were carried out over secondary aureoles of deposits distribution by calculating their productivities over areas Pi (in $m^2\%$) with consideration of their similarity coefficients $Hi \neq 1,0$ in respect to the distribution aureoles of referential deposit ($Hi = Pi/P_{ret}$).

7. The construction of the geochemical model of a deposit resulted in concrete recommendations concerning geological prospecting activities which provide their effectiveness.

APPLICATION OF SEQUENTIAL EXTRACTION TECHNIQUE IN PROSPECTING FOR HIDDEN ORE DEPOSITS

Zhou Liyi, Yang Shaoping and Sun Xiaoling

Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849
P.R.China

A sequential extraction technique was developed which can partition metals in geochemical samples into 7 fractions: fraction 1 is related to water-soluble and exchangeable metals; fraction 2 related to metals incorporated in Mn oxides; fraction 3 in organic matter; fraction 4 in amorphous Fe oxides; fraction 5 in crystalline Fe oxides; fraction 6 in sulfides and fraction 7 in silicate residue.

This technique was tried in the surrounding of a known Cu-Ni ore in ultrabasic intrusion. Residual soil samples were taken in a 35 km area. Results obtained show that Ni and Cu in fraction 1, Ni in fraction 5 and 6 can be used to delineate the possible trend of blind Ni-Cu intrusions.

The technique was also tried in Flood Dragon Paw, Gansu Province, where a Pb-Zn ore deposit is completely covered by thick layer of loess (10-120 m). No Pb anomaly and only very weak expression of Ag, Mo and Zn are shown over the deposit by conventional geochemical sampling of the surfacial loess. But very distinct anomalies of Pb and Zn in amorphous Fe oxides can be discovered by applying sequential extraction technique.

16A

MAPPING OF NATURAL AND MAN-MADE STREAM SEDIMENTS AND DISPERSION HALOES IN THE TAIGA TOPOGRAPHY OF EASTERN SIBERIA

[1]I.S. Lomonosov, [1]A.E. Gapon, [1]A.G. Arsentjeva, [2]V.A. Zagoskin, [2]A.I. Zagoskina, [2]V.S. Zelikson, [1]V.I. Lozhkin, [1]G.I. Kobeleva
1- Institute of Geochemistry, Irkutsk, USSR
2 - TsNIGRI, Moscow, USSR

The complex geochemical mapping of river streams and dispersion haloes, which includes sampling of solid-liquid run-offs, soils, plants and underground waters, is the first stage in the study of diverse processes of man-environment interaction. Snow survey is made in towns and their environs (the centers of pollution) at the end of the winter. The density and shape of prospecting grids is estimated considering the expected parameters of pollution zones and areas, as well as local windrose. The geochemical mapping indicated, that the areas affected by man-made activity are rather vast. This factor permits to use sparse sampling grids (1 point per 10-20 km^2) . Under unfavourable climatic conditions of Siberia even the populated areas with poorly developed industry are the source of high technogenic pressure on the environment. The surface waters are easily polluted because of low temperatures and continuous ice cover, and their self-purification capacity is extremely small.

The following procedure is used for differentiation of natural and man-made anomalies. Along with sampling from the channel facies of river alluvium (ecogeochemical survey) the combined samples are collected from the material of its flood plain facies covered by valley soils (geochemical-prospecting survey). The latter serve as natural protection from air and flood pollution. The samples are collected from under the cliff of the flooded (concave) shore through the deepening to 0,3-0,5 m along the horizons. To obtain "pure" samples from the soils, the sampling depth increases to 35-40 cm, i.e. the upper part of the underlying transitional horizon- VS is sampled instead of the illuvial layer, which as a rule lies at the depth of 10-30 cm. For mapping of man-made pollution the combined samples of their mossy cover are collected simultaneously (A_0). Hydrogeochemical sampling is made through the selection of paired samples from various "close" waters, which include all types of underground waters and waters of intraalluvium run-off and from surface river waters.

The comprehensive approach for solving ecological and prospecting problems diminishes the time and expenditure needed for appropriate works. The joint interpretation of geochemical maps, compiled using data interpretation of surface (ecological) and deep-seated (prospecting) sampling, processes by computers increases the reliability of information.

For the first time, the complex estimation of pollution degree of vast areas by geochemical methods, including snow and soil surveys, the analysis of underground and surface waters as well as vegetation is made in the Baikal area. The priority and succession of each survey type is recognized in Siberia. This permitted the geochemical mapping to be made with relatively small expenditures and the maps to be compiled, through diverse methods of data interpretation by the computer.

Geochemical mapping of stream sediments and dispersion haloes permits to plan prospecting works, to recognize ecologically risky zones and areas, which are characterized by heightened concentrations of various chemical compounds and metalls. It also permits to plan rationally constructing of industrial objects and resedential areas, considering ecological situation. This promotes helth protection.

GEOCHEMICAL CHARACTERISTICS OF RARE-METAL GRANITES FROM KALGUTINSKY MASSIF (SOUTH-EAST ALTAI).

I.N.Malikova, Institute of Geology and Geophysics,
Siberian Branch of the Academy of Sciences of the U.S.S.R.

The relationship of the rare-metal mineralization with granites is demonstrated not only by their space-temporal interrelation but geochemical data also. The rare-metal granites are the concluding stage in geochemical evolution of granitoid magmatism with the accumulation of sialic elements, including rare metals. This regularity is strikingly demonstrated during the formation of Kalgutinsky granite massif, accompanied by rare-metal mineralization.

From the biotite porphyric granites of the basic field and the granite-porphyres towards the leucocratic granites and microgranite-porphyres the coefficients of leucocrativity (K_1) and the peraluminous degree (Al') increase; the agpaitic coefficient (K_{agp}) and the sum of alkalies are approximately constant. The Rb/K-index of differentiation and the average value of rare-metal index permanently increase (Table 1). Clark content in many rare elements is several times as large (Table 2).

The distribution of REE in the granites of Kalgutinsky massif is asymmetric: LREE predominate over HREE, the Eu-minimum increases. The total content of REE regularly decreases in the process of differentiation, correlating with the lower in the content of Th, Hf and P_2O_5.

The rare element and REE distribution characterizes the Kalgutinsky massif as a single whole association with the common tendency of development. Obtained geochemical characteristics may be used for ore-content in the rare-metal granites.

Table 1. Some petrochemical and geochemical characteristics of the granites.

NN*	K_1	A_1'	K_{agp}	(K_2O+Na_2O) %	$Rb/K_3 \cdot 10^3$	$F\frac{(Li+Rb)}{(Ba+Sr)}$	Σ 9 REE, g/t	Eu/Sm
1.	$\frac{19,3}{14,7-25,2}$	$\frac{27,9}{6-57}$	$\frac{0,72}{0,62-0,76}$	$\frac{7,6}{6,8-9,2}$	$\frac{5,5}{4,7-5,3}$	$\frac{1326}{339-2907}$	155,3 (n=2)	0,13
2.	$\frac{32,4}{24,0-44,0}$	$\frac{13,2}{(-10)-28}$	$\frac{0,81}{0,78-0.84}$	$\frac{8,0}{7,6-8,4}$	$\frac{8,2}{5,9-9,3}$	$\frac{2935}{1644-7391}$	119,1 (n=2)	0,12
3.	$\frac{41,6}{28,5-59,5}$	$\frac{26,5}{1-49}$	$\frac{0,80}{0,75-0,88}$	$\frac{8,1}{7,4-8,1}$	$\frac{9,3}{8,0-11,8}$	$\frac{7166}{877-23330}$	71,9 (n=2)	0,07
4.	$\frac{50,0}{36,7-69,3}$	$\frac{50,2}{24-69}$	$\frac{0,74}{0,69-0,78}$	$\frac{8,0}{7,6-8,3}$	$\frac{12,3}{11,1-15,1}$	$\frac{55297}{19663-91636}$	44,6 (n=2)	0,07

* The rocks: 1- biotite porphyric granites (n=14), 2- granite-porphyrs (n=7), 3- leucocratic granites (n=16), 4- microgranite-porphyrs (n=11). In numerator - means values, in denominator - limits of variation, in brackets - number of analises.

$K_1 = \frac{Si+Al+K+Na}{Fe+Mg+Ca}$, atoms; $Al' = Al-(2Ca+K+Na)$, atoms; $K_{agp} = \frac{K+Na}{Al}$, atoms.

Table 2. The element's formulae of the granites, by V.D.Koslov (1985).

NN	Number of analises	Element's formulae
1.	22	B 5,4-W 4,5-Li 3,0-Be 2,8-F 1,6-Sn 1,5-Rb 1,5 -Pb 1,4-Zn 1,3 Ba 0,3
2.	10	B 5,6-Be 4,6-F 4,3-W 4,3-Li 2,3-Rb 1,7-Mo 1,2-Sn 1,1-Pb 1,1 Zn 0,6-Sr 0,4-Ba 0,1
3.	20	W 5,0-B 3,8-Be 2,9-Mo 2,3-Li 2,2-Rb 1,9-F 1,3-Sn1,2-Pb 1,1 Zn 0,7-Sr 0,3-Ba 0,1
4.	13	W 9,4-B 8,0-Li 6,7-Be 5,3-F 3,4-Mo 2,9-Rb 2,8-Sn 1,5 Pb 0,8-Zn 0,4-Sr 0,3-Ba 0,03

Reference:

Koslov V.D./1985/: Geochemistry and ore-content of granitoids of rare-metal provinces. Moskow, "Science", 303 p.

Methodology of Geochemical prospecting applied for Pb-Zn ore in carbonate medium at Djebel Bou Arif; Batna (Algeria).

R. **MARMI** : -Department of Geology, Institute of Earth Sciences, University of Constantine.

ABSTRACT:

This paper deals with the methodology and the results of two geochemical methods (lithogeochemistry and pedogeochemistry) applied in carbonate environment. Based on statistical analyses of the obtained data, the geochemical anomalies and associations were determined.

The controls of the prospected mineralization were found to be mainly litholigical and structural. Consequently, the applied methods can be successfully used for the prospection of such in deposits in similar semi-arid zones.

INTRODUCTION

Djebel Bou Arif at Batna (East Algeria) is an anticline trendind SW-NE. The location and geological formations are represented in Fig. 1. Rocks are mainly of Cretaceous age (J.M.Vila, 1980).

The first purpose of this work is to try to establish the methodology of geochemical prospecting for searching polymetallic (Pb-Zn) deposits in carbonate medium.

The second purpose is to study the distribution of elements in rocks and soils.

About 460 soil and rock samples were collected following a mesh of 100 x 20m, in an area of about 1Km^2. Chemical analyses were carried out by Plasma Spectrometry for the determination of the elements: As, Ba, Co, Cu, Fe, La, Mn, Mo, Pb, Sb, Sr, Ti, V, Y and Zn. The chemical analyses data of rocks and soils were separately worked out (lithogeochemistry and pedogeochemistry).

Lithogeochemistry

The main objectives of the present work are :

- determination of the distribution character of chemical elements;
- determination of different geochemical associations;
- delineation of geochemical anomalies .

From the correlation of simple geochemical profils with bedrocks, it is observed that the high grades of As, Cu, Pb, Sb and Zn are particularly related to dolomitic and/or siliceous limestones. It is also noted that the relative abundance of Fe and Mn are related to dolomites. The E-W fracture system is often associated with high Pb and Zn contents. The average trace element contents in the limestones of Bou Arif are as follow :

As	Ba	Co	Cu	Fe	La	Mn	Mo	Pb	Sb	Sr	Ti	V	Y	Zn
36	600	19	5	2.2	31	850	13	46	45	220	.01	20	19	64

(all in p.p.m. except for Fe and Ti which are expressed in %)

18

Fig.1

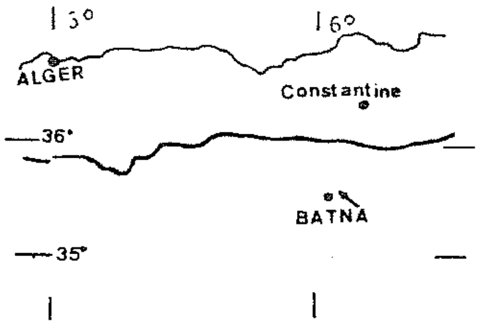
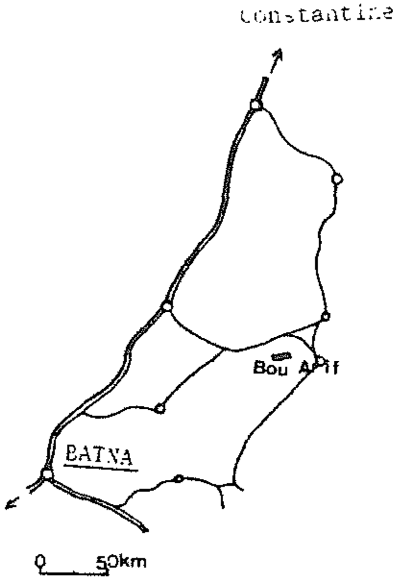


Fig.1. a- Location map



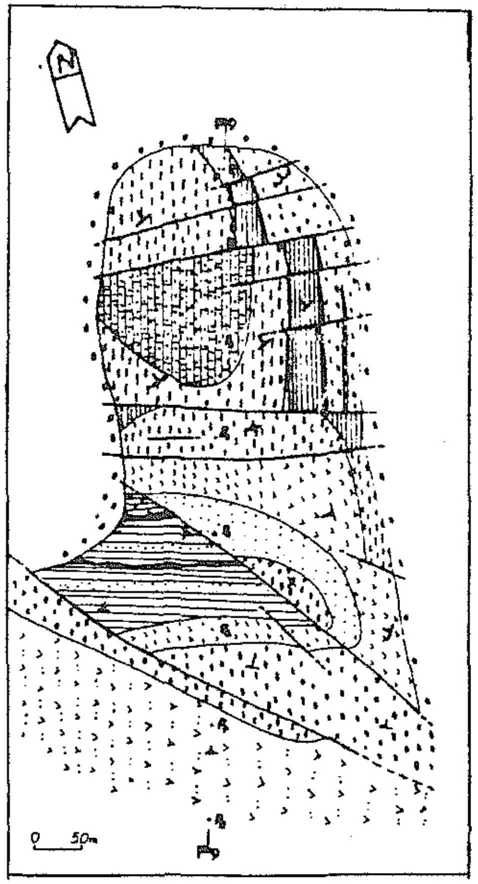


Fig.1. b- Geological map of the area.

1 ▦ 2 ▤ 3 ▤ 4 ▨ 5 ▭ 6 ▤ 7 ▨ 8 ▨

9 ⬚ Sst / Fractures

1. Siliceous Lst. 2. Lst with brown dottes.

3. Lst with lamellibranch. 4. Orbitolined Lst.

5. Marl. 6. Intercalation of Lst and Bedded Sst.

7. Yellowish brown dolomite. 8. Arrenaceous dolomite.

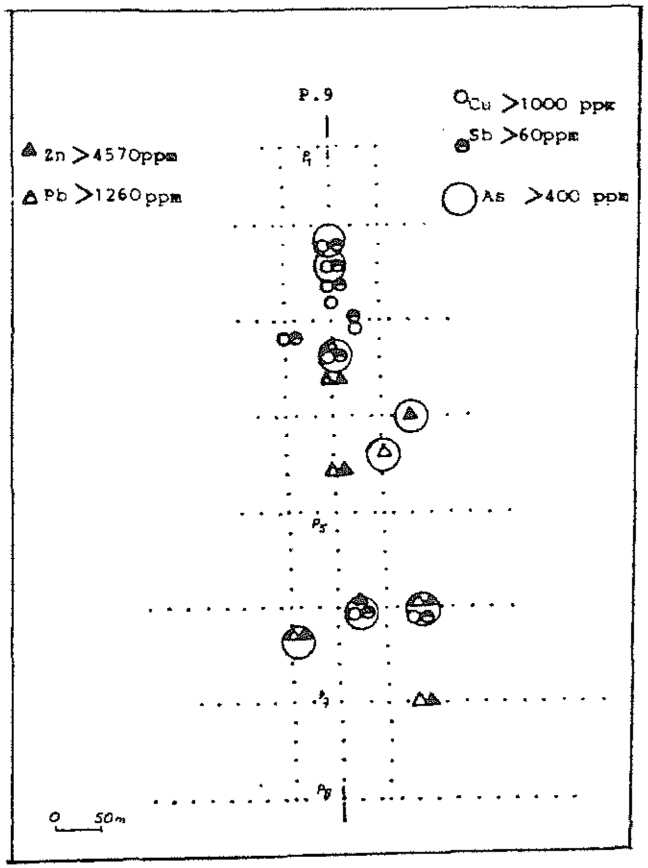


Fig.3. Multi-elements geochemical map of Pb, Zn, Cu, As and Sb (in rocks).

Statistical analysis of data

1.Univariate analysis

Considering the graphic (histograms) and the mathematical (test of Ahrens) analyses, it is found that the distribution of most elements is lognormal. It was previously indicated by Till, 1974 (In Dejongh, 1985) that the role of the lognormal distribution predominates in the statistical distribution of trace elements. The analyses undertaken in this study are based on the works of Lepeltier, 1969 and Sinclair, 1976 and 1986. The probality curves of the principal elements generally reveal polymodal distribution (Fig .2). The population of high values characterizes the dolomitic limestones. However, the population of the low values corresponds to sandstones as to limestones with intercalations of marls and sandstones away from mineralized zones.

The local geochemical background (b) for some of the analysed elements is given in the following table:

Elements	As	Ba	Cu	Fe	Mn	Pb	Sb	Sr	Zn
b (p.p.m)	59	399	4	.56	553	106	39	63	369

The threshold concentration (t), was determined using the following formula :

$$\log t = \bar{x} + 2s$$

where, $\bar{x}$: denotes the arithmetic mean of logarithms of concentration of the element,

and s : denotes the standard deviation of logarithms.

A multi-elements geochemical map of Pb, Zn, Cu, As and Sb is given in Fig .3. Analysis of this map revealed that :

- the two lead-zinc and copper mineralization types are whether superposed or separated in space,
- the anomalous As contents follow the two mineralizations,
- the mineralization control is both tectonic and lithologic

2 Bivariate analysis

Correlation matrix

The significance level of the correlation coefficient is calculated using the following formula (Dixon and Massey, 1957) :

$$r_o = \sqrt{T^2 / T^2 + (n-2)}$$

where T, is the Student value and n is the number of samples. The significance level in this case is $r_o = .152$ at a probability level of 99 %, with T = 2.33. The followings are the high correlation coefficients obtained from the correlation matrix.

a. Cu-Sb (.791), Cu-As (.757) and As-Sb (.827)
b. Pb-Zn (.741), Pb-Cd (.793) and Zn-Cd (.704)
c. Fe-Mn (.726)

The first principal association (Cu,As and Sb) corresponds to the copper mineralization, represented by the grey copper ore.

The second association (Pb,Zn and Cd) corresponds to the lead-zinc mineralization which is fondamentally represented by galena and sphalarite. The third association (Fe and Mn) represents the relatively high contents of these elements in the ferrodolomites.

Plots represented by dispersion diagrams, clearly reflect the good positive correlations revealed from the correlation matrix.

3.Multivariate analysis (Factorial Analysis)

Data processing by factorial analysis has been used in addition the other statistical analyses. Its application of aims to cheek the previously obtained correlations and search for new possible ones.

Principal component analysis of the lithologic data has been used in the processing of the "mode R" (concerning the element contents), (A.M. Karpoff, 1973). The obtained results with orthogonal rotation of the factorial matrix (Varimax Method) are given in Fig .4. The factorial analysis has confirmed as well the geochemical associations previously obtained.

PEDOGEOCHEMISTRY

In certain regions the pedology surface penalize the direct prospection where large areas are still unexplored (Wilhelm and al., 1983).

By the geochemical prospecting of soils, the aims to achieve are the following :

- the study of the behaviour of elements such as Pb,Zn and Cu in soils with carbonate substratum ;
- verification of the previously obtained geochemical anomalies ;
- determination of the different geochemical associations .

From the simple geochemical profils and the ratios of the average contents of elements in soils and in bedrocks, an enrichment of some elements such as As, Cu, Fe, Pb, Sb, V and Zn in soils is observed. This is probably the result of high retention of such elements by iron and manganese oxides. It should be noted that the measured pH of soils varies from 7.8 to 8.8 indicating a slightly alkaline medium.

Statistical analysis

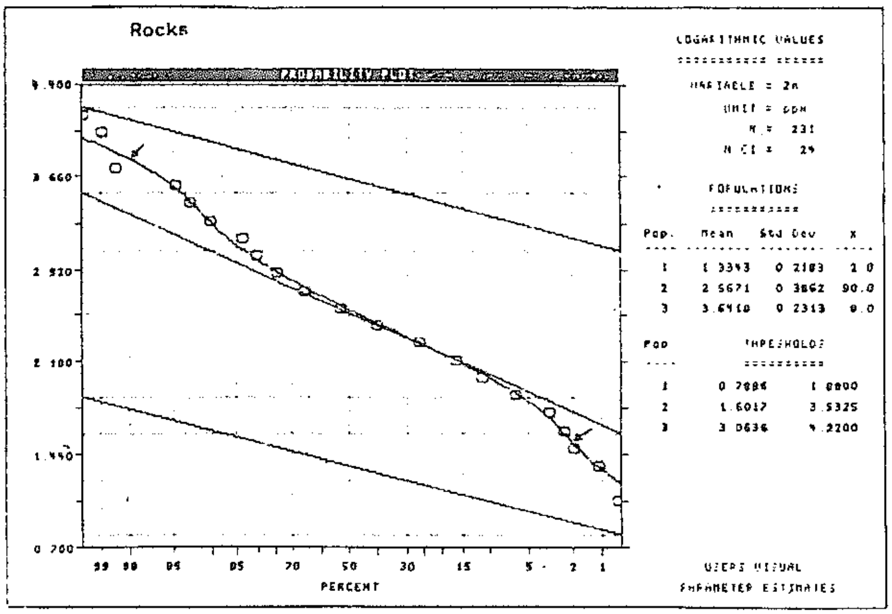
a. Univariate analysis

The histograms, probability curves and mathematical processing confirm that the distribution of the principal elements (Pb,Zn and Cu) approximates the lognormal law with a polymodal character.

From Fig .5 representing the geochemical map of the elements: As, Cu, Pb, Sb and Zn in soils, it is clear that :

- the Pb-Zn mineralization which is often separated from the copper one is also related as well to certain fissures and to the dolomitic facies;
- the copper mineralization (Cu, As and Sb) appears clearly in soil covering the siliceous facies;
- the soil geochemical map reveals as well the litho-structural control and the two principal mineralizations (Pb-Zn and Cu-AS-Sb).

19A



```
LOGARITHMIC VALUES
=========== ======
VARIABLE = Zn
UNIT = ppm
N = 231
N CI = 29

POPULATIONS
===========
Pop.   Mean     Std Dev    x
----  --------  --------  -----
 1    1 3343    0 2183    1 0
 2    2 5671    0 3862   90.0
 3    3.6910    0 2313    9.0

Pop         THRESHOLDS
----        ==========
 1      0 7886      1 8800
 2      1.6017      3.5325
 3      3 0636      4.2200

USERS VISUAL
PARAMETER ESTIMATES
```

Fig.2. Cumulative Frequency Distribution.

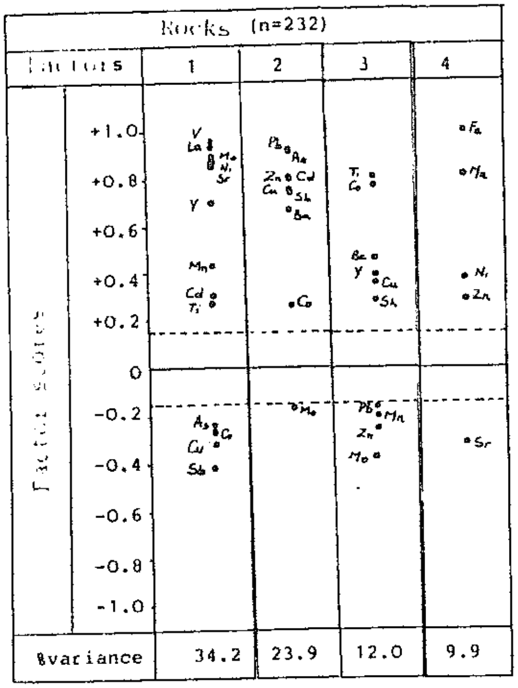


Fig.4. Graphic representation for results of factorial analysis.

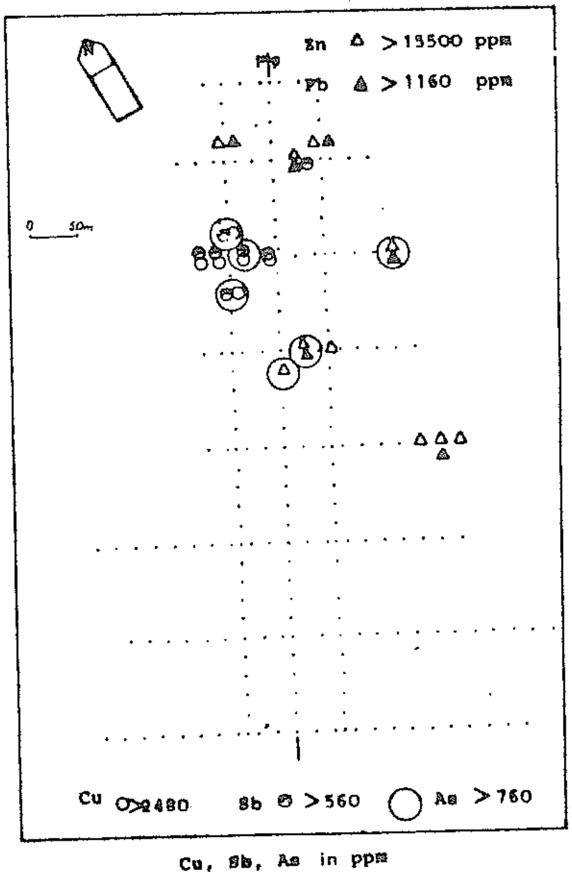


Fig.5. Multi-element geochemical map of As, Cu, Pb, Sb and Zn (in soils).

b. Multivariate analysis

b.1. Simple correlation

The calculated coefficients of correlation clearly reflects the following geochemical associations: Fe, Mn; Ni, V, Co; Pb, Zn ,Cd and Cu, Sb, As, Ba. The positive high correlations are given with their corresponding correlation coefficients: Fe-Mn (.859), Co-Ni (.833), Zn-Cd (.926), Zn-Pb (.911), Pb-As (.855) and Cu-Sb (.802). These correlations are also verified using dispersion diagrams.

b.2. Factorial analysis

The results obtained using this method are tabulated below:

Soils (73.1% explained variance)		
F_1:	Co, Ni, Y, V, Ti	(31.4%)
F_2:	Cu, As, Sb, Ba	(19.3%)
F_3:	Zn, Pb, Cd	(12.2%)
F_4:	Fe, Mn	(10.2%)

F_1: accessory mineralization resulting from the process of coprecipitation related to Fe and Mn oxides.

F_2: copper mineralization (grey copper and supergene minerals).

F_3: lead-zinc mineralization (galena and sphalarite and their alteration products: cerussite, smithsonite, hemimorphite...).

F_4: oxides (or hydroxides) of iron and manganese.

CONCLUSION

The statistical distribution of elements are found to be lognormal with a bimodal or polymodal character.

Lithogeochemical and pedogeochemical maps showed clear anomalies that correspond to indices of mineralization.

The obtained geochemical associations caracterize the two principal types of mineralization Zn, Pb and Cu, As, Sb.

Geological and geochemical maps revealed the litho-structural control.

The technics of this prospection can be satisfactorily used for searching such ore deposits in similar semi-arid zones.

A SUMMARY OF DATA OF THE LITHOCHEMICAL SURVEYS OF 1:200000 SCALE WITH A PURPOSE OF METALLOGENIC ANALYSIS AND REGIONAL PREDICTION

A.A.Matveev, Moscow State University, USSR

An effective exploration of vast and poorly areas of the North-Eastern part of the USSR is provided with lithochemical surveys by dispersion trains; sampling of the recent stream sediments with an average density of 1 sample per sq. km that corresponds to 1:200 000 scale survey. The surveys result in identification of new and in studying of known ore mineralisation areas and they prepare areas for the first priority lithochemical surveys of 1:50 000 scale and more detailed geochemical activity. A complex metallogenic characteristic for specific metals is obtained for the territory studied and it estimates a real ore-bearing potential as resources of P_3 category.

For the metallogenic analysis and regional prediction a summary of data at an area of 120 000 sq. km has been done. With this purpose a calculation of an average higher-then-background contents of 11 specific for the territory studied metals by 240 "elementary cells" has been done. An "elementary cell" is meant to be two adjacent 1:50 000 scale toposheets (area of 500 sq. km). The data obtained are used for compilation of monoelement maps on specific productivity of main ore elements (in t/m/sq.km) and on geochemical indeces (ν) of the first, second and third orders. The interpretation has proved previously discovered ore mineralization and revealed new promising areas for the first priority detailed geochemical work with the quantitative estimate of expected reserves of main metalls. An analysis of geochemical maps has shown that deposits and occurrences of these metals in the area are located to be perivolcanic zone - to the transitional one between the Mesozoids and the area of late volcanic activization. This is of great significance for further geologic-exploration works in the North-Eastern of the USSR on the whole.

The quantitative analysis of obtained data is made by calculating the total sum of productivity P_i for each element on all 240 cells and finding the number of magnitude classes m based on relationship $\Sigma P_i/m$ = const. For such culculation the productivity of a large deposit dispersion aureole can be find according of the relation $P_{large} = Q_{large}/H_{large}$. Here Q - the reserves of a large deposit - is given in tons and H - the total vertical longitude of a large deposit in m. The results of such calculations have permited to estimate the total expected reserves of main metalls for the studied territory and indicate by the isoconcentration maps the localisation of the largest deposits.

21

APPLICATION OF GEOCHEMISTRY TO GEOTHERMAL EXPLORATION IN TENGCHONG GEOTHERMAL AREAS OF CHINA

Shen Minzi Tong Wei Zhang Zhifei Zhu Meixiang
(Geology Department, Peking University)

Tengchong is a famous volcano-geothermal area in China. It is situated on the western slope of Gaoligong mountain in south-west part of Yunnan province, extending from latitude 24°38' N to 25°51' N and from longitude 98°05' E to 98°45' E. Geologically, it is a volcano-geothermal region and belongs to the southward extension of the Himalayan continent-continental convergence type geothermal belt. The numerous volcanoes and active hydrothermal manifestation have attracted geoscientists in the past and at present. After 1973's reconnaissance, in 1980s the investigation extended and covered a wide range, including geochemistry method such as hydrothermal fluid and isotope study, trace element and hydrothermal alteration study. The study object is essentially in its natural state and field work is limited to surface. So our study could be equivalent to predevelopment or preexploration prospecting phase.

Based on the chemical data of 49 gas samples, 77 thermal spring and 5 cold spring water samples, it is clear that the gas composition is broadly similar to those from the most volcanogeothermal regions in the world, the type of HCO3-Na is the most common species of thermal waters, only some high-temperature waters are of Cl-HCO_3-Na or HCO_3-Cl-Na type. Estimating by chemical geothermometers, five high-temperature geothermal systems have temperature of more than 150°C and others are of 90-150°C.

On the basis of deuterium and oxygen-18 analyses of 69 thermal springs and other waters it has been confirmed that all geothermal waters are originally meteoric. Most of geothermal waters have oxygen isotope shift of less than 2%, but some high temperature geothermal systems. By deuterium data the flow systems, flow paths and the recharge areas of most geothermal systems have been deduced.

According to 49 hydrothermal carbon and 48 hydrothermal sulfur samples it is suggested that some mantle-derived materials might have probably arisen to the surface, then mixed with the hydrothermal waters. Because of no isotope fractionation among the sulfur-bearing materials with different valences it could be supposed the temperature at shallow depths might be so high as to be unbearable for the sulfur bacteria.

Study on hydrothermal alteration has provided that such carbonate efflorescences as travertine, calcite, trona, thermonatrite and such simple sulfates as thenardite and gypsum are commonly present around the low temperature hydrothermal areas, but the siliceous sinter and salt efflorescences, composed of such complex sulfates as alunogen and halotrichite, are only present in some high temperature hydrothermal areas.

The Hot Sea geothermal field is one of the most potential geothermal areas in China. The geochemistry study has been concentrated here. The investigation of soil mercury, arsenic, antimony and bismuth was carried out around the field of 61 km2 and with 107 soil samples. It has got the idea of location the boundaries of Hot Sea geothermal field. It is found recently there is no connection between Hot Sea and Langpu Hot Pool geothermal systems. But arsenic and antimony isoanomalies have shown some connection between their fossil precursors. The hydrochemistry concepture model of Hot Sea suggests that the temperature of parent hot water from heating zone may be no less than 276°C. The temperature of the separated water from vapor at the depth over 300m may be of about 230°C. The oxygen and hydrogen stable isotope composition of thermal waters and steams provide a water-steam separation temperature of 104°C and delta D and delta 18O values of deep thermal fluid. In the light of the delta D and delta18O values as well the tritium content of spring waters it is clarified the subsurface boiling, the mixing-subsurface boiling and subsurface boiling-mixing processes during fluid ascent from geothermal reservoir to surface and the distribution of springs with these processes has been contoured. The hydrothermal alteration manifestations on the surface also give the zoning of Hot Sea geothermal field which is compatible with that by water isotope method. The first zone is of alunite+kaolinite-kaolinite+I-S mixed layer minerals from inside to outside respectively. The second zone is of I-S mixed layer minerals+kaolinite along its outside subzone. Furthermore, the presentation of the uranium-bearing minerals in hydrothermal area provides an important inspiration to the original types of the uranium deposits.

GEOCHEMISTRY OF THE GOLD-BEARING MAGMATIC SYSTEMS AND PREDICTION PROBLEMS OF THE GOLD DEPOSITS

A.G. Mironov, Geological Institute, SB AS USSR,
Ulan-Ude

The model of the gold ore deposits related to small intrusions and dykes was developed out on the basis of the experimental data and the summary of the published geochemical materials. A wide range of the experimental investigations of the gold behavior in the magmatic systems was carried out with the aid of the radioactive tracers method. There were the limits of the gold solubility in silicate melt (n.10^{-7} + 10^{-5} mas.%) established. These limits are conditioned by many factors (PH_2O, Pfl, CMeO and others) depolymerizing the melts.

It was ascertained that gold-quartz-sulphide mineralization has the genetic relationship with the dykes and stocks representing the melt-fluid system transporting gold at the moment of the intrusion. The implications of the fluid saturation (autometasomatism, accompaning inclusions, eruptive breccias) and composition, hybridization (unbalanced mineral associations, relicts of the xenoliths of the country rocks, etc.) as well as higher gold content (n.10^{-6} - 10^{-5}mas.%) are typical of these dykes and small intrusions. The ore-bearing fluid-saturated magmatic system forms in the front of the magma formation of the granitic batholites, where the hybrid magma forms as a result of assimilation of the enclosing series by the granites or as a result of a mixture of the acid and basic magmas.

On the basis of this model the criteria of the gold deposits prediction were developed. The main ones among them are the gold ore times to regional hybrid facies of the granitic intrusions, the higher gold content in the dykes and small intrusions, the presence of the country rocks with the gold-bearing varieties such as ophiolites, black shale with sulphides and other more.

22

Geochemical Exploration in Heavily Contaminated Areas: The Experience of the Last 20 Years in South West England

C.J. Moon
Leicester University, England

Geochemical exploration in this major mining district has proved problematic as a result of the previous several hundred years of mining and smelting. Waste from mined deposits is spread over the order of km^2 and gives a surface signature several times stronger than an undisturbed deposit.

The aim of this contribution is to synthesise the academic and commercial work of several tens of prospects over the last 20 years: much of the latter information has only recently become available in the public domain.

Classical surface geochemistry, particularly stream sediment sampling, is of little use within 5km of significantly mined areas. Soil sampling can delineate vein mineralization but is often ambiguous and can only be resolved by deep augering or trenching. As a result many commercial companies have made deep sampling their primary exploration approach; it also has the advantage of not assuming that the overburden is residual. A detailed example will be discussed from a 40 km^2 area around the producing Wheal Jane mine. Rock geochemistry has not been widely applied as the fissure veins have very limited primary concentration haloes and outcrop is poor; however, fractionated and altered granite bodies associated with stockworks can be defined using this method. The example of a major disseminated tungsten deposit will be used.

Regional geochemical maps emphasise the mined areas at the expense of more subtle responses from other, previously unsuspected, deposit types and mask background lithological signatures. The example of recently discovered gold and massive sulphide prospects in South Devon will be discussed in detail.

A MODELLING APPROACH TO DEVELOP A NEW TECHNIC FOR FINDING A HIDDEN SKARN-TYPE OREBODY IN THE CAMBRIAN LIMESTONE BEDS OF THE TAEBAEG BASIN IN SOUTH KOREA

Kun Joo Moon, Korea Institute of Energy and Resources

Most of significant ore deposits in south Korea such as the Sangdong W-Mo, the Yeonhwa Pb-Zn and the Geodo Cu-Fe skarn ore deposits occur at the southern limb of the Hambaeg Syncline in the Taebaeg Basin. The mineralizations took place in the interbedded limestone of the Myobong Formation and the Pungchon limestone of the Great Limestone Series of the Cambrian age, generally striking E-W and dipping 25-30° to the north.

There are no outcrops of the skarn-type orebody at the northern limb of the syncline. In order to find a clue of a possible hidden orebody localized at the limestones in the northern limb, a lithogeochemical exploration by using carbon isotope and some elements such as Si, Ca, Fe and Al at the Sangdong Mine area has been attempted as for a modelling study.

For this study, 50 samples from the Pungchon limestone which do not show any megascopic indication of mineralization have taken in both the mineralized zone and the unmineralized zone at the Sangdong mine area.

Analytical data show that there are big differences in the contents of CaO and Al_2O_3 between the Pungchon limestone of the mineralized zone and that of the unmineralized zone. Carbon isotope data exhibit that delta C^{13} values of the Pungchon limestone in the mineralized zone are lighter than those in the unmineralized zone. The difference in the analytical values of CaO, Al_2O_3 and the carbon isotope between the mineralized and the unmineralized zones is as follows ;

	Unmineralized zone	Mineralized zone
CaO	48.6%	40.6%
Al_2O_3	0.6%	2.4%
Delta C^{13}	- 0.39 permil	- 0.56 permil
Fe^2O^3	0.9%	1.6%
SiO^2	3.0%	2.5%

The decrease in the Si content of the Pungchon limestone in the mineralized zone is contrary to the result of the previous study (Moon, 1987). On the basis of identification of the increase in the Al content of the limestone in the minerzlized zone, it could be deduced that the decrease in the Si content of the Pungchon limestone might be due to the result of increase in the alteration products mainly occurred along fracture-systems such as joint cracks or minor faults. And that the phenomena shown by the Si and Al contents in the mineralized zone might be derived from the extended mineralizing activity to the overlied limestone on the surface.

Higher mean values of Ca, Fe and Al as well as lower mean values of the delta C^{13} than mean values of those in the Pungchon limestone at the northern limb of the Hambaeg Syncline may be applicable in exploration for blind orebodies.

Reference :

Moon, K.S./1987/: Host-Rock Lithogeochemistry Applicable to Exploration in the Hambaeg Syncline (Hambaeg Basin), Korea. Jour. Geochem Exp., 28, 119-132.

THE USE OF ELECTRON PARAMAGNETISM AND TRACE ELEMENTS CONTENT OF VEIN QUARTZ IN MINERAL EXPLORATION

J.C. van Moort, University of Tasmania, Australia

Two and a half thousand microcrystalline vein quartz samples from various types of ore deposits were analysed by electron paramagnetic resonance spectroscopy (EPR) and two hundred of these were analysed for thirty trace elements each by proton induced x-ray emission (PIXE) and atomic absorption spectroscopy. All quartzes were selected on purity, pulverised and treated with acid in order to remove possible carbonate and sulphide inclusions.

The paramagnetism of the quartz is presumably caused by the presence of $[AlO_4]^-$ centres in Ge containing H^+, Na^+, Li^+ compensated quartz.

The practical outcome of this investigation is that the EPR powder spectra of auriferous and argentiferous quartz show in most cases a pronounced electron paramagnetic resonance peak at the spectroscopic splitting factor g 2.0025. Barren quartz rarely shows this paramagnetism. This relation was worked out in detail for the Devonian Beaconsfield reef in Tasmania; the Devonian shear zones at Fosterville, Victoria; the Tertiary gold deposits in Waihi and Karangahake in New Zealand, and Rodalquilar in Spain; and the Cambrian gold-bearing volcanogenic massive sulphide deposits in western Tasmania. The intensities of the paramagnetic signal however vary between geological areas. Statistical evaluation of the Beaconsfield and Fosterville deposits indicates that the intensity of the EPR signal correlates with the gold content with a Spearman ranking correlation coefficient of 0.62, shown in Figure 1. The reason for this fair correlation is presumably that the chemical processes of quartz and gold deposition are related (rapid drop in temperature and pressure).

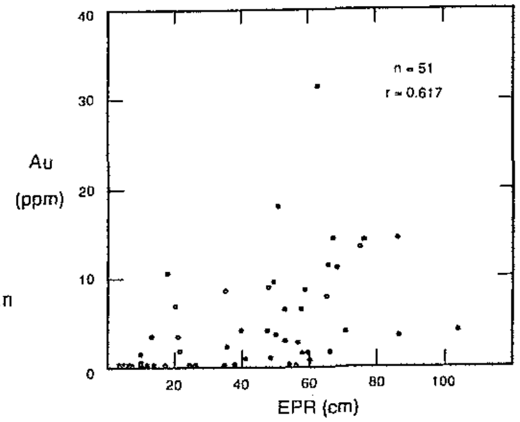


Figure 1

Scatter plot of intensity of the paramagnetism of Fosterville vein quartz (measured as the height of the first derivative EPR peak at g 2.0025-2.0030) against the Au content of the host rock in which the vein is located. The EPR scale (in cm) is a relative scale. Spearman ranking correlation coefficient of 0.62.

The Ge content of the quartz correlates very well with its paramagnetism and consequently the Ge content of the quartz can also be used as an indicator whether adjacent mineralisation may occur. See Fig. 2

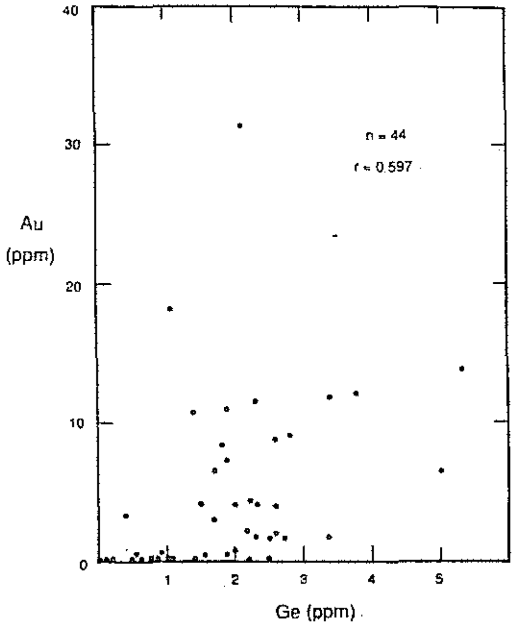


Figure 2

Scatter plot of the Ge content of Fosterville vein quartz against the Au content of the host rocks. Spearman ranking correlation coefficient of 0.60. Note that the relation is non linear.

Ge can only be trapped in the quartz lattice during very rapid growth. Germanium is an element typically enriched in late magmatic and hydrothermal fluids. The relation of the Au content of the host rock with the Ge content of the quartz is of a secondary nature like the relation with its paramagnetism.

All auriferous and argentiferous quartz studied contained submicroscopic sericite. This leads to a positive correlation of the Au content and the intensity of the EPR signal with the concentration of Al, K, Rb, Mg, Na and, to a lesser extent of Li.

REFERENCES

van Moort, J.C. and Russell, D.W. (1987): Electron spin resonance of auriferous and barren quartz at Beaconsfield, Northern Tasmania. *J. Geochem.Exploration, 27:1-11.*

van Moort, J.C. and Brathwaite, R.L. (1988): Electron paramagnetic resonance of the epithermal quartz from the martha Hill gold-silver deposit, Waihi, New Zealand. *Bicentennial Cold 88. Geol.Soc.Australia No.23, Vol.2:575-578.*

van Moort, J.C. Cohen, D.D. Russell, D.W. and Katsaros, A.(1990): Relation between chemical composition as determined by PIXE and paramagnetism of auriferous quartz. *Nuclear Instruments Physical Research.* (in press)

GEOCHEMICAL ORIENTATION SURVEY FOR TIN AND RARE ELEMENTS IN IGLA AND ABU DABBAB AREAS, EASTERN DESERT, EGYPT

M.A. Morsy
Geology Department, Faculty of Science, Alexandria University, Egypt

This geochemical investigation was carried out in two localities, south the Eastern Desert of Egypt, which are characterized by Precambrian apogranites. Fifteen selected samples from both occurrences, including stream sediment, soil rock types, were analyzed for 45 elements using Instrumental Neutron Activation Analysis (INAA).

The two occurrences are characterized by enrichment in granophile and other elements- such as Sn, W, Ta, Rb, Zr and PEE. Simple use of multiplicative ratios as (Rb3 / Ba X Sr X K) gives values for most studied samples greater than $1X10^{-3}$ which is indicative of specialized granitoids mostly Sn.

PROSPECTING AND EVALUATION OF COPPER MINERALIZATION THROUGH THEIR GEOCHEMICAL AUREOLES IN KHASHM EL FAKH AREA; SINAI; EGYPT.

M.A.Morsy and A.M.A.El. Makky

Geology Department, Faculty of Science, Alexandria University, Egypt

Khashm el Fakh area is located in the southern Sinai, about 35 km north of Sharm el Sheikh at the gulf of Aqaba. The area is composed of greywacke, mudstone and metabasalt within the tarr complex, which is the southern portion of the Precambrian Kid group. Three hundreds samples were collected from the studied area for the lithochemical surveys and analyzed spectrographically for Cu, Pb, Zn, Co, Ni, Ba, Sr, V, Sn, Be, Mo, Ag, Bi and Mn. The background and thershold values were estimated for these elements. Then the quantitative evaluation of the copper mineralization was carried out based on two stages: semidetailed and detailed lithochemical surveys. In the semidetailed lithochemical survey (scale 1:50000) using the dispersion trains, the estimated geological reserve of copper was 110454 tons (Cu). While in the detailed lithochemical survey (scale 1:10000) using the secondary dispersion aureole, the estimated geological reserve was 110434 tons (Cu).

GEOCHEMICAL PROSPECTING OF DEEPLY CONCEALED ORE BODIES IN THE CAUCASUS ACCORDING TO THE SECONDARY SUPERIMPOSED DISPERSION HALOES

J.G.Nadareishvili, B.A.Sudov

Caucasian Institute of Mineral Resources
Tbilisi, USSR

The practical experience gained in the Caucasus has demonstrated that effectivity of geochemical prospecting with regard to the secondary dispersion haloes can be significantly improved by using the secondary superimposed haloes in different forms of occurrence of the elements (sorbed, water-soluble, organometallic) which are to be explored at a considerable depth.

Diffusion of dissolved ore elements in the loose deposite pores, which is due to the capillary ascent and temperature gradient, is considered as the most universal mechanism controlling the formation of the secondary superimposed dispersion haloes. A detailed investigation was carried out into the dynamics of element migration and adsorption processes at the geochemical barriers where the secondary superimposed dispersion haloes form.

Thus, there arises a possibility to compare theoretical and practical models of the secondary dispersion halo formation,of geochemical zoning of different forms of occurrence of the elements which is of high importance in prospecting.

A comparative study of sorbed, water soluble and organometallic forms of elements was carried out over various ore deposits of the Caucasus that revealed different specific landscape geochemical features of the secondary dispersion halo formation. The results were compared with traditional lithochemical survey data on the secondary dispersion haloes, with the bulk spectral identification of the indicator elements.

The studies involved three instances of formation of the secondary dispersion haloes characteristic of the Caucasian highlands:
a) high and middle mountain reliefs with deluvial sediments of 3-10 m thickness;
b) high and middle mountain reliefs in the river gorges and over landslide areas with alluvial, deluvial and other allochthonous sediments of 20-50 m, occasionally, of up to 100 m thickness;
c) low mountain and piedmont reliefs with alluvial and, more seldom, deluvial sediments of 10-15 m, occasionally, up to 100-150 m thickness.

The main processes of the secondary dispersion halo formation under these conditions consist in the saline migration of the elements in the liquid phase with subsequent retention of the elements at different geochemical barriers. Mechanical migration is confined within a 3-5 m thick covering.

The investigation have demonstrated that in the case of loose thin (up to 3-5 m) sediment layers on the mountain slopes, the geochemical zoning of different forms of element occurrence in the secondary dispersion haloes is as follows (down the slope, from the concealed ore bodies): sorbed form - water-soluble forms - organometallic forms - bulk forms. As the thickness of the loose sediments grows, the forms of occurrence (up to the surface from the concealed ore bodies) are arranged in the following order: bulk form - sorbed and water-soluble forms organometallic form. Geochemical zoning of individual elements is observed within the halo of each form.

It has been shown that the sorbed forms of element occurrence create the secondary dispersion halo directly over the outcropping of the concealed ore bodies into the erosion section at the depth of about 50 m in the Greater Caucasus and 100-150 m in the Lesser Caucasus.

The water-soluble forms of the elements occurrence in the secondary dispersion haloes are retained at the depth of up to 50 m in the Greater Caucasus and up to 25 m in the Lesser Caucasus, with the 10-40 m displacement down the slope from the concealed ore body outcropping into the erosion section. (The maximum depth of exploration for this form of occurrence has not been established).

The oraganometallic forms of the element occurrence in the secondary dispersion haloes are detected with a 20-60 m displacement away from the concealed ore bodies, with about 100 m thick sediment bed in the Greater Caucasus and over 150 m thicker one in the Lesser Caucasus. (The maximum value of the halo has not been found).

The secondary dispersion halo displacement down the slope, with the bulk spectral identification of the elements, is usually 30-100 m.

The theoretical calculation of the element migration in the superimposed secondary dispersion haloes under the specific landscape and geochemical conditions of the Caucasus have proved that the depth of exploration may reach 200-250 m.

Thus, the geochemical prospecting of deeply concealed ore bodies according to the secondary superimposed dispersion haloes is an important potential means to improve the effectivity of prediction of ore deposits.

25A

Naumov G.B.,Yasnosh N.Ye.

COMPOSITION OF ORE-ASSOCIATED HALOES AND MECHANISMS OF ITS FORMING

Geochemical haloes are widely used in geological practice. However , the successful use of geochemical data depends on our knowledge of regularities of haloes composition and mechanisms of its forming.

Usually the forming of ore-associated haloes is considered to be the result of interaction of hydrothermal solutions, which move in interstice of fracture, with the wall-rocks. At the same time ore components are not only deposited in veins but also disperse in wall-rocks. That's why ore-associated haloes are often called haloes of dispersion. For example, if uraniferrous vein is accompanied by the albitization halo with the increased content of uranium, then Na and U are supposed to be introduced into the wall-rocks by a solution from fracture. As migrations mechanisms of elements into wall-rocks filtration and diffusion are theoretically admitted. In fact diffusion model doesn't always correspond to real distribution of permeability and overfalls of pressure. It demands considerable amount of filtrating solutions [5] and doesn't explain contrary migration of separate elements [10]. The diffusion model is restricted by rate of diffusion penetration of elements:

$$l=\sqrt{D*\tau}$$

(l- depth of diffusion penetration, D - coefficient of diffusion ,τ - time).

New data explaining the mechanisms of element migration in haloes have been received recently during the research of fluid inclusion in zone of ore-associated alteration.

In tectonic zones hosting orebodies along with macrofaults great amount of microfaults is observed. Many of this microfaults don't break the bounds of individual grains of host rocks.

Microfaults of such kind usually are filled up by the same mineral. At the same moment microinclusion of pore solution are preserved in it. It's second fluid inclusions in minerals. The more of this microfaults the more second fluid inclusions [8]. Usually haloes with such inclusions are several times wider than metasomatic and geochemical ore-associated haloes. The intensity of its presents increase towards ore veins or axis parts of vein bunches.

Another tendency is characteristic of the concentration in inclusions of gas components. Its concentration usually decrease towards the axis parts of faults zones [Fig.1]. The partial pressure and total fluid pressure are lower in the axial parts than in the far-away parts of halo. It means that the central parts of the zones aren't the feeding but draining structures.

The analysis of another elements in fluid inclusions gives supplementary data concerning the forming of ore-associated haloes.

The concentration of Na in albitization zones [Fig.1] is considerably less than in surrounding slightly altered rocks, the Cl concentration doesn't changed essential.In this case albitization is connected with migration $NaHCO_3$ towards the axis, much more "opened', parts of geological structures. Here takes place the degassing of CO_2, and surplus Na is combined in albite.

Mass determination of numbers of plagioclases in sections [11] indicated, that gradual deoxidization of plagioclases starts far from albitization zones. At the same time Ca is combined in sphene, epidote and carbonate. Slight propylitization of rock turns to albitization. This process increases from periphery to the centre .Its intensity correlates with the number of microfractures. Therefore forming of those albitization zones is connected with the redistribution of rock-building elements and with the directed migration of Na from external metasomatite zones to the internal ones. The whole process is connected with microfractures of rocks.

Detailed sampling of ore-associated haloes usually reveals rather irregular distribution of ore elements [Fig.2]. Along with increased contents there one can see a group of samples containing ore elements in considerably less than background.

Substantial irregularity of distribution is caused not only by introduction, but also by redistribution of ore elements. This phenomenon is fixed also outside of overbackground haloes. Have got a special name of subbackground haloes. Here average contents are equal to background contents ($C_a \approx C_b$). but dispersion of contents is more considerable than in background one. Deficit of ore elements is characteristic for subbackground haloes. The sample number with $Ci<Cb$ is larger than sample number with $Ci>Cb$. As a result average content of ore element is 20-30 %,seldom 40-60%, lower than background contents. Such zones have been found out in the deposits of U, Au,Sn,Pb,Zn,Cu, etc [1,2,4,6,7,10].

So,the forming of geochemical haloes can be connected not only with dispersion ,but also by concentration of elements(elements, that are dispelled in rocks).

Mechanism of substance migration in the processes of collective recrystallyzation differs from classic mechanisms of filtration and diffusion. Microdislocations play here the determinative role. Any recrystallyzation is connected with microredistribution of elements. Elements cover microdistances rather quickly, this movements take place in pore solution by means of diffusion and microconvection. Such "Brownian" migration in barren tectonic zones leads to alteration of elements microdistribution(Fig.3). If macrogradients of chemical potentials appear, then irregular micromigrations gets trend. Modulation of micro- and macropowers results in integral effect; this effect is different from the result of action of each power separately:

$$Z=f(\varphi,\lambda) = F(\varphi) + \Phi(\lambda)$$

We have called such migration translational migration[9], i.e. such migration when transportation of object proceeds along the axis of translation. The model of translational migration gives good explanations to the geological and geochemical regularities of ore-associated haloes composition. This regularities aren't explained by the means of classic filtration and diffusion models.

Fig.1.Fluid halo of rare metal albitites Eastern Zabaikal'je.

Fig.2. Distribution of Zn in the rocks of Sumsarskoje deposit: a - background, b - ore-associated halo (according to S.W. Grigoryan, 1982).

Fig.3. Distribution of traces of induced division of U in granite-gneisses (Eastern Zabaikal'je) : a - stable block; b - zone of faults.

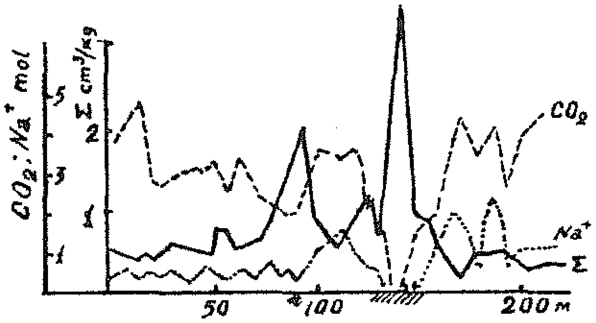


Fig. 1

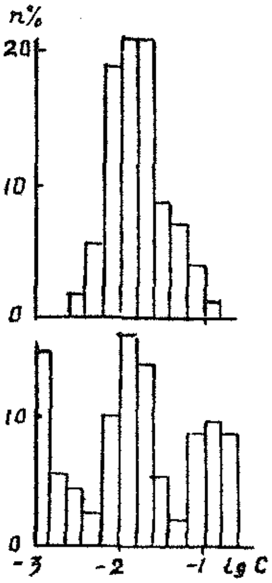


Fig. 2

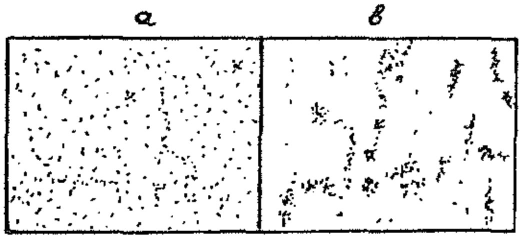


Fig. 3

THE DISTRIBUTION OF SILVER BETWEEN FLUID AND MELTS AND GENESIS OF VOLCANOGENIC GOLD-SILVER DEPOSITS

I.Ya.Nekrasov

The Far East Geological Institute, Vladivostok, USSR

Many large silver and gold-silver deposits are genetically related to volcanogenic rocks. Thus, it was important to determine the solubility of Ag in silicate melts and its distribution coefficients between salting fluid and melt. Experiments with Ag solubility in rhyolitic melts were carried out at 1000°C and P_{fl} =101.3 MPa using the double-capsule technique. The distribution of Ag between fluid and melts was studied at the same parameters. At f_{O2} corresponding to Ni-NiO buffer, Ag solubility was 4.5 ± 0.5 mass % in fluid, 6.8 ± 0.2 mass % in andesitic melt, and 8 ± 0.4 mass % in basaltic melt. Melts of any composition could be silver-bearing, but andesitic-basaltic melts are most favourable for Ag concentration. Thus, it is no coincidence that the majority of silver deposits are generally related to these melts.

During the interaction of supercritical water or very diluted chlorite fluid (0.05 to 0.1 N HCl), distribution coefficient of Ag ($C = C_{fl} / C_{rh}$) was less than 1, i.e., Ag diffused in melts and the conditions for its concentration were unfavourable. With the increase of salt concentration in fluid (from 0.5 N HCl + 1% NaCl to 0.5 N HCl +20% NaCl) its extractional ability increased sharply and C_d changed from $n.10^{-1}$ to 24. It was accompanied by an extraction of Ag (from 0.1 to 0.8 mass %) and many petrogenic constituents, particularly SiO_2, K_2O, Na_2O, MnO, and FeO, from silicate melts. For example, fluid extracted as much as 4 mass % SiO_2 and 1.5 % K_2O from rhyolitic melt. As a result, fluids enriched in metals were separated from silicate melts during the postmagmatic stage, forming silver and gold-silver quartz-adular veins in volcanogenic rocks.

27A

CONDITIONS OF FORMATION AND MAJOR PARAMETERS OF DIFFUSIVE-DEFLUCTION SECONDARY DISPERSIVE HALOES OF THE SOVIET CARPATHIANS ORE DEPOSITS

Yu.A.Novikov,Institute of Mineral Resources,Ministry of Geology,USSR

1. The territory of the Soviet Carpathians belongs mainly to the European family of coniferous-broad-leaved landscapes of acid class of aqueous migration. They form under conditions of low-mountain relief,mid-mountain relief and somewhat highland.The high washing of soils and large quantity of atmospheric precipitation(800 - 1600mm/y) determine very low general mineralization of surface and ground waters(0,03 -0,2g/l). In the field of development of the Carpathian flysch groundwaters of deluvial formations - are hydrocarbonaceous-calcic-magnesic and hydrocarbonaceous-chloridic-magnesic groundwaters.Ground waters of deluvium in regions of development of metamorphic rocks of Upper Proterozoic-Lower Paleozoic are hydrocarbonaceous-chloridic-sulphatic-calcic-magnesic ones(in the composition of cations also often presents natrium).

The reaction of groundwaters is neutral or(in the field of development of metamorphic formations) weakly acid one. Existence under conditions of the mountain relief of active water-exchange powerful zone caused close genetic connection of ground- and surface waters and similarity of their chemical composition.

According to intensity of water-exchange and mechanical migration almost all the geo chemical landscapes of the region belong to landscapes of the third genus(according to classification ofA.I.Perel'man,1966),i.e. are characterized by vigorous water-exchange, sharp preponderance of slopes over watersheds(latter are not more than 15% of a territory),by preponderance of mechanical migration of dissolved matter.

The soils of the region are mainly mountain-wood dark-brown and light-brown sour soils.Sharp excess of atmospheric precipitation over evaporation from soil surface(in 2,5 -5 times) causes their over-moistening.

2. The formation of lithochemical residual secondary dispersion haloes of ore deposits in the region is clearly defined by semultaneous proceed of processes of mutual displacement of particles of deluvium,diffusion,defluction,slope denudation,and by acid leaching of soils.Lithochemical streams of ore deposits dispersion are formed,mainly,under influence of defluction and slope denudation of residual dispersion haloes.The region is characterized by high rate of slope denudation: in different parts its annual layer of denudation is 0,3 to 0,9mm/y.

Relation of module of solid and soluble run-offs is estimated as 7 : 1.This relation characterizes a comparative role of lithochemical(mainly,mechanical) and hydrochemical (saline) forms of migration.

3. In the region modern deluvial and(more seldom) eluvial formations of ore-bearing rocks are,mainly, halo-forming medium.Experimental study of secondary dispersion haloes of the group of ore objects made it possible to establish dominant character in regions ofdiffusional-defluctional secondary dispersion haloes,which,according to their accessibility and manifestation in section of soils and deluvium,are opened to normal intensity, relaxed at the surface and closed(maximum impoverished and leached in upper part of a section of soils and deluvium). Expansion of diffusive secondary dispersive haloes is limited by area of development of autonomous eluvial landscapes and gentle,medio-slope landscapes of near-watershed part of slopes.

4. In structure of diffusive-defluctional secondary dispersion haloes 3 parts,differ in morphology and conditions of formation,are singled out: (a) upper,diffusive-defluctional(essentially diffusive one); (b)middle,defluctional and (c) lower,accumulative one.

The main features of diffusive haloes are:

- large elongation of haloes down the slope;
- unlike diffusive haloes,dimensions of proper defluctional component of halo decisively depend on length(extension) of a slope,but not on a scale of mineralization,

that is why dimensions of area of halo are, as a rule, large;

- the point C_{max} (maximum content of halo-forming element) of a halo is not always clearly marked;
- real halo displacement on slopes as to outcrop of ore body on the surface of the bedrock ranges from 50 - 60 to 200 -250m;
- in plan haloes have mantle-like character, but in section -ribbon-like one;
- the most extended part of a halo is its "train of a halo", within the limits of which vertical efficiency of a halo is not almost changed;
- in defluctional part of the halo content of element-indicators of polymetallic and other mineralization does not almost depend on depth of sampling.

5. The main parameters of diffusive haloes and formula of their calculation are well-known. As regards parameters of diffusive-defluctional haloes they are quite different and are not fully elaborated. The most important parameters of these haloes are vertical (M_B) and linear (M') efficiency of the halo. Taking into account the dual character of diffusive-defluctional haloes, we suggest the following formulae of their linear efficiency:

$$M' = 2 \cdot M_B^{max} \cdot x \cdot \frac{h-h_1}{h^2} ,$$

where M_B^{max} - maximum value of vertical efficiency of the secondary dispersion halo;

x - distance of the halo section with M_B^{max} from watershed in meters;

h - thickness of loose formations in vertical section of the halo;

h_1 - depth of occurence of the halo from the surface, m.

All above-mentioned causes necessity of an additional stage of geochemical reconnaissance - the stage of detalization of revealed diffusive-defluctional haloes, which precedes trench sinking on haloes estimation The task of this stage is the study of the vertical section of the halo on a slope with determination of value M_B^{max} and the position on a slope section of the halo with M_B^{max}.

Trench and ditch sinking is performed depending on point position on a slope with M_B^{max} of the halo and S - value of halo's point C_{max} displacement with regard to the outcrop of the ore body on the surface of bedrocks under given langscape-geochemical conditions.

Fulfilment of works of present stage of detalization of revealed haloes and employment of their indicated parameters will make it possible to increase essentially geological efficiency of prospecting (with semultaneous reduction in prices) in the regions of development of diffusive-defluctional and defluctional secondary dispersion haloes of ore deposits. In addition wide employment (as an overtaking method) of lithochemical survey method on stray fluxes as an overtaking method has a great importance: in the region under influence of defluction and slope denudation of secondary dispersion haloes of ore objects in proluvial and alluvial deposits of shallow channels form, mainly, open residual stray fluxes of normal intensity.

The present recommendations are applicable in search for ore deposits not only within the limits of the Soviet Carpathians, but also in another regions of the world with similar landscape-geochemical conditions of secondary dispersion haloes and stray fluxes formation.

ON PRIMARY AUREOLES OF DISPERSED HYDROCARBON GASES

Yu.Kh. Ovcharenko

Ukrainian Research Institute for Geological Prospecting
Ministry of Geology of the USSR, Lvov

As a rule dispersed methane gas aureoles accompany any productive objects during their forming. Primary gasospheres near ore and oil-gas pools are in many features similar to each other by mechanism and/or forms of fluid accumulation. First of them are rather seldom, therefore it is logical to use analogous principle by modeling structural features of oil-gas pool aureoles.

Our generalized geochemical model of gas field consists several system elements: 1) anomalous body of chlorine-calcium type waters; 2) the outer (zonal), and 3) the interior aureoles of dispersed gas. According to this model, each of deposits is separated from regional geochemical background with two envelopes which differ from each other by specific density of gas concentration.

Compact interior aureole has symmetrical shape of vertical concentration (partial pressure) gradients which are equal to ± 11.6 1/1 for one altitude kilometer and 0.596 bar/m. This object is completely con-nected with gas pool owing to mechanism of mobile equilibrium, and is adjustable and syngenetical to it.

The outer aureole embraces the whole gas-bearing interval in the field. Its vertical gradients are equal to ± 11.74 1/1 km or 0.134 bar/m (while for regional background - 0.026 bar/m). The last aureole together with hydrochemical anomaly could be treated by system features as being analogous to pre-ore aureole of hydrothermal leaching.

Originally both primary gas aureoles are superpositional objects. According to our model, fluids accumulate in underground reservoirs in the following sequence: 1) hydrochemical anomalous body; 2) the outer gaseous aureole; 3) gas pool together with its own interior aureole. Quite often an endogenic fluid supply into sedimentary cover is broken off on the second stage. Then economical productivity lacks and there is only dissolved gas anomaly.

Ascertained fact is that in natural occurrences there are two different primary gaseous aureoles which coincide in space and are independent on each other in time. Such a theoretical conclusion one has to account during geological prospecting for ore, oil and gas-bearings in order to choose more optimal strategy.

Geochemical soil and rock surveys in search for tin in the Eastern Erzgebirge (GDR)

PÄLCHEN, W.; RANK, G.; ZERNKE, B.; HARPKE, B.

Areal geochemical soil surveys (250 km^2, 100 samples per km^2, subsoil horizon) and investigation of rock samples from boreholes were carried out in connection with geological and geophysical surveysand light exposure works for tin in the eastern Erzgebirge. The samples were analysed for Ag, As, B, Ba, Be, Bi, Co, Cu, F, Li, Mn, Mo, Nb, Pb, Sn, Ti, V, W and Zn.
The areal distribution of tin mineralization is very well reflected by increased tin content in the soil samples. Multiplicative and factor score maps of the element association Sn-Bi-Mo-(-W-Be-Li-F-Cu) support and precise this result. Tin-rich multielement anomalies were contoured on this basis. The investigation of zonality of primary halos in reference objects renders it possible to apply coefficients of primary geochemical zonality to the secondary geochemical field. The coefficients of zonality base on Cu, Pb, Zn and Ag as supraore elements and Bi, Mo and W as subore elements. In the result of these calculations remarkable differences between coefficients of some neighbouring anomalies were established. With some caution, concerning the comparability of anomalies this fact can be interpreted as expression of different erosion levels, caused by postmineralization fracturing. Comparing these results with other geological and geophysical observations a mosaic of relative upthrown and downthrown blocks is constructed, which is applied to evaluation of tin mineralization. By means of this results effectively are guided the follow-up geochemical prospecting and other exploration activities in this region.

29A

GEOLOGICAL EXPLORATION IN MOZAMBIQUE

António M. A. Pedro - Instituto Nacional de Geologia, Maputo, Moçambique
M. Serrano Pinto - Departamento de Geociências, Universidade de Aveiro, Aveiro, Portugal

The first geochemical prospecting survey in Mozambique was carried out in 1955, with no other major development until 1969.

The seventies saw an increase in geochemical exploration activities in the country. About 1/5 of its area was surveyed from 1970 to 1976, the largest volume of surveying being of the reconnaissance type in areas of occurrence of crystaline rocks using stream sediments as sampling medium. Apart from that, some regional surveys (river waters mostly for uranium and stream sediments for base metals) and detailed surveys (soils) were also undertaken.

The Mozambique Geological Survey and a French firm were responsible for most of the surveying operations which were carried out in conjunction with reconnaissance geological mapping and geophisical prospecting.

In these early surveys, Co, Cu, Ni, Pb and Zn were almost invariably the only elements analysed, irrespective of lithological composition of the surveyed areas and of type of ore deposits searched for. Intensive use of atomic absorption spectrometry provided the necessary laboratory support for the analysis of base metals in more than 80 000 samples.

Statistical treatment of data was carried out following the common procedures used at that time, chiefly the Lepeltier technique, and allowed the definition of several target areas at the recconnaissance level. This was done on a basis of either multi-element associative anomalies or single-element anomalies (base-metals), that due a variety of reasons were not subject to follow up work in the seventies). The results of the uranium surveys were discouraging.

Major geochemical exploration programmes were conducted from 1978 to 1984 covering about 30% of the area of the country, in some cases in conjuntion also with geological mapping activities and geophysical prospecting.

The programmes were undertaken by private West European firms and by technical assistance (United Nations and Eastern European countries) in conjunction with the Mozambique Geological Survey (MGS).

The surveys were conducted at different scales (1 : 100 000 to 1:1 000) and rock, soil and stream sediment were the most commoly used sampling media. It is estimated that some 100 000 samples have been collected in the course of these activities.

Geochemical analysis of a variety of elements was carried out in the MGS laboratories, making fully use of this modern analytical facilities, that include ICP-, AA- and XRF- and OES-spectrometers, control analyses being normally done abroad. Statistical data analysis in most surveys was done using the Lepeltier technique, but several multivariate techniques have also been applied (e.g. factor analysis, principal component analysis).

All this has lead to the identification of several anomalies.

At present time emphasis is being given to computerization of the geochemical data. Previously, geochemical information was available under different, non-standardized forms such maps, repports and magnetic tapes. This computer standardization is a first step of a process that hopefully will lead to the comprehensive evaluation of the available data and the search for new target areas in the country.

One of the objectives is to prepare geochemical maps covering the whole country and the International Geochemical Mapping Project provides a challenging opportunity for these studies to be implemented.

Several types of geochemical maps that have been produced in the course of the surveying activities in Mozambique are exhibited.

GEOCHEMICAL ZONATION OF MAIN STAGES LAVRAZIY BELT PLATFORM EVOLUTION

V.S.Pevzner, All-Union Geological Institute, Leningrad, USSR

Siberian, Russian and American platform form the Lavraziy belt of old platforms with similar development in the Late Proterozoic and Phanerozoic. They are characterized by polycyclism, evolution of lithogenesis.

Study of geochemical zonation of main stages of lateral and vertical development confirms Geochemical sense of geological periodicity. Asymmetry of geochemical properties is conspicuous at the background of periodicity. Alternation of various geochemical types of associations with transitions from lithophylic to chalcophylic or from lithophylic to lithosiderophylic occurs within geological cycles. The latter most commonly occurs in the Pre-Cambrian of the Russian platform. The sequence of associations is similar to the sequence of the tectomo-sedimentary cycles. Cyclic types of the geochemical associations are outlined when zonation of Pre-Cambrian and Phanerozoic stages of development of the platforms are compared.

Geochemical zonation is accompanied by alternation of main elements of the associations. This phenomenon designated by the author as a geochemical resonance, may serve for prognostication of geochemical properties of geological objects. Sequence in alternation of the associations characterizes geodynamic conditions. Sharp increase of main elements of the associations and the level of homogeneity control the stages of tectonic stability. So, we may come to the conclusion about later stabilization of the tectonic regime on the Siberian platform.

The presence of geochemical boundaries characterizing the unstable balance is typical of the platforms. Chemical elements occur more frequently at boundaries and their gradient and peculiar geochemical mutation resulted in complication of geochemical associations takes place.

Geochemical zonation not invariably agrees with formational. It is related to the fact that geochemical data retain memory not only about events correlative to the formations under study, but about the proceeding events and about young non-sedimentogenous rock transformations, Is connected with geodynamic changes the earth's crust, resulted in the pronounced influence of endogenic processes on shaping of formations, blocks and platform mantle. Study of the geochemical zonation shows that in hypergenesis endogenic stimuli of change of energy and substance appear at regular intervals. It was noticed that the younger the stage, the simpliar zonation and composition of geochemical zones. At the same time areals of their distribution increase. This phenomenon points to the common tendency in development - the quest for homogenization.

NEW LOCAL PREDICTION METHODS APPLIED TO ORE DEPOSITS UNDER EXPLORATION BASED ON MINERALOGIC-GEOCHEMICAL DATA

Nikolai P.PISKORSKY, VNIIZARUBEZHGEOLOGIA, USSR

Questions related to local prediction methods development have gained great significance in various countries as a result of the necessity to meet the requirements in prospected and mined deposits reserves.

Estimation of ore content by geochemical methods is based on the study of zonal structure of ore endogenic aureoles. However, complex structure of deposits under study, fracture abundance, descreet character of aureole structure e.t.c., require further development and updating of geochemical methods. The principal methodological technique applied is a system approach to deposit structure study which assumes that any deposit consists of a number of different scale ore formations. Deposit as a whole, its sectors, orebearing zones, ore bodies, ore columns, e.t.c. - up to individual minerals, are taken into consideration. Mineralogic-geochemical studies of different scale ore formations carried out at a number of non-ferrous and precious metals deposits revealed certain typical features. Their practical appliance secures a reliable mineralization forecast within the limits of the above mentioned deposits. These features are as follows:

- deposits sectors, ore-bearing zones within their limits, separate ore bodies and ore columns are characterised by zoning of the same quality type;

- the difference shows in the decrease of zoning ratio variation gradient accordant to ore formations along with their scale increase (from 0,5-1,0 / 100 m - for deposits, up to 4,0-5,0 - for individual ore bodies);

- variation range of different scale formations zoning ratios is characterised by unique stability - 3-4 orders from upper to lower ore areas. This permits well-grounded perspective estimation of deposit deep levels (below the deepest holes) based on diagrams reflecting zoning ratio variations recognized down the dip of different scale ore formations;

- ore body zones with low ore content are characterised by constant associate elements predominance over host rock. Ore columns located within the ore bodies differ from other sectors by associate elements redistribution in veins and adjacent sectors: column upper parts and flanks are marked by top concentrations of upper-level elements in veins, and of underlevel elements - in near-vein metasomatite; lower sectors are marked by reverse ratio of these chemical elements group;

- as a whole geochemical zoning of the bodies correlates with their mineralogic zoning. Element position within the geochemical zoning determines the degree of their concentration and dispersion in ore minerals. The dispersion degree of the main component of any ore phase increases with the mooving up and down off the maximum emission zone of this ore phase. Above mentioned characteristics favour the optimum estimate of potential ore content based on the constant zoning study of admixture elements in minerals.

GEOCHEMICAL FIELDS OF MULTILEVEL CONVECTIVE ORE-BEARING SYSTEMS

V.M.Pitulko

All-Union scientific research institute, Leningrad, USSR

Amalgamation of different orders occurrence to a whole ore-deposit system is only possible with such geological-genetic models, which are able to describe the development of both the ore-region and separate ore-body. These models are realized as a consequence of ordinary processes of lithosphere's evolution, and ore-genesis is a byside result of self organizing differentiation of lithosphere's substance.

Multilevels convection is an example of such models in the presence of which older structures are synchronically or consequently formed to nonuniforms of more local level. Differentiation of lithosphere, presence of different movable mediums in these layers, presence of powerful heat stream - all this gives good influence to apperance and stationary long-term functioning of convection.

As a result of convection and thermodiffusion of fluids, ore-deposit objects get reliable features. In section the productive systems show ability of polar zonality as situated in vertical diameter zones of summary (top) and evacuation (bottom) of all analyzed elements. The base of polar zonality are heatphysical features of fluid components, determining his macrocomposition. Therefore anomalous fields of structure of different ranges are formed by combination of their elements: for the cells of 20-30 km diameter (ore regions and junctions) - it is general ore-forming elements (for example, for acid ores a row of decreasing activity is following (Si - Al - Na, K - Fe, Ca, Mg - Ti, P, Mn,Cl), For the cells of 5-10 km (ore-fields) the shift of polar zonality to small elements (Ti, Mn, V - are alkali - Se, Ni) is becoming more, for the cells of 1-3 km (potential mineral deposits) the elements of ore complex are becoming a base of zonal distribution.

In a plan all the members of ore-genetic system have closed to concentric type of prime zonality or transformed to complex data of physical-geochemical fields. The structures boundaries of each range are arc zones of decreased content of peripheral set of elements with the isometric blocks of high element content what indicates to next zones. Studied ore-genetic system (gold ore, rare metal objects, stratiformed polymetallic ore-deposits, kimberlites) have the same structures of geochemical fields: circle outside zone (peripheral clusters), local inside zone (central clusters) and intermediate ring of low data, formed along the perimeter of contact of central and peripherral clusters.

Resume:

1. There are general features of ore-deposit system unrelated to different age of inclusions, geological position of ore-bed, metal associations, which are the result of heat transfer process in lithosphere, and the systems themselves are equal to structures of central type with ordered set of claughteer elements;

2. Ore-concentrating structures have mozaic-cell building of physical, geochemical, methasomatic fields. There are periodical and polar zonality of central and peripheral clusters indicators in these fields. Some of main details of control of ore-bed are in every range structure by their element association;

3. Zonal system of multilevel geochemical field is alike to geometrical system of self organizing of ore-bed structure due to conventive model what may mean the verification of the last one.

31A

GEOCHEMICAL FEATURES OF GRANULAR PHOSPHORITES: PROSPECTING ASPECTS

Victor.I.POKRYSHKIN, VNIIZARUBEZHGEOLOGIA, USSR

Due to burning problems facing the present-day geochemistry, the knowledge of geochemical specialization of the most representative geologo-productive types of the phosphorite deposits, and, above all, the bodies of granular phosphorites, acquires a considerable significance. A keen interest in prediction of and prospecting for new economic deposits of granular phosphorite is explained by the fact that this type of phosphate material composes as a rule large deposites of easy-to-treat ores. Due to special genetic features these phosphates always contain various and higher-than-background concentrations of U, Rare Earths, Sr, Ba and other admixtures either in phosphates components themselves or in matrix. Phosphatic (fluorine-carbonate-apatitic) matter is especially active in sorption with respect to U, Sr and Rare Earths.

Interpretation of the existing geological and geochemical materials obtained from phosphorite-bearing sediments in conjuction with facial and paleogeographic analysis considerably enhances the efficiancy of assessment of paleogeochemical environment of phosphate deposition in sedimentary basins and allows to outline the area most favourable for formation of phosphorites, and also litho-stratigraphic horizons with concentrated economic distribution of granular phosphorite bodies.

References:

Balashov V.I., Turanskaya N.V., Bratishko (1974): Zoning of The Rare Earth element distribution in oceans. - Geochemistry, 5, 791-762.

Pokryshkin V.I., Bolshov V.A., Kharitonova R.S., Boyko V.S., Berman I.B. (1982): Peculiarites of distribution of uranium in The Grained Phosphate Rocks of The Arabian-African phosphate-bearing province and Middle Asia. - 8, 1165-1171.

O'Driscoll M.: Rare Earths. - Industrial Minerals (1988), 254, 21-55.

Geochemical anomalous waters and metamorphic mineral assemblages in Daba- and Maquarin areas of Jordan - Comparison to laboratory results

Pöllmann, H.[*] & Khoury H. N.[**]
[*](Mineralogical Institute of University Erlangen, W.-Germany)
(University of Amman, Jordan)

Unusual mineralization in N-Jordan was first noticed by KHOURY and NASSIR(1982) in the bituminous limestones. The high pH-Waters result from meteoric water passing through metamorphosed rocks (KHOURY & NASSIR). By passing through the rock-complexes the waters are mainly enriched in Ca^{2+}, OH^-, SO_4^{2-}, trace metals and others. Two metamorphoses took place.

1. A prograde metamorphic mineral assemblage (Sanidinite and pyroxene-hornfels facies) characterized by decarbonation, recrystallization and dehydration.
2. A retrograde metamorphic mineral assemblage characterized by rehydration, recarbonation, sulfatization and silification.

The reactions in the two types of metamorphic processes can be described by using the model of a natural cement factory and the following hydration process of the clinker.

Due to the understanding of the sequence of low-temperature mineral formation and precipitation from the unusual satured waters laboratory work was done to synthesize different hydration products and compare the results to natural occurences.

The following minerals were found in the different rock types (Khoury, Nassir, Pöllmann):

graphite
sulfur
pyrite
opal
quartz
chalcedon
low-cristobalite
maghemite
hematite
perowskite
magnesioferrite
anorthite
afwillite
lepidocrocite
magnesiochromite
spinel
magnetite
gibbsite
portlandite
calcite
dolomite
kutnahorite
halite
barite
chlorite
apophyllite
gypsum
bassanite
anhydrite
ettringite
thaumasite
metatuyamunit
veatchite
hashemite
hydrocalumite
fluorapatite
wilkeite
kaolinite
jennite
francolite
titanite
andradite
merwinite
monticellite
spurrite
melilithe
diopside
hedenbergite
wollastonite
tobermorite
smectite
plombierite

The hydrates often contain typically high contents of trace elements. The calcium silicate $1.78CaO \cdot SiO_2$ contains 0.34 % Zn (Khoury). Varying fluorine contents occur in the different minerals with apatite structure and in the apophyllites. CrO_4^{2-} replaces SO_4^{2-} in the minerals. Solid solutions and stability reactions of different minerals were investigated in the laboratory for comparing purposes.

The formation of the ettringite can be explained by the following reaction mechanism :

$$\underset{\text{portlandite}}{Ca(OH)_2} + \underset{\text{gypsum}}{CaSO_4 \cdot 2H_2O} + \underset{\text{kaolinite}}{Al_2[(OH)_4/Si_2O_5]} + H_2O$$
$$\downarrow$$
$$\underset{\text{ettringite}}{3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O} + \underset{\text{tobermorite}}{6CaO \cdot 5SiO_2 \cdot 5H_2O}$$

Solid solution between ettringite and thaumasite seems to occur.

Reaction mechanism for precipitation of hydrocalumites with varying composition is due to:

$$Ca(OH)_2 + Cl^- + Al(OH)_3 \longrightarrow Ca_4[Al_2(OH)_{12}]^+ [Cl \cdot nH_2O]^-$$

Cl^- can be replaced by OH^- and CO_3^{2-} (Pöllmann).

Isomorphic substitution of the anions by CO_3^{2-}, SiO_4^{4-} and CrO_4^{2-} OH^-, Cl^- can take place.

In the phosphatic sediments different types of apatites with isomorphic substitution are crystallizing. The bonding of different trace elements to the hydrate-mineral assemblage is of great importance, because otherwise they can act as environmental poisons.

Literature:

Hauf, P.L., Ford, E., and Rosenblum, S. (1983): Hashemite, a new mineral from Jordan.
Am. Mineral., 68, 1223-1225.
Khoury, H.N.,Salameh, E. & Abdul-Jaber, Q.: Characteristics of an unusual highly alkaline water from the Maquarin area, northern Jordan
J. of Hydrology 81, (1985), 79-91
Khoury, H.N. & Nassir, S.: High temperature mineralization in the bituminous limestone in Maquarin area - north Jordan
N. Jb. Min. Abh. 144, (1982), 197-213
Khoury, H.N., Pöllmann, H. & Meissner, E.: The low temperature mineral assemblage of Maquarin and Daba area in Jordan
Fortschr. Min. 66, Bh. 1, 77, (1988)
Nassir, S.G. & Khoury, H.N. : Geology, Mineralogy and Petrology of daba Marble, Jordan
Dirasat IX, (1982), 107-130
Pöllmann, H.: Crystal chemistry of compounds formed under the influence of aggressive compounds to cement (in german)
Thesis, University of Erlangen,(1984)

CONTRIBUTIONS OF THE STREAM SEDIMENT GEOCHEMISTRY TO THE FINDING OUT OF THE ENDOGENOUS ORE - CONTROLLING ZONALITY AND TO THE INDICATING OF HIDDEN GRANITES

Rentzsch, J.; Birke, M.; Eichberg, M.
Central Geological Institute Berlin /G.D.R

The detection of a hidden ore - controlling zonality in the distribution of mineral or element associations and the presentation of the hidden granite surface belong to the most important fundamentals of the metallogenic evaluation of mineralizations confined to the roof region of granites. The reflection of the zonalities of the endogenous geochemical field in the secondary dispersion halos and stray fluxes is of decisive importance for the geochemical-metallogenic interpretation of the results of the water - stream sediment - prospection. A classical example for the zonality of endogenous veined mineralizations in the surrounding of a granite intrusion is the ore zone of the Lower Harz, which is confined to the Ramberg lineament striking NNE-SSW. The regional geochemical surface prospection in this area gives new knowledge about the distribution of the elements in the secondary dispersion halos of the Late Variscan and Post Variscan mineralization cycles and the inner structure of the ore zone of the Lower Harz. The zonality of the distribution of special elements and element ratios, e.g. As, As-Hg, Sn-Cu-PbZn, Rb/Sr in the exogene geochemical field reflects the zonal arrangement of the high-thermal mineral association including the quartz-sulphide-succession over the hidden flank of the Ramberg granite which shows a gentle dip to SSW. It becomes evident, that there is a possibility to predict the depth of hidden intrusive bodies of geochemically specialized granitoid magmas by help of the As-halo, if the magmas were intruded into anchimetamorphic clay schists and the mineralizations in the roof region show a clear structural control.

GEOCHEMICAL CHARACTERIZATION OF U-Mo-Cu MINERALIZATION IN THE PERMIAN OF THE SLOVENSKÉ RUDOHORIE MTS., THE WEST CARPATHIANS.

Igor Rojkovič, Geologický ústav SAV, Bratislava, Czechoslovakia
Ladislav Novotný, Uránový prieskum, Spišská Nová Ves, Czechoslovakia

U-Mo-Cu /Pb,Co,REE/ association is characteristic of most of the localities of uranium mineralization in the Permian of the Slovenské rudohorie Mts. Mo is typical element of volcanic and volcanoclastic rocks. Increased contents of P and B and rarely also of W, Re, Au, Ag, Se, In and Cd were established in some localities.

Acid volcanites and their volcanoclastics of the Permian have increased contents of U and accompanying elements. They were an important source of accumulation of these elements. U of rhyolites and their tuffs is bound mostly to their matrix, while U of dacites and andesites is bound mostly to Ti-oxides. During the Upper Permian U and others elements were redistributed and deposited in the water bearing horizon and due to it ore bodies are stratiform. Uranium was adsorbed by clay minerals, Ti-oxides and Fe-hydroxides. Tectonic structures formed by the alpine tectono-metamorphic processes during the Cretaceous caused easy circulation of geothermal waters and uranium and accompanying elements were remobilized and concentrated. Later manifestations of the alpine orogeny and metallogeny represented by hydrothermal activity, formed vein Cu-mineralization. Variability of S and C isotopic composition suggests also different character and origin of mineralization in the region studied.

33A

GEOCHEMICAL PROSPECTING FOR GOLD AT THE DEEP LEVELS OF DEPOSITS

N.V. Roslyakova, Institute of Geology and Geophysics, Siberian Branch, Academy of Sciences of the U.S.S.R., Novosibirsk, U.S.S.R.

The cost of the underground workings and drill holes is sharply increasing in depth, especially deeper than 500 m. Because of the uneven gold distribution a share of the ore crossing is less than 30% of the total number of the stripped ore-bearing structures. Hence before a prospection of the deep levels of deposit it is expedient to make its preliminary evaluation corresponding to results of the complex geochemical researching of its upper, prospected or already utilized, part, and only after that to search and estimate the ore bodies at the deep levels using the revealed geochemical criteria.

Our investigations (Roslyakova et al.,1968,1975,1981,1987; Shcherbakov and Roslyakova,1970,1972,1983,1987) and literary data, especially about Kolar (Raghavan, 1963; Rozhkov,1966; Safonov et al.,1980; and others), show that under the favourable geology-structural position of deposit (a large thickness of the host rocks; the lengthy ore-controlling and ore-locating structures till large depth; the extensive hydrothermalites and so on) there is the sufficient authentic positive assessment of the gold ore deep length according to the stability in vertical diapason of the next parameters: 1)the gold contents in ore; 2)the increased average contents and wide distribution dispersion (in comparison with the local background) of Au, Ag and other elements, which are indicated ones for this deposit, in the ore field rocks and especially in rocks within deposit; 3) the highly contrasting halo elements zones (first of all for Au) near the ore-bearing structures; 4)the mineral composition of ores and nearore metasomatites; 5)composition and quantity ratios of the trace elements in minerals; 6)the gold purity within the same generation; 7)the variation range of the relative concentration coefficients (CC, after Shcherbakov,1979) of pairs of geochemically related elements in hydrothermal metasomatites, ores and minerals; 8)the temperature of the ore deposition, especially of its Au-productive stages (gradient is not more than $5-7^{\circ}$ per 100m); and others. If the stability of all above mentioned factors take place it is possible to prognosticate the commercial gold mineralization to the depth not less than its vertical length of the prospected upper part in this deposit.

Next stage of the work - geochemical prospecting of the concrete ore bodies at the deposit deep levels - can be carried out according to results of the mineralogical and geochemical mapping of the lower available level of the underground mining and of the deep hole core. The differences between irregularities in element distribution near the ore shoot, near its nip out and near the barren unpromising vein or its part; ratios of the trace elements in minerals; presence of quartz with the inclusion homogenization temperatures and the thermoluminescence which both are peculiar to quartz of the productive mineralization stage; the increased Au contents (up to more than 10 mg$\cdot$l^{-1}) in the inclusion solutions; the increased deviations of the rare earth elements (REE) distribution in the ore quartz in comparison with that of host rocks may be used in this case. In the vein quartzes the REE serve as geochemical pathfinder of the vein Au-bearing at a few tens meteres'distance from ore shoot along both strike and dip of vein. Barren quartz veins are characterized by the more smooth curve of the REE distribution which differ from that of host rocks very little. To judge in what direction from this section to carry out the prospecting for the ore it is possible to use the knowledge of the halo elements complex in the parts above, under and near the ore. Forecasting the occurence of displaced sectors of the ore bodies or else revealing of their lack behind the tectonic dislocation (Kutina,1963; Roslyakov and Zvyagin, 1972) could be done according to peculiarity of distribution of ore-forming elements in material of tectonic structure.

HYDROGEOCHEMICAL EXPLORATION FOR METALLIC MINERALS IN BASALT-COVERED REGION JILIN PROVINCE, CHINA

Jiang Ruijin and Ren Tianxiang

Institute of Geophysical & Geochemical Exploration,
Langfang, Hebei, China

There is an area of more than 16,000 square kilometers covered by Cenozoic basalts in the southern part of Jilin Province, China. This area lies in the eastern section of the northern margin of the North China Platform, one of the well-known polymetallic and gold mineralization belts in China. Over the years a number of large-scale strata-bound base-metal and gold deposits have been found in the western and central section of the belt and in the adjacent area in Korea. Consequently, the eastern section of the belt has long been considered a promising potential area for Cu, Pb, and Zn exploration. Unfortunately, the majority of this area is covered by basalts with a thickness in the tens to hundreds of meters. It is difficult or impossible to explore the mineral resources in the underlying bedrock with routine prospecting techniques. As a result, there has been little progress in mineral exploration for several decades in this area.

From 1986 to 1989, hydrochemical research was carried out during dry seasons to determine the feasibility and effectiveness of hydrogeochemical method in such basalt-covered areas. The annual precipitation in the area is from 800 to 1,400 mm, and there are enough sampling points such as springs,wells and perennial streams for a hydrogeochemical survey. The many well-developed vertical and horizontal tectonic joints in the basalt connect with the underlying bedrock, which makes it easy for groundwater to circulate. When the groundwater reaches the surface, it often reveals geochemical information about the underlying bedrock. Therefore, we have tried to use hydrogeochemical method for the exploration of minerals in this area. Our research has focused on:

1) hydrogeochemical anomaly patterns of the known Cu, Pb, and Zn deposits in the area under investigation;
2) the migrating characteristics of major ore-forming and associated elements in surface and ground waters;
3) seasonal variation in the ore-related hydrogeochemical anomalies;
4) the chemical composition of the groundwater in the basalts and its influence on hydrogeochemical exploration.

The hydrogeochemical investigations of known ore deposits were carried out in the Huanggoushan Pb-Zn deposit and Liudaogou Cu-Mo deposit occurring in basalt-covered Proterozoic metasedimentary rocks. A hydrogeochemical orientation survey was conducted in three testing sites with a total area of about 700 square kilometers. The results of the investigations show that: 1) In the Pb-Zn mineralization area the characteristic indicators in the surface and ground waters are Zn, Pb and SO_{42-}, as well as Ag, As Sb and Mn, while in the Cu-Mo mineralization area they are Mo, Cu, and SO_{42-}, as well as Zn, Ag and Pb. 2) Ground and surface waters in the basaltcovered area are rich in Cu, Ni, Fe, Mn, Ti, Cr, and Zn, which often obscures the ore-related hydrogeochemical anomalies in this area; by using the Cu/Ni and Zn/Ni element ratios the effect of the basalts can be eliminated and the ore-related anomalies clarified. 3) By analyzing spring sediments with a selective dissolution procedure, the migration activity of the major indicator elements in the groundwater of the Cu-Mo mineralization area was determined to be Mo>Zn>Ag Cu>Pb>Ni. The orientation survey carried out in the Changbai testing area delineated a multi-element hydrogeochemical anomaly of I, Cl, Pb, As and Zn/Ni correlated with the regional metallogenic structure. Both the follow-up for anomaly conducted in the hydrogeochemically anomalous area and subsequent drilling showed that the hydrogeochemical anomaly is primarily caused by the widely-developed pyritization in the Pleozoic sedimentary rocks (believed to be a mineral-bearing stratum) under Cenozoic basalt and sedimentary layers. Further prospecting is still going on in this area.

It can be concluded that, in spite of the complicated geological and geochemical conditions and the relative low background concentrations of indicators in the waters of the area studied, relative to those of other geochemical landscapes, hydrogeochemical surveying can serve as an effective regional prospecting method in basalt-covered areas, especially near their margins.

34A

GEOELECTROCHEMICAL METHODS OF PROSPECTING FOR ORE DEPOSITS

Yu. S. Ryss, I. S. Goldberg, N. A. Voroshilov
NPO "Rudgeofizika", Leningrad, USSR

1. The necessity of solving geological problems associated with prospecting results in applications of new methods. In the last decade new technical means and methods of prospecting and valuating of mineral deposits based on the peculiarities of behavior, transformation and distribution in ore bodies and host rocks of various forms of occurrence of elements termed geolectrochemical have been developed.

2. The first group of methods based on the extraction (at electrical excitation including) and analysis of elements being in easy moving forms of occurrence, within which they are able to migrate for large distances, permits to reveal and to trace deep seated and overlapped ore objects. This type of methods includes: methods of prospecting according to metalloorganic compounds (MPF), the thermomagnetic geochemical method (TMGM), the method of diffuse extraction of metals under the action of electrical current (CHIM).

3. The methods mentioned may be used in all the stages of geologicoprospecting works, beginning with regional geologico-geophysical investigations of vast poorly studied terrains. It is advisable to use MPF and TMGM as more efficient methods in the early stages of geological survey works on a 1:50,000 scale together with common prospecting. The CHIM methods as a more tiresome but more informative method is to be used in the stages of prospecting and prospecting-evaluating works (1:10,000 - 1:50,000). The application of these methods is more efficient during prospecting for deposits in closed regions with the thickness of overlapping deposits up to 200 m and at the depth of ore bedding up to 800 m.

4. For estimating the depth of ore object bedding and the extension of mineralization there were developed the methods based on geoelectrochemical transformation of sulphide minerals under the action of electrical current: non-contact method of polarization curves (BSPK) and contact method of polarization curves (KSPK). BSPK allows to determine from the surface at the thickness of loose deposits about 100 - 150 m from borehole drilling the composition of ore zones and to characterize their dimensions and probable reserves of metals within upper boundaries. KSPK is realized in several versions in various stages of works (from prospecting-evaluating to exploration). It permits to characterize the composition and dimensions of ore objects, element of their bedding and reserves.

5. The application of the complex of geoelectrochemical methods allows to accelerate the studying of territories and to increase geological and economical efficiency of geological survey and detailed prospecting and prospecting-evaluating works.The experiment shows the acceleration of prospecting works more than twice while reducing the bulk of drilling in separate areas with the use of new methods by 40-50%.

GEOLOGICAL AND GEOCHEMICAL MODELS OF ORE FIELDS AS A BASIS FOR SOLUTION OF PROBLEMS IN FORECASTING AND PROSPECTING (ON THE EXAMPLE OF KAZAKHSTAN)

V.V.Shatov, E.V.Plushchev, All-Union Geological Institute, Leningrad, USSR

Images registered cartographically (or by any other means), reflecting the history of originating of specialized geochemical resources in corresponding blocks of the earth's crust and describing the hypothesis of hydrothermal mineralization formation due to realization of these resources by hydrothermal systems serve as geological and geochemical models of ore fields. Specialized geochemical resources are estimated for associations of trace elements occurring in reworred rocks in regions of hydrothermal system feeding in superclark concentrations and in forms extracted by hydrothermal solutions. Results of petrographical-geochemical investigations in 1:50,000 sc scale carried out within type ore regions and fields of the Kazakhstan folded orea (Zn-Pb-Cu, Au, Cu-Mo, Mo-W, Ba) formed the basis for geological and geochemical models of the ore fields. Creation of rather regular network of base stations within investigated ore fields, where samples were collected from the most characteristic rockes and rocks altered, to a variable degree, samples for petrographical thin sections and lumps of geochemical samples 200-500 g in weight was the methodocal basis of performed research. The network of base srations was on 1;50,000 scale with sampling interval bridging up to 250x100 m in localities of hydrothermal-metasomatic alteration (HMA).

This work resulted in compilation of sets of petrographical and geochemical maps on 1:50,000 scale for most of these ore fields consisting of (a) the map of the background geochemical specialization, (b) the map of regional metasomatic zonation, (c) the map of anomalous geochemical field and (d) prognostic geochemical map.

Construction of geological and geochemical models of the ore fields was based on these data. The procedure of particular model construction included (1) estimation and cartographic representation of specialized geochemical resources of rock blocks constructing the ore field on sum of indicator trace elements; (2) formational analysis and "subdivision" of regional metasomatic zonation into constituents - regional metasomatic formations; (3) construction of volumetric models of ore - forming hydrothermal systems representing reconstructions of geological bodies, accupied by separate segional metasomatic zonations; (4) revealing of geochemical effect, caused by manifestations of certain regional metasomatic formations; 5) quantitative estimation of scales of metal transport in conjugated HMA zones of hydrothermal systems.

Large-scale (1:50,000) prognostic zonation on petrographical and geochemical basis was carried out and number of areas was distinquished in the rank of potential ore fields and formational affinity of supposed mineralization was determined for them.

PRODUCTS OF NEAR RESEDIMENTATION AS AN IMPORTANT INFORMATION SOURSE FOR MAPPING THE WEATHERING CRUSTS

Boris L. Shcherbov, Institute of Geology and Geophysics, USSR

When studying the kaolin weathering crusts of North Kazakhstan and South Siberia these have been shown to be overlapped by products of near resedimentation in the absolute majority of cases. They are formed in the environment of deluvial-proluvial, alluvial-lake and lake-marsh facies under the same climatic conditions and close in time as the weathering crusts. The products of near resedimentation have feature of both sedimentary and eluvial rocks. That is why many investigators consider them to be intermediates between the weathering crusts and sediments. These, however, could be referred to neither of them.

One of the main processes when forming the near resedimentation products is the mixing of the weathering crust material formed on the substrate of various composition, with no essential grading. For example, an admixture of some mineral components of scist eluvium (muscovite, tourmaline) has been stated by various methods in the resedimentation products occured on the weathering crust of one of the granite massifs of the Kokchetav blok (North Kazakhstan). According to the mapping data, the sampled section is 1,5-2 km apart from the contact of granites with a vast field of metamorphic rocks. In another section of the same region the content of TiO_2 in the resedimented matter of the granite weathering crust is the ten times as much as in eluvium. Undoubtedly, there are rocks of the higher titanium mineralisation occured somewhat nearly. There are similar pattern in the other regions (Shcherbov et al., 1985). The admixture of other weather-proof minerals (sphene, zircon etc.) to the eluvium of any particular profile can be easily admitted. Their presence can be a reason for investigating the area more thoroughly and prospecting on purpose. The examples given evidence that the near resedimentation products carry more information about the weathering crust of any site. To get a picture of the weathering crust from sedimentary rocks, the sampling of all their varietes is necessary. In fact, sands and sandstones will provide information about residual minerals of the primary rocks, and shales will inform about hypergenic ones. The near resedimentation products characterise mainly not only the eluvium of a given site but also that formed somewhat nearly. This property is especially valuable in the regions where initial rocks are of heterogeneous composition in lateral.

In the field sometimes, the near resedimentation products are hardly discriminated from subjacent eluvium. Simpl laboratory investigations can provide a safe basis to distinguish clearly between these cognate formations. These investigations involv the study of vertical section as to a change of density, pH value of rock suspensions, granulometric and mineral composition. It would be very useful to study the rare-element distribution and structural pecularities of clay minerals. All these techniques have been discribed somewhere (Shcherbov, 1987). In most cases, however, to solve the problem it is sufficient to fulfil two former operations which are not time- and money-consuming and available to any both research and industrial geological unit.

The fact of the near resedimentation products being more informative then initial weathering crust was in general beyond the the discussion of the scientific literature. This feature, however, makes them especially valuable when carring out practical geological surveys on the weathering crusts. A thorough study of the near resedimentation products can provide a basis for search mineral associated with both weathering crusts and initial crystalline rocks.

References:

Щербов Б.Л., Солотчина Э.П., Сухоруков Ф.В. Бор в продуктах ближнего переотложения каолиновых кор выветривания.- Новосибирск, I985, I39 с.

Щербов Б.Л. К изучению продуктов ближнего переотложения каолиновых кор выветривания.- Новосибирск, I987, 3I с.

GEOCHEMISTRY OF RARE AND TRACE ELEMENTS IN THE SEDIMENTARY MANTLE OF YOUNG PLATFORMS

G.M.Shor, All Union Geological Institute, Leningrad, USSR

Geochemical background of rare and trace elements in geological formations of the sedimentary mantle in young platforms was formed during lithogenesis, which took place in various paleogeographic and climatic conditions.

Lateral geochemical zoning of back-ground contents of rare and trace elements is subordinated to lithological-facies, lithological-geochemical and facies-paleogeographical zonings.

Vertical zoning of background contents is related to manifestations of epochs of accumulation of rare and trace element and derivation of geochemically specialized formations.

A series of marine biogenic rocks, enriched with sapropel and containing rare and trace elements is an example of formations with specialized organic matter of oil origin, Wide spectrum and high background of selenium, rhenium, tellurium, molybdenium, tungsten, and other elements is caused by similar conditions of formation and insignificant influence of lithogenesis specifics in space and time. Predominating position of some elements in natural associations is caused by forms of their ties with consentrators.

Geochemically specialized formations serve as a source of ore substance in ground-infiltration, stratal-infiltration and, probably, hydrothermal ore mineralization.

In marginal parts of young platforms (in a conjugation region with postplatform orogens) in the arid climate, supply of rare and trace elements into permeable rocks of the sedimantery amntle from adjacent mountain-folded structures and evacuation of elements from water-bearing rocks and their accumulation on reduction and sorptive geochemical barriers, are connected with activity of oxygenated ground, stratal and fracture waters of infiltragebous origin.

Infiltration activity of undergroupg water is responsible for significant changes in background contents of rare and trace elements in permeable rocks and provides formation of regional geochemical zones of their evacuation, supply and accumulation on the barriers.

Redistribution of rare and trace elements in central parts of young platforms, connected with activity of hydrocarbon, sedimentogenous and ancient infiltragenous waters and with migration of carbon dioxide (extiltration processes) takes place in channels of hydraulic connection of water-bearing horisons, on water/oil and gas/water contacts. Exfiltration processes are manifestated in local regions and have no influence to regional geochemical background of rare and trace elements.

36A

GEOCHEMICAL MOBILITIES OF NA, CA, SR, BA, PB, REE, P AND AS in LATERITIC SOILS

Roland G. Schwab, Hardy Herold, Christian Götz
University of Erlangen-Nürnberg, Germany
and Nilson P. de Oliveira,
Universidade Féderal do Pará, Belém, Brasil

According to the classical theory the geochemical mobilities of elements in the weathering zone are a direct function of their solubility in water and this is governed by their ionic potentials. Therefore under lateritic conditions with generally much water present, Na^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, $PO_4{}^{3-}$ and $AsO_4{}^{3-}$ are considered as very mobile ions, wheras the Rare Earth Elements (REEs) are considered as a more or less immobile group. Consequently laterites are generally thought to be leached out with respect to Na, Ca, Sr, Ba, Pb, P and As, and relatively rich in REEs, especially in cerium.

This opinion is only valid, however, if the different ions do not occur in a coupled form; that means two ions like Sr^{2+} or $AsO_4{}^{3-}$ can be considered as mobile separately, but if they occur together in a lateritic weathering zone arsenogoyazite ($SrAl_3(AsO_4)_2(OH)_6 \cdot H$) will form under complete immobilization of both of them.

The same holds for $PO_4{}^{3-}$ which can immobilize these ions in form of either (arseno)-crandallites ($MAl_3[P,As)O_4]_2(OH)_6 \cdot H$) or wardite ($NaAl_3(PO_4)_2(OH)_4 \cdot 2H_2O$).

Therefore Na, Ca, Sr, Ba and Pb are only mobile in laterites if $PO_4{}^{3-}$ and $AsO_4{}^{3-}$ are not present and especially in case of $AsO_4{}^{3-}$ extreme traces are sufficient for their immobilization. The same holds for the REE-group, which forms extremely stable REE-(arseno)-crandallites ($REEAl_3[(P,As)O_4]_2(OH)_6$) and may be enriched in presence of $PO_4{}^{3-}$ or $AsO_4{}^{3-}$ up to lateritic REE-deposits.

Reference:

Schwab, R.G., Herold, H., da Costa, L.M. and de Oliveira, N.P. /1989/: The Formation of Aluminous Phosphates Through Lateritic Weathering of rocks. - Weathering Vol. II, Products, Deposites, Geotechnics, Theophrastus Puplications S.A., Zographou, Athens, Greece, 369-386.

37

AN APPLICATION OF CYANIDATION TO GOLD EXPLORATION IN GLACIATED TERRAIN, BRITISH COLUMBIA, CANADA

by S. Sibbick and W.K. Fletcher,
Department of Geological Sciences
University of British Columbia
Vancouver, B.C., Canada

The Nickel Plate Mine, a 2900 tonne-per-day open pit operation in the southern interior of British Columbia, is a gold producing skarn genetically related to intrusion of Jurassic diorites into limy sediments of the Upper Triassic Nicola Group. Gold occurs as blebs, generally smaller than 25 microns in diameter, and is associated with arsenopyrite in tabular bodies of garnet-pyroxene skarn.

Physiographically, the mine site is in the subalpine zone close to the southern limit of the Thompson Plateau - a moderately rolling upland that represents the late Tertiary erosion surface in this part of British Columbia. During the last glaciation the Cordilleran ice sheet, moving regionally across the plateau in a south and southeasterly direction, deposited a stony basal till that now varies from less than one to several meters in thickness. The climate is relatively arid and the soils are principally eutric brunisols and orthic gray luvisols: C horizons are commonly cemented by calcium carbonate.

Geochemical studies involved collection of soil horizons from profiles sampled along traverses downice from the deposit and roughly perpendicular to the direction of ice movement. Gold was determined in the minus 212 micron fraction by fire assay-atomic absorption. Results indicated a zone of enhanced gold values extending approximately 1 km downice of the supposed source. However, gold concentrations were extremely erratic. To evaluate this problem, distribution of gold between different size and density fractions was studied in samples from six pits, representing anomalous, intermediate and background gold populations. These studies established that: (i) approximately eighty percent of the gold is in the minus 53 micron fraction, and (ii) the erratic results were a consequence of the nugget effect, introduced by the presence of rare particles of coarse gold.

On the basis of the foregoing, it was decided to evaluate the possibility of using cyanidation as an alternative to fire assay for the extraction of fine gold from the minus 53 micron fraction. Minus 53 micron material, prepared by wet sieving soils from the six detailed study pits, was disaggregated and split into two, 30 g portions for determination of gold. One split was analysed for gold by conventional fire assay-atomic absorption (FA-AAS), the other using cyanide extraction-solvent extraction-atomic absorption based on Fletcher and Horsky (1987). Gold content of the residue from the cyanidation was also determined by FA-AAS.

37A

Results from the cyanide leach give gold values ranging from < 15 to 510 ppb versus 30 to 595 ppb total gold by fire assay. The residues contained from 5 to 145 ppb of gold that could not be extracted by cyanidation. On average approximately seventy percent of the total gold content was cyanide extractable. However, this value was as low as twenty percent in some A horizon soils but was usually close to eighty percent in B and C horizon samples. With regard to anomaly recognition and contrast, based on averages of proximal and distal samples, cyanidation gives a local anomaly:background contrast of 5.2 that is reasonably comparable to the value of 6.1 obtained with total FA-AAS.

Results suggest that the bulk of the gold is present in soils and till as particles of free gold finer than 53 microns. This is in good agreement with trends for liberation of gold in the sand-sized heavy mineral fractions (Sibbick, in preparation) and presumably reflects both the fine grain size of the gold in the orebodies and its release from the matrix by glacial comminution and weathering. Low recoveries of gold by cyanidation from some A horizon soils probably result from reduction of dissolved gold by organic matter as is used in the carbon-in-pulp process for metallurgical recovery of gold from cyanide solution.

In conclusion, cyanidation of soil and tills can be used to delineate gold dispersion trains extending downice from the Nickel Plate Mine. Compared to fire assay, use of cyanidation offers the potential advantage of allowing very large samples to be analyzed, thereby minimizing the nugget effect caused by presence of rare grains of coarse gold.

References:

Fletcher, W.K. and Horsky. S. /1988/: Determination of gold by cyanidation and graphite furnace atomic absorption spectroscopy. Jour. Geochem. Explor. 30: 29-34.

Sibbick, S. (In preparation) Dispersion of gold in soils and tills in the vicinity of gold mineralization, Nickel Plate Mine, southwest British Columbia.

THERMOLUMINESCENCE DOSIMETRY (TLD) RADIOMETRICS IN OIL EXPLORATION, TAKLA AREA, TARIM BASIN, WESTERN CHINA

Frederic R. Siegel, George Washington University, Washington, D.C., USA; Xuejing Xie, Institute for Geophysical and Geochemical Exploration, Hebei, China; J. Eduardo Vaz, Venezuelan Institute of Scientific Research, Caracas, Venezuela

A thermoluminescence dosimeter radiometric survey of the near-surface gamma radiation flux was done as an adjunct to oil exploration studies in the Takla area, Tarim Basin, western China. The basin is in a desert region with an annual precipitation <10 cm; several years can pass without rain. Faults trending ENE and WNW and which truncate similarly trending foldbelts dominate the structural fabric of the basin. The basin is comprised of Mesozoic and Cenozoic dark, organic-rich lacustrine mudstones (sourcebeds) and fluviodeltaic sandstones (reservoirs, sometimes with multiple horizons) in tightly folded asymmetrical anticlines. These are often cut by thrust faults along the steep limbs and form structural-stratigraphic traps. Important oil-producing wells have been completed at depths of between 2000 and 3000 m in this major exploration area. We surveyed 80 km^2 of the basin using LiF TL dosimeters buried at 0.5 m with the aim of finding small areas in the overall region with greater probability for containing oil and natural gas in the subsurface so that costly seismic work could be focussed there. These small areas are defined by their anomalously low value radiometric signals. A similar approach was successful in another climatic regime at the Shengping oil pool, northeastern China, a flat topographic area which includes swamps and cultivated land (Siegel and others, 1989).

Radiation dosages accumulated during the burial period ranged from 0.43-1.37 nanocoulombs, with an average of 0.69 nanocoulombs. The sample population has a positive skew and the cumulative frequency plot approximates a lognormal distribution.

The structural nature of the area was indicated by the near-surface radiometrics distribution pattern and suggested the possibility of fault-influenced traps in the subsurface. Three wells had been drilled in our study area. One was completed as an oil-producing well and was at a radiometric target defined by TLD. A second was a dry hole and was located away from any radiometric target. The third well was initially completed as a dry hole, but drilling was subsequently continued to a greater depth and it was brought in as an oil producer. We were unable to clearly relate this second producing well to the radiometric data because an unexpected massive (150-200 year) flood inundated part of the study area suddenly before all the TL dosimeters could be recovered and the lateral erosion and scouring carried away many of them. Two other oil-producing wells are located 5 km to the east and 10 km to the east-northeast along a structural trend from the first oil-producing well.

TLD radiometric surveys can be used to reduce large exploration tracts to smaller zones with more probability of containing petroleum and natural gas. As such, front-end costs in hydrocarbon prospecting are lowered because costly seismic surveying ($1000 to $10,000 or more per km^2) can be directed to the higher probability zones. TLD radiometrics may also be useful in defining extensions to existing oil and/or natural gas fields. The method is labor intensive as it requires the burial and retrieval of dosimeters but this and the lowering of overall project costs make TLD radiometry especially attractive to energy exploration in developing nations.

Reference:

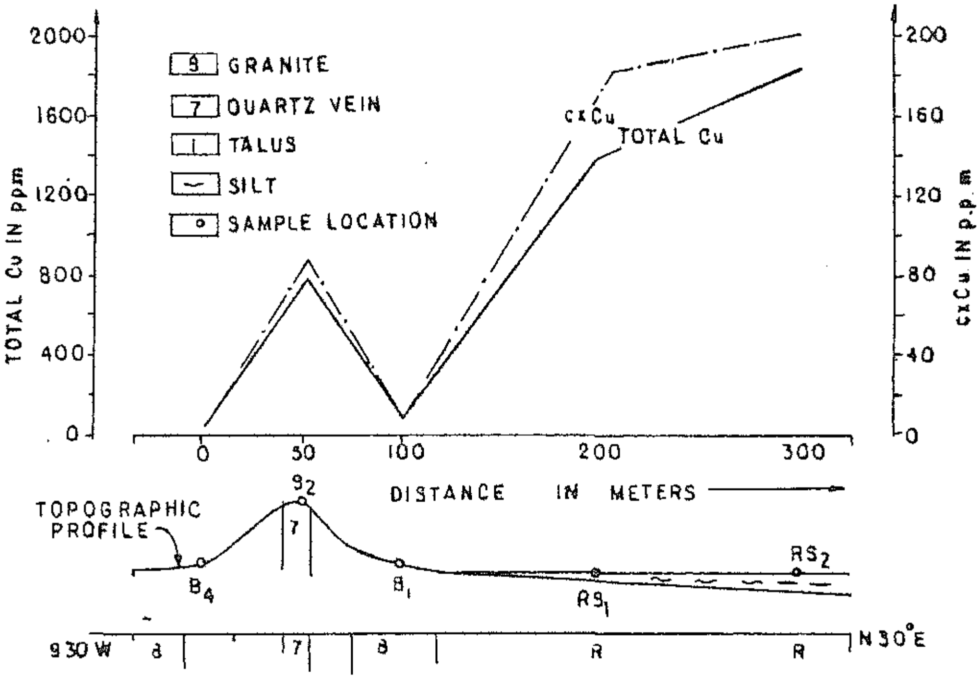
Siegel, F.R., Hu, D., Vaz, J.E., Wang, Z. and Viterito, A. /1989/: Areal thermoluminescence radiometric survey of the Shengping oil field using buried dosimeters. - Oil & Gas Jour., 3 July, 53 - 57.

38A

COLD EXTRACTABLE CU AND TOTAL CU IN SOILS: A STUDY FROM MALANJKHAND COPPER DEPOSIT, INDIA.

J. P.Shrivastava
Department of Geology, University of Delhi DELHI - 110007

Cold extractable copper analysed, ranges from 2.88 to 17.03% of the total copper present in forty two soil samples. Hot extractable copper concentration varies from 39.30 to 98.29% of total copper. Soil samples were digested in HF and $HClO_4$ acids and analysed by AAS to determine total copper concentrations. cxCu varies from 1.5-200 ppm as compared to 15-320 ppm of hot extractable copper. Anomalous samples could be distinguished from background ones on the basis of cxCu data alone and are sympathetic to total copper, as analysed by AAS represents longnormal distribution in this area. Relative variability stands at 1.3 and 0.95 for cxCu and total copper data respectively.



GEOCHEMICAL PROFILE OF PROFILE NO III

THE GEOCHEMISTRY OF THE CARBONATE-HOSTED, DISSEMINATED GOLD DEPOSIT AT GAUTELISFJELL, ROMBAK PROTEROZOIC BASEMENT WINDOW, NORTHERN NORWAY

Trond Skyseth & Paul Reitan, Univ. at Buffalo, Dept. of Geology, 4240 Ridge Lea Campus, Buffalo, New York 14260

The Gautelisfjell gold deposit is situated in the Proterozoic Rombak Window within the Caledonides, Northern Norway. The gold is finely disseminated in dolomitic impure dark carbonates overlain by a thick sequence of turbiditic graywacke with tuffite and conglomerate layers. This supracrustal unit rests on a presumably Archean tonalite complex with a basal conglomerate at the contact. The Rombak Window consists mainly of granites, with a Rb-Sr age around 1.7 Ga, which crosscut the supracrustal unit. A striking abundance of several generations of mafic dikes characterize the geological environment associated with the deposit. One set of dikes can be classified as lamprophyres, and contains anomalous Au values relative to other country rocks (>25 ppb).

The deposit has a low sulphide content along with associated silification and hydrothermal breccias. The grade varies between 0.1-10 ppm with anomalies over 300 ppm in thin zones. The trace element chemistry is characterized by a high Au/Ag-ratio with associated elements As, Sb, Ba, $C_{graphite}$, ±Cu, (±Ni, ±Co, ±Se, ±Te, ±Bi). Tungsten is spatially associated peripheral to the gold mineralization. The characteristics are broadly similar to Carlin-type hydrothermal replacement Au deposits. Observed gold grains range in size from 2-40 µm, and are associated with quartz, calcite, chlorite, pyrite, arsenopyrite and magnetite. Three main styles of mineralization have been outlined with different mineralogy and associated trace elements.

Preliminary results from field relations and paragenetic studies indicate that the gold was introduced at a late stage (possibly postdating the main Caledonian deformation events). Lead isotopes will contribute to the unravelling of the age relationships. The ore forming fluids have also been investigated by fluid inclusion studies. The area has undergone Caledonian lower amphibolite facies metamorphism and later greenschist facies retrogression. It is possible that the Caledonian metamorphism mobilized gold-bearing hydrothermal fluids that moved up and deposited the gold at its present site. It is important to recognize to what degree later tectono-metamorphic events have obscured the primary characteristics, or been genetically associated with gold deposition.

Local stream sediment analyses do not show Au-anomalies, and the deposit has a subtle expression in the field. It was discovered by drilling and soil geochemistry. Thus, this type of deposit would easily be overlooked in a regional exploration program; careful statistical interpretations of the geochemical data will be developed to determine a "geochemical fingerprint". Similar deposits have not been described elsewhere in Scandinavia, and explication of the detailed geochemical characteristics and genesis of this deposit will provide the basis to evaluate the exploration potential for Au in these areas.

GEOCHEMICAL MAPPING OF RARE-METAL ORE KNOTS OF MOUNTAIN-STEPPE REGIONS IN MONGOLIAN ALTAI

A.M.Spiridonov, B.A.Gnilusha, V.D.Kozlov, A.B.Goreglyad, V.V.Ignatov, Institute of Geochemistry, Irkutsk, USSR

Based on ore knots of Kyzyl-Tau (W,Mo) and Khaldzan-Buregteg (Zr, Nb, REE), the geochemical survey from stream-sediments was made for prospecting of rare-metal mineralization as well as for mapping of ore-bearing intrusions under the conditions of mountain-steppe topography of the Mongolian Altai.

The Kyzyl-Tau ore knot is composed of sand schists and acid volcanics, broken by the Paleozoic Kyzyl-Tau granite and leucogranite intrusion. This intrusion is genetically related to commercial tungsten and associated molybdenum-rare-metal mineralization. The Khaldzan-Buregteg region contains magmatic formations of alkaline syenites (nordmarkites). The body of older alkaline rare-metal granites, possessing abundant niobium-rare-earth-zirconium mineralization, occurs within nordmarkites. The present mineral paragenesis is not recognized by panning.

The survey grid from stream sediments in sampling all ephemeral streams was 500x250-150 m. The samples were collected from the depth of 10-30 cm, the 1,5+0,25 mm fraction was analysed. The bedrocks of ore-bearing intrusions, rare-metal mineralization and the rocks, hosting mineralization were sampled by point specimens as well as by cross sections. The samples were analysed for a wide number of elements via the atomic emission spectrometry (AES) through evaporation from the electrode channel.

Geochemical features of the granitoids of the Kyzyl-Tau massif are reflected in anomalous fields of W,Mo,Bi,Cu,Li,Be,F which are distinct on the ore knot area. The low-contrast anomalous field of molibdenum was found to coincide with granitoids outcrops of the main intrusion phase, while the fields of its high concentrations are confined to hydrothermal molybdenite mineralization. In contrast to molibdenum, the anomalies of other elements reflect only the areas of hydrothermal mineralization. For instance, intensive tungsten haloes are evident in the regions of wolframite-quartz mineralization, the more extensive tungsten anomalous fields occur in endo-exocontact zones of ore-bearing leucogranite domes of the final intrusion phase (Fig. the Kyzyl-Tau deposit N1, the Burat ore occurence, N2).

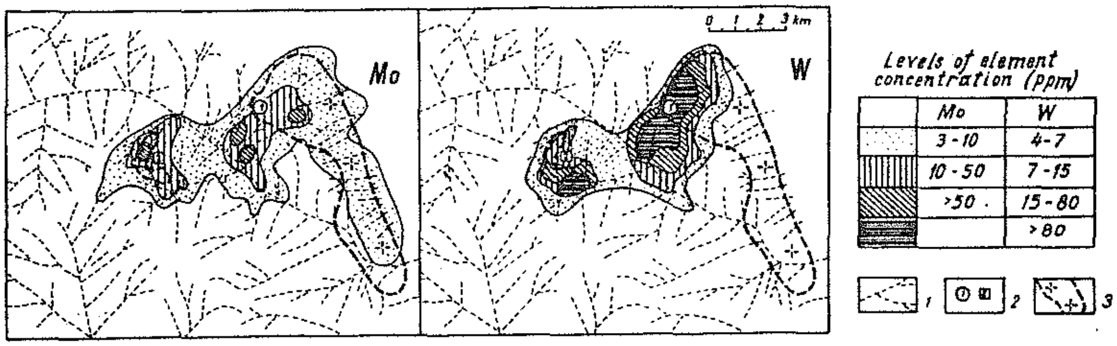


Fig. The fields of W and Mo anomalous concentrations of geochemical survey from stream sediments of the Kyzyl-Tau ore knot. 1 - scheme of sampling of ephemeral streams; 2 - ore objects; 3 - outlines of granite massifs.

The possibility to apply the geochemical survey from stream sediments to map alkaline (agpaitic) rare-metal granites is exemplified by results on Khaldzan-Buregteg massif. It is established, that lithochemical streams are characterised by the background concentrations of the elements analysed within the nordmarkite field, while the massif of alkaline rare-metal granites is revealed by anomalous Zr,Nb,Hf,Ce,La,Y,Li concentrations. The anomalies of the above elements actually coincide with geological boundaries of rare-metal alkaline-granite massif. So, geochemical survey from stream sediments may be applied for prospecting rare-metal mineralization and for mapping geochemical objects in the arid climate.

SOME CRYOGENIC GEOCHEMICAL ANOMALIES OF GOLD ORE DEPOSITS IN BALD MOUNTAINS - TAIGA LANDSCAPES IN SIBERIA

Trofim Taisaev, Buryat Geological Institute, USSR

In the cryolithic zone of bald mountains - taiga landscape of middle mountains by repeated phase transformations and the presence of non-freezing pellicular water an active cryogenic transformation of gold ore deposits and their preglacial oxidation zones occurs. Moreover, large gold free separates, but thin-dispersed gold changes into solution. Gold-quartz low-sulphide veins incorporate Archean- Proterozoic gneiss fault and are subjected to post-ore mechanical splintering. In the cryogenic zone of the veins disintegration free separated from quartz and sulphides large gold (class -2,5+0,1) accounts for 50-70% of general content. Large gold residual concentration presented by elluvial halo and placer deposits are formed in the upper parts of slopes over veins outcrop by the regular evacuation of fine products of weathering and fine gold. They provide with gold alluvial placers. In the elluvial halo gold concentration is 1,5-5 times greater than in primary ores. Such surface horizons of gold enrichment are formed in cryogenic and preglacial oxidation zones. Small gold and fine gold make up secondary aureoles, fluxes and gold-bearing sediments in subpond reservoir. At the foot of rock stream slapes open suffosional gold aureoles are typical. On the platforms of river valleys gold is sorbed from gold bearing water by clay, ferric hydrate, peat and falls on native gold.

The cryogenic zone of sulphate and oxide oxidation is distinguished over gold-sulphide ore in Paleozoic black schists. It its composition side by side with original minerals (pyrite, pyrrhotite, chaleopyrite, galenite) goethite, hydrogoethite, jarosite, melanterite, malachite, azurite take place. In cryogenic zones of fractured sulphide ores a great number of soluble metallic salts transfer to day surface with pellicular water in winter. Oxided ores are accompanied by cryogenic saline anomalies. Burried under solifluction sediments mineralization is reflected by contrasting water, biogeochemical and little-contrasting lithochemical gold anomalies. In ferrigenous sediments and peats of law moors and water-bearing fault zones as in arboreous and shrub vegetation on the gold anomalies are informative. Lichen, the predominant kind of vegetation of bald mountain landscapes, concentrates gold drastically.

Thus, the conjugate cryogenic mechanical and saline (lithochemical, water and biogeochemical) gold anomalies are formed in the zone of gold-ore deposits cryogenesis. The cryogenic cores of gold-quartz veins weathering are the source of elluvial and alluvial placers in subpond reservoirs. The lithochemical stray fluxes are connected with fundamental sources and Late-Pleistocene gold-bearing glacial and fluvio-alluvial sediments. The weak lithochemical stray fluxes of gold intensify by moss and plants aleurite testing along the river-bed flux and are distinguished by contrasting biogeochemical anomalies.

40A

PRINCIPAL COMPONENT METHOD IN SHELF GEOCHEMICAL INVESTIGATIONS

E.V.Tichomirova
Institute of MIneralogy, Geochemistry and
Crystallochemistry of Rare Elements, Moscow, USSR

Geochemical shelf investigations show that the formation of an active stratum of sediments is accompanied by differentiation of a great number of elements. It is found that whole groups of elements respond similarly to different natural factors. Therefore it seems to be justified to basically solve prospecting tasks on a multiple variant basis, which enhances the informative significance and reliability of conclusions.

The principal component method, one of the methods for multiple statistics, has been used to solve multiple tasks. The method permits identifying a number of factors that govern the formation of the geochemical field. Zones affected by various factors are outlined and studied with the purpose of bringing out spatial relationships with geological structures.

In this respect, the most interesting are fields in which contents of fifteen or more elements increase simultaneously and which correspond with regions of the inherited development of accumulation processes. In different water basins, at different geostructural and lithodynamic settings, such regions may include subsided tectonic blocks, large basins, or those parts of shelves that were associated with marine regine for a long period of time. In contrast, regions of intense removal of materials (negative anomalies) of a given complex. The principal component method identifies such structural anomalies by weak correlations, where lithological control is absent.

On the whole, geochemical investigations of shelves resulted in delineating complex anomalies of differing nature; heavy concentrate anomalies of the first mechanical barrier, abrasive drainages, present and buried accumulative coastal shapes resulting from mechanical separation of materials; hydrogenic anomalies in river mouths which have physicochemical nature; complex anomalies of mixed composition that trace fault and mixed zonal anomalies of estuary zones.

41

GEOCHEMICAL MAPPING OF ANCIENT PLATFORM SHIELDS USED FOR REGIONAL METALLOGENIC ANALYSIS

V.K. Titov, E.A. Landa, Z.S. Galetskiy
All-Union Scientific-Research Geological
Institute, Leningrad, USSR

1. Zonation of Precambraian regions is carried out on the basis of small scale mono- and polyelemental geochemical maps for revealing for potentially ore-bearing structures such as metallogenic provinces, regions, structural-metallogenic zones and ore districts as well as for solving some other tasks of geological and forecasting character (correlation and standardization of geological formations, determination of geochemical specialization of rocks, revealing main epochs of ore generation, sources of ore matter). It is advantageous to make sets of such maps both on the basis of the small-medium scale geochemical investigations according to secondary media, sampling density being 1 sample per 4-5 km2, using automatic map-building system like "Geoskan" and on the basis of available data on rock geochemistry (such maps of Baltic, Ukrainian and Aldan shields were made in VSEGEI "in the manual variant").

2. Three categories of structures are distinguished as a result of investigations carried out on the shields with regard to the level of elements accumulation in rocks, degree of homogeneity-heterogeneity of their distribution in space, character of correlation links between them: 1) central parts of Archean cartons with quality of homogenically distributed elements which is low or close to klark; this indicates to the initially low metal content in geological formations or to homogenization of the matter of separate blocks as a result of metamorphism and to the absence of subsequent epigenetic processes (Verkhnee Pobuz'e, Ukrain, Murmansk, and White Sea blocks of Baltic Shield, central part of Anabar etc.); 2) the regions with the presence of specialized rocks, initially enriched with ore elements usually as a result of one of the main syngenetic processes of exogene or endogene profiles (amphibolite-gneissic belts with jaspilites, epicraton depressions with auriferous conglomerates or cupreous sandstones, districts of development of copper-nickel-bearing ultrabasites and raremetal granitoids); 3) regions of high heterogeneity in distribution of elements at presence of anomalous concentrations caused by complex of epigenetic endogenous and exogenous processes superimposed on geochemically specialized rock types (regions of tectonic-magmatic activization, repeated processes of granitization). The last category of structures includes most polygenetic and polichronic ore objects typical for shields including occurrences of "non-conformity" type.

3. Optimization of metallogeneous forecasting should be carried according to the results of geochemical investigation and exploration accompanying large-scale geological survey in regions acknowledged as promising at the previous stage. IT is fulfilled by the way of both direct detection, distinguishing and evaluation of ore objects (ore fields and large deposits) and by the use of formal methods, taking into consideration the total geological, geochemical, geophysical and other information presented on the corresponding maps (systems of automatic operative forecasting).

4. Information received as a result of evaluation of mineral potential in geochemically specialized geological objects is especially important for shields.The applied methods are based on the comparison of the objects and investigation with standard objects having reliable geochemical characteristics. For example, such are investigations on prospects of nickel commercial potential of ultrabasites in synclinore Wind belt, Baltic shield (D.M. Orlov), gaochemical estimation of alkaline-ultrabasic complexes for rare metals (Lando E.A.).

41A

CORRELATION BETWEEN CHEMICALLY AND PHYSICALLY TRANSPORTED BARIUM ANOMALIES OVER THE VITENGENI LEAD/BARITE MINERAL DEPOSIT, COAST PROVINCE, KENYA

Mwakio P. Tole, Moi University, KENYA

The Vitengeni lead-barite deposit occurs along a fault in Triassic sandstones of coastal Kenya. The mineralised fault zone extends for several kilometers along a NE - SW strike, although intermittent mining has been confined to one area extending for about 200m length over the last 70 years. The main mineral is barite, with associated galena and traces of chalcopyrite, Cinabar and oxidised minerals of lead, zinc and copper. Soils in the area were analysed for Pb, Zn, Ba, Cu, Mn and Hg to get an indication of the extent of the mineralization.

Chemical Pb, Zn and Ba in soils show good correlations with the mineralized vein. Copper defined the vein to a lesser extent, and mercury, where it occurred showed very board dispension holes. Physically dispersed barite shows very good correlation with the mineralised fault location, although the extent of the physical dispersion is less restricted than that of the chemically dispersed Ba. This would imply that in barite-associated mineralizations, it may be faster and more cost effective to analyze for physically dispersed barite.

CLASSIFICATION OF ENDOGENIC GEOCHEMICAL ANOMALIES OF ORE REGIONS

Yu.P.Troshin, V.I.Grebenschikova, M.A.Mitichkin, Institute of Geochemistry, Irkutsk,USSR

The ore regions of Kuznetsky Alatau and East Trans-Baikal areas with developed granitoid magmatism include several main types of geochemical anomalies different in composition, zonation and genesis.

1. Intra-intrusion syngenetic and epigenetic anomalies associated with crystallization and emanation differentiation of melts at pluton origination.

a) Contrasted petrochemical differentiation may cause formation of anomalous element concentrations and appropriate mineralization characteristic of each rock type.

b) Geochemical zonation within the same granitoid facies is due to emanation differentiation; the volatile components are separated in accordance with a number of their diminishing mobility and volatility:(H_2O)-CO_2-H_2S-HCl-(B_2O_3)-H_2Se-H_2O-H_2Te-HF-(B_2O_3). The metals show the tendency to be subdivided and concentrated according to affinity to volatile components. The zonation may be direct, reverse or rhythmical within the intrusive. The composition and zonation of mineralization are closely associated with zonation of anomalies (Fig.1).

2. Near-intrusion geochemical anomalies (Fig.2).

a) Positive anomalies formed as a result of intensive emanation supply of elements from the intrusions to host rocks(K, F, B, Li, Rb, Cs, Sn, W, Be, etc,);

b) Negative-positive anomalies around strongly heated but low-volatile intrusions result from substance removal together with water from the exocontact under the influence of intrusive heat to distance over 1-2 km from the intrusive (e.g. H_2O, Cl, B, Au, Ag,S, Se, Te, Zn, Cu and other elements around gold-bearing plutons);

c) Anomalies around volcanic bodies and minor intrusions resulting from the substance transportation via convective flow of cold underground waters towards heated magmatic body; leaching and mobilization of the substance (Au, S, Cu, Zn, As and other elements) occur at a distance from the magmatic body while deposition of ore mineralization near it.

The positive anomalies of 2a type are characteristic of the rare-metal intrusions rich in volatiles and associated with greisen and hydrothermal deposits Sn, W, Nb, Ta, Mo, Be, U. The amomalies of 2b and 2c types are common for the massifs associated with gold, copper and polymetal deposits.

3. Geochemical anomalies of tectonic faults. Their geochemical specific features are closely connected with ore-magmatic and metasomatic activity.

4. Geochemical anomalies of ore fields and deposits. They are local and occupy a definite position within the structure of above types of geochemical anomalies around intrusions and have higher levels of elements concentrations.

The classification of geochemical anomalies and data bank allow solution of the reverse problem for recognizing the image of a geochemical anomaly from data of geochemical mapping.

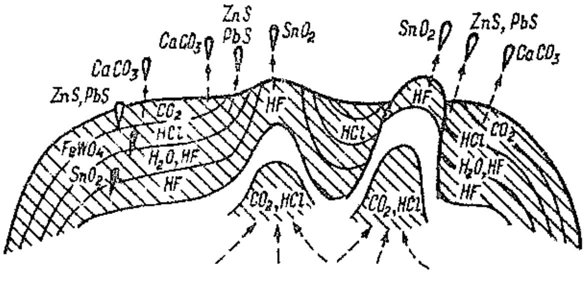


Fig. 1. An example of vertical geochemical zonation in the apical part of rare-metal granites and zonation of hydrothermal mineralization

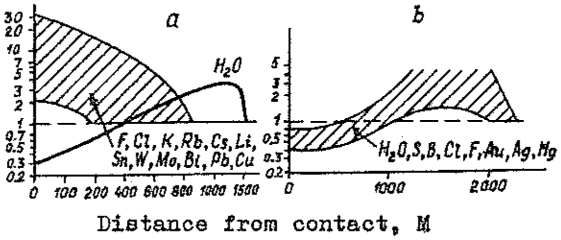


Fig. 2. Distribution of chemical elements and water in emanation haloes around massifs of rare-metal granites (a) and gold-bearing diorite-granodiorite batholiths (b)

ENHANCEMENT OF Cu GEOCHEMICAL ANOMALIES USING PARTIAL EXTRACTION TECHNIQUES. APPLICATION IN GEOCHEMICAL EXPLORATION (PORTUGAL).

M. Margarida Vairinho, D.G.G.M., Lisboa, Portugal
J. Claudino Cardoso, Departamento de Geociências, Universidade de Aveiro, Portugal
E. Cardoso Fonseca, Departamento de Geociências, Universidade de Aveiro, Portugal

The study described herein concerns the application of selective chemical extraction in two areas situated in Southern Portugal. A Mediterranean climate prevails in the areas.

The Salgadinho area is situated in a Upper-Devonian Volcanic-Siliceous Complex. The stratabound replacement pyrite - chalcopiryte mineralisation is presented in variably altered felsic pyroclastic rocks.

The Tinoca area is situated in the Arronches-Camp Maior belt, were stratiform copper mineralization is found, related to Precambrian gneissic formations.

About 440 soil samples were collected in the Salgadinho area and 300 soil samples in the Tinoca area. The minus 80 mesh fraction is used for acid decomposition and was submitted to an extraction procedure.

For the Kinetic study in soil samples, in order to obtain the Cu bearing phases, the minus 80 mesh fraction was submitted to a sequential extraction procedure using the following reagents : NH_4 acetate, hydroxylamine hydrochloryde, NH_4 oxalate in darkness, NH_4 oxalate under U.V. radiation and finally strong acids.

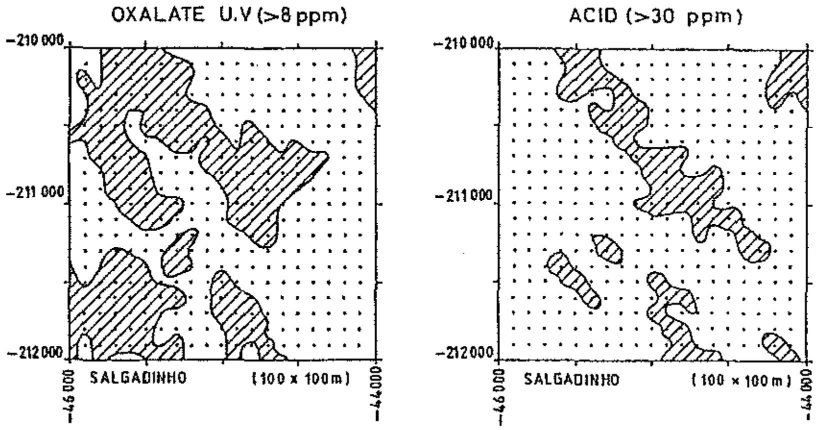


Fig. 1 - Salgadinho area: anomalous areas in oxalate U.V. and acid decomposition

The use of NH_4 oxalate under U.V. radiation in partial extraction compared with the hot mixed-acid extraction for copper, gives a better geochemical anomalous area and contrasts for both areas studied here (Figs. 1 and 2).

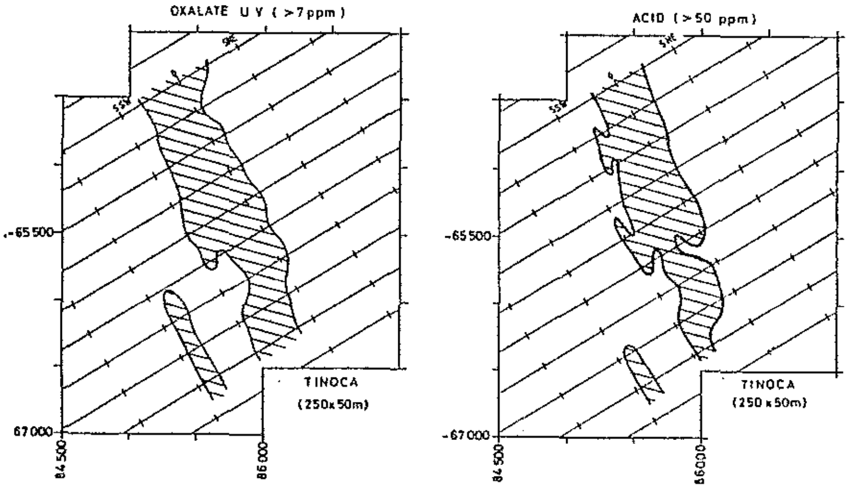


Fig. 2 - Tinoca area: anomalous areas in oxalate U.V. and acid decomposition.

REGIONAL VARIATIONS IN MAJOR ELEMENT AND TRACE METAL CONTENTS IN THE FINE FRACTION OF TILL.

Henry Vallius
Geological Survey of Finland
SF-02150 Espoo, Finland

The Geochemical Atlas of Finland, based on the fine fraction (- 0.06 mm) of till, shows several regional multielement anomalies. One of them is located in SW- Finland. The study area, 17,000 km^2 in size, is situated at the eastern edge of this anomaly. The element contents are highly anomalous in the western parts of the area and decrease going eastward, until the concentrations reach background values, after some 50 km:s. Rock samples were taken in order to find out the correlation between bedrock and till. The bedrock analyses show local variations in element contents, due to the different rock types, but there are no signs of any regional anomalies, like those found in the fine fraction of till. Correlation analysis showed positive correlation between bedrock and till in the western parts and no correlation in the eastern parts of the area.

New reference till samples were collected along two profiles across the study area. XRD- analyses of the samples indicated an increasing amount of quartz and feldspars in the eastern part, and a higher amount of mafic minerals in the western part of the area. The samples were chemically analyzed using total dissolution and aqua regia leaches, showing eastward increasing contents of Ca, Na, Si, Sr and Zr. Both methods indicate higher quantities of felsic minerals in the fine fraction of till, in the eastern part of the area.

The good correlation between bedrock and till in the anomalous western part indicates a short glacial transport, and that the till represents the underlying bedrock. In the eastern part till does not correlate with the bedrock. Here the amount of felsic minerals is higher, and the anomaly pattern is more flat. The mafic minerals may have been partly washed out, or the till may represent several cycles of till, in which resistant felsic minerals and accessories have been mechanically enriched. Two types of till is represented: the western, 'normal' type, that correlates with the bedrock, and the eastern type, without any correlation, and an origin that is more complex than the 'normal' tills.

THE EFFECT OF WITHDRAWAL ON GROUNDWATER CHEMISTRY

Irén Varsányi, Public Gealth Department of Csongrád County, Hungary

It is supposed that thick and highly permeable deep artesian aquifers might be endangered by overdevelopment indicated by diminishing pressure (Erdélyi and Gálfi, 1988). The effect of withdrawal on chemical water quality on the basis of long term variation in the composition of groundwater is discussed.

The study is based on the analysis of water samples from 140 walls of Water Supplying Plants, and on the variation of water head depending on depth and time during a 15-year period from 1975 to 1989. Groundwater samples from the Pleistocene aquifer in the Southern Great Hungarian Plain were analysed for eleven chemical variables, these are: electrical conductivity , alkalinity, water hardness, chemical oxygen demand (COD), iron, manganese, ammonium ion, nitrate, chloride and sulphate anions. Data were evaluated by multivariate statistical methods.

Water quality is not uniform in the study area. Cluster analysis was performed to separate water samples with similar water quality. The groups resulting from cluster analysis correspond to different parts of the study area with different hydrological features (Varsányi, 1989). Principal component analyses were performed to determine the processes influencing chemical composition of groundwater. Water head and pressure gradient were also determined.

Wells with similar water quality, head and pressure gradient were chosen to study the variation of water quality. Long-term trends of the different chemical constituents were detected using concentration-time relationship.

The dissolved components exhibit considerable fluctuations but a linear trend in the long term may be detected. This long-term trend was quantified during the period 1975-1989 using linear regression between concentration and time. The most characteristic trends are the increase of water hardness and decrease of chemical oxygen demand. There were no regular measurements of pH during this period but the increase of water hardness together with the decrease of COD suggest that pH plays an important role in the variation of chemical water quality. These changes are in good agreement with the decreasing trend in water head, monitored in several groundwater wells during the same period (Rónai, 1985).

References:

Erdélyi,M., J.Gálfi (1988): Surface and subsurface mapping in hydrogeology. Akadémia Kiadó, Budapest

Rónai,A. (1985): The Quaternary of the Great Hungarian Plain. Geologica Hungarica. Tom.21 Institutum Geologicum Hungaricum, Budapest

Varsányi,I. (1989): Tracing groundwater flow using chemical data. Hydrological Sciences Journal 34, 3, 265-275

GEOCHEMICAL PROSPECTING IN PORTUGAL: A REVIEW

L. Viegas, DGGM, Coimbra, Portugal

M. Margarida Vairinho, DGGM, Lisboa, Portugal

L. Rodrigues, DGGM, Porto, Portugal

E. Cardoso Fonseca, Univ. de Aveiro, Portugal

F. Muge, IST, Lisboa, Portugal

The actual state of geochemical prospecting in Portugal is outlined.

The already sampled area, the sample media, (Fig.1) sample spacing and analytical procedures used are illustrated by global maps.

The sampled area covers a surface of about 30 000 Km2.

The more often used sample medium is the minus 80 mesh size fraction of soils and stream sediments but other media like water for uranium prospecting, rocks or gossans for local studies have been analysed. Occasionally selective extraction techniques (using either physical or chemical processes) have been investigated.

Several anal tical techniques are applied: colorimetry, atomic absorption spectrometry and direct current plasma emission spectrometry.

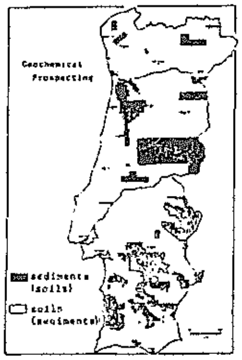


Fig 1. Geochemical Prospecting in Portugal - sampled areas

In some cases, studies are presented as they are examples of geochemical maps used for representation and/or interpretation of geochemical data.

Most of these maps are actually computer processed and several algorithms have been used for contouring or mapping anomalies (mobile average, factor score, inverse distance, krigging, factorial krigging, etc).

Practical recommendations such as analysing old samples and resampling at selected pilot areas, implementation of a National Sample Base, Inventory and Review of Geochemical Data, are made in order to achieve a correlation and normalization of data.

This should permit to maximise information no. only to guide the exploration but also environmental and agricultural studies.

GEOCHEMICAL EXPLORATION IN THE NORTHEASTERN PART OF THE CATALONIAN COASTAL RANGES (NE SPAIN)

M. Viladevall *, X. Font*, A. Ferrer*, R.M. Marimón**, A. Casas*, R.Vaquer *, J.M.Carmona* and M. Cardoso* (*). Dept. of Geochemistry, Petrology and Geological Prospecting. Zona Universitaria de Pedralbes. 08028 Barcelona. Spain. (**). Geochemical Service Analisys. Zona Universitaria de Pedralbes. 08028 Barcelona. Spain.

The Montseny-Guilleries, Gavarres and Montnegre Massifs in the Hercynian context of the Catalonia Coastal Ranges (CCR) occupy an extension of 2854 km2, and are located 50 km NE of Barcelona.

The physio-graphic features of the region are of Alpine type and its climate is Mediterranean. Its highest altitude is 1714 m, with an average of about 600 m.

The CCR lithologies are mainly intrusive, sedimentary and metamorphic materials (fig.1.). The intrusive Hercynian rocks are chiefly monzonitic and granodioritic granites with little leucocratic-monzonitic granite stocks.

The most metamorphic materials are composed of Cambro-Ordovician gneisses, micaschists and marbles; slates and black shales with embedded Upper Ordovician volcanic tuffs; Silurian-Devonian black shales and black limestones; and finally carboniferous slates and greywackes. All these materials affected by a metamorphic contact aureole.

The ore ocurrences are mainly F-Ba-(Pb-Zn) and Ba-(Cu) vein-type post-Hercynian mineralizations ; Cambro-Ordovician Cu-Zn-(Cd)-Pb-Fe stratiform deposits;Upper Ordovician Fe stratiform deposits; late Hercynian Cu vein-type mineralizations; and Hercynian W-Pb-Zn-Cu-(Sn) skarn deposits, associated with Cambro-Ordovician and Upper Ordovician materials.

Geochemical stream and panning survey was made during 1982-83-84 and 1987-88. A total of 3729 stream sediment samples, 450 panning concentrates and 1832 water samples were collected. These studies were made with the support of the Geological Survey of Catalonia and partially financed through a project of the "Comision Asesora de Investigacion Científica y Tecnica (CAICYT)" .

The analyzed elements were:Pb, Zn, Cu, Fe, Mn, Ni, Co, Cd and Ag by the ASS technique with conventional flame was used; for As, Sb, Bi and Hg by the AAS technique with hydride method; and for Ba, W and Zr by XRF technique; and finally F was analysed by Specific Electrodes technique.

Results :The Paleozoic cover

A) There are two anomalous areas having high values on the Zn-Cd-(Cu-Pb-Hg) factor score, with an extension of 10 and 15 Km2 respctively, located at the North and the South of the Montseny-Guilleries Massif, related to micaeschists, gneisses and marbles of the Lower Cambro-Ordovician.

B) Four anomalous areas, in Zn-Pb-(Cu-Fe-Mn-Cd-As-Ni-Co), associated with slates and black shales over the Upper Ordovician tuffaceous formations (the most anomalous -40 Km2 in extension- is located in the Montseny-Guilleries Massif, and the others are in tha Gavarres and Montnegre Massifs).

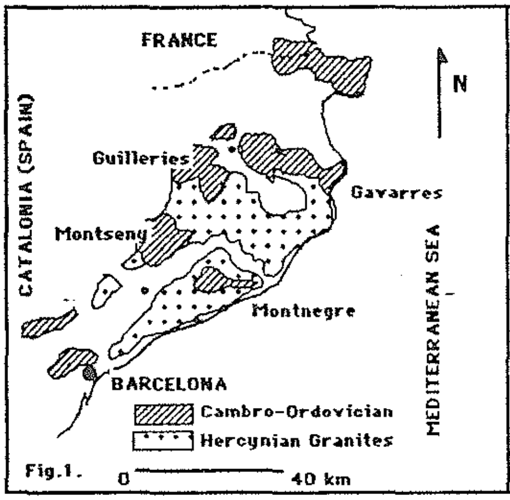


Fig.1.

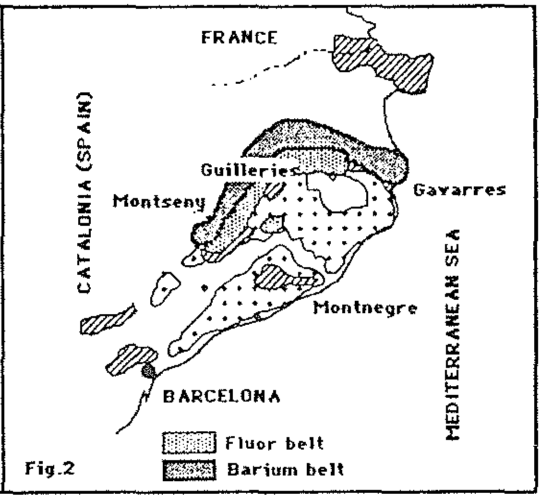


Fig.2

The granit materials:

A) There are two Ba-(Cu-Pb) and F-(Pb-Zn) anomaluos concentric belts (fig.2), about 7 km wide, bordering the Montseny-Guilleries and Gavarres Massifs;

B) A 30 Km2 anomalous area, in Pb- Cu-(Zn-Cd-Bi), located in the northern part of the Montseny-Guilleries granitic materials.

GEOCHEMICAL ANOMALY OF ALTAI ORE FIELDS

V.M. Vildyayev
PGO "Centrgeofizika", Aleksandrov, USSR

The region described hereinafter is a part of the limited number of mineralized provinces of the USSR where geochemical exploration was initiated as early as in 1930th.

Important scientific and practical knowledge has been collected since that in the most efficient prospection methods, studies of that period were fruitful in data on distribution of anomalous geochemical fields (AGF) in soils, transported unconsolidated material, weathered rock and bed-rock of Paleozoic basement. This information permits to picture the existing state of geochemistry of the region which is a necessary prerequisite for optimization of prospection depending on deposit characteristics (outcropping, blind, buried or blind-buried) and for solution of ecological problems that appear now in this old mining region. Evolutional aspects of these geochemical fields (of Paleozoic-dated primarily) may also be considered. It is important for metallogenetic mapping and solving background problems of these ore deposits.

Studies of AGF for the sake of prospection has shown that the most efficient technique applicable within the exposed metallogenetic areas in Altai is prospection following secondary ore guide aureoles. In buried regions the most promising method is a deep lithochemical exploration following secondary (buried) and primary aureoles of mineral- and rock-forming elements accompanying a geophysical prospection (resistivity and magnetic measurements).

Evolutional aspects of AGF studies show that the present geochemical picture of Paleozoic base rock is a consequence of two actions: geosinclinal formation of polymetallic ores and orogenic events with silico-alkaline metasomathosis and with regeneration of the earlier polymetallic ores. The second stage fields are more extended and associated mainly with despersed sulphide mineralization where concentrated Au-Ag metallization is eventually present.

AGFs of any stage have quite definite geochemical assemblages determined by their formation environments.

A special feature of these ore deposits is their formation within "sodium hole" areas (regions of abnormally low Na content).

The "sodium holes" formed during both stages of mineralization. The first stage formations are syngenetic to polymetallic ore. The "sodium holes" of the second stage are associated with silico-alkaline metasomathosis though periferic parts of these "holes" have narrow zones of superconcentrated sodium and of deficient potassium (K is overabundant in all other zones within the "holes"). This anomaly is codimensional with mineralized fields and thus it is an important instrument of prospection.

As a rule AGFs of both stages are correlated in space and demonstrate nodal distribution: anomalous geochemical nodes are formed to occupy 7 to 10% area within productive series.

Geological structural analysis of these nodal anomalies in Altai shows that their arrangement is associated with extended linear structures that may be specified with geological, geophysical and with airborne and space-sellected data. Negative gravitational effects accompany the greatest part of geochemical nodal anomalies and this is indicative of acid volcanism centers.

Data concerning AGF of the region permits to correlate major polymetallic mineralization to Devonian volcanism. These ores regenerated and recrystallized to a certain extent during Carboniferous and Permian periods, hence the present disseminated sulphides in enclosing and overlying rock.

The existing data on AGF of this region permits to provide for more efficient prospection for ore deposited at 500 meters and deeper.

45A

GEOCHEMICAL PROSPECTING FOR ORE DEPOSITS IN VIETNAM

Nguyen Khac Vinh,
Research Institute of Geology and Mineral Resources, Hanoi

Geochemical prospecting for ore deposits in Vietnam has been conducted for over 30 years.

The geochemical survey on bedrock and secondary haloes accompanied with geological and geophysical surveys has been undertaken on three stages, e.i. at the scales of 1:500,000 ; 1:200,000 and 1:50,000 and has contributed to the location of thousands of primary and secondary geochemical anomalies of Cu, Pb, Zn, Bi, Sb, etc. This approach has proved to be the most suitable one for Vietnam, which is covered by thick zones of soil or detrital material and dense forests.

Geochemical prospecting has been adopted and become an integral part of geological work.

EXPERIENCE IN GEOLOGO-GEOCHEMICAL FORECASTING OF CHALCOPYRITE-BASE METAL DEPOSITS OF SOUTH-WEST-GUISSAR TYPE

S.A. Volodko,E.I. Filatov

Mingeo USSR, Institute of Mineralogy, Geochemistry and Crystallochemistry of Rare Elements
Moscow, USSR

1.Anomalous geochemical fields, equivalent to the ore fields are expressed by the following series of typomorphic elements:Pb - Zn - Cu - Ag - Mo - Ba - As - Sb - Ca - Ni - Sn - Cr - Mn - V - Cd - Bi - W - Au - Ga - Ge.

The deposits are characterized by lateral zonality of endogenous halos along the stratigraphic normal from the bottom upwards: Co - Sn - Be - Ni - Ag - Cu - Mo - Zn - Ba - Pb.The ore bodies are fixed by primary halos with zonality from a flat wall to a hanging wall:Co - Ni - Cu - Zn - Ag - Pb.

2. The structure of anomalous field of different hierarchic levels is described by the coefficient of lateral (Pb.Ag/Co.Ni) and axial (Ba.Pb.Ag/Mo.Co.Sn) zonalities.

3. To distinguish potential ore fields at the stage of geological survey of 1:50 000 scale with general exploration it is recommended to carry out aeromagnetic survey, seismic prospecting, geophysical prospecting by electric means, litho-geochemical survey of bedrocks and overburden.

To reveal potential deposits at the stage of prospecting it is necessary to carry out magnetometer and gravimetric surveys, geophysical prospecting by electric means and litho-geochemical investigation of primary halos.

As a result of works at both stages it is necessary to create geochemical bases for prognostic maps of corresponding scales, which increase efficiency of geological mapping and local forecasting of mineral potential.

The hydrogeochemistry of a sedimentary basin at Idanha a Nova, Portugal. Thermodynamic modelling used in Uranium exploration.

S.P. Vriend, M.J. Dekkers, and P.F.M. van Gaans
Institute of Earth Sciences
Department of Geochemistry
PO Box 80.021 3508 TA Utrecht
The Netherlands

ABSTRACT

A hydrogeochemical study was carried out to prospect for areas with a potential for Uranium mineralization in the Tertiary basin of Castelo Branco, Portugal. Water samples were collected south and east of Idanha a Nova. The samples were filtered over $0.45\mu m$ and analyzed for major, minor and selected trace elements.

With the aid of Fuzzy C-means clustering, a method allowing for the composite character of waters, the samples are classified in four major types: 1. bicarbonate-waters; 2. polluted bicarbonate waters; 3. schist-type or surface waters and 4. granite-type waters. Non-linear mapping of the clustering confirms the partition. The water types show geographic consistency. Uranium concentrations are highest in the bicarbonate waters.

WATEQX calculations on the composition of these dilute waters confirm the free principal ions to be the major species for all elements, except for P, Al and U. Phosphorous is predominantly present as HPO_4^{2-} or $H_2PO_4^-$, Al as $Al(OH)_4^-$ or $Al(OH)_2^+$, depending on pH. For Uranium an uranyl phosphate complex ($UO2(HPO_4)_2^{2-}$) is dominant.

Nitrogen was measured in the laboratory as nitrate. The results of WATEQX indicated the thermodynamic stability of ammonium at the measured Eh-pH conditions. Considerations based on the ionic charge balance lead to the conclusion that kinetic barriers prevent the formation of ammonium in the eastern part of the basin.

This nitrate-ammonium distribution corroborates the gradual decrease of Eh from northeast to south-west in the basin, which apparently coincides with an increase in Uranium concentrations.

In the relatively oxidizing part of the basin U has either never been present in considerable amounts or has virtually been leached. In the more reducing area the elevated U-concentrations in the waters are close to equilibrium (within two orders of magnitude) with minerals like uramphite, schoepite and rutherfordite.

THE AUTORADIOGRAPHY STUDY OF GOLD DISTRIBUTION IN A PROCESS OF THE BLACK SHIST METAMORPHISM

Zhmodik S.M., Kulikov A.A., Shestel S.T. (USSR)

The dimensional distribution of gold in the carbon-bearing of Proterozoic age of Vitim-Patom highland was studied by a method of the activation beta-autoradiography. A series of the samples studied by the autoradiography method represented the ore-bearing carbonaceous schits: prosedimentary these with the syngenetic schistously distributed sulphides: metamorphogenetic these with a wide development of lenses of quartz-pyritic and arsenopyrite with the quartz margins, schistous pyrite-quartz veins cutting bedding.

Gold does not form the independent emanations in the black schists with a schistous dispersed sulphide mineralization assigned to the prosedimentary one. In the process of a collective recrystallization and a consolidation of the sulphides takes place a redistribution of dispersed gold in pyrite with an enrichment of the places timed to the little fissures of a content of Au 0,n -0,0n%. In the single cases in the little fissures in pyrite are fixed the emanations of gold sized 2-5 mkm with the content Au - 90%; Ag - 10%. In the zonal metacrystals of pyrite gold in the form of the micron emanation is concentrated in the central parts of the crystals, around the granulomorphological "embryos" of pyrite. On the whole, the distribution of gold in this type of the ores is subordinated to layering that evidences about the prosedimentary (volcanogene sedimentary or hydrothermal sedimentary) nature of gold. Only native gold (from 2-3 mkm up to 20-30 mkm),spatially timed to the faces and fissures of the sulphides (pyrite,arsenopyrite) is established in metamorphogene hydrothermal formations.

The obtained data evidence about the existence of the dispersed form of gold and its entry into the defects of the crystalline lattice of pyrite. Under metamorphism takes place the diffusive redistribution of gold in pyrite in the direction of the fissures (dislocations) and its isolation in the form of the independent emanation. The use of the autoradiography method allowed to establish the local distribution of gold in the black schists in the different stages of the ore process.

47A

LOW-TEMPERATURE SORPTION OF GOLD AND SILVER BY THE SULPHIDE MINERALS (ACCORDING TO AN AUTORADIOGRAPHY)

Zhmodic S.M., Mironov A.G.

The dimensional relation of gold with the sulphides is most often explained by a superposition of silver-gold ore mineralization on the earlier formed sulphide minerals.

The interaction of the sulphide minerals with gold- and silver containing solutions was studied by a method of the radioisotope indicators in combination with the autoradiography. As radioactive tags were used the radioisotope ^{195}Au (T/2=183 days) and ^{110m}Ag(T/2=253 days) that allowed to conduct the experiments with the contents of gold and silver in the solutions equal to 5-10 mkg/1, that in close to the natural ones under the different pH. The polished plates made from the samples of the most typical ores of gold were taken for the experiments . The opposite shears were used in the experiments on a sedimentation of gold and silver. The samples were placed by the polished surfaces into the working solution for 72 hours under the temperature of 239°K and pressure 1 bar. Exposing was conducted with a use of the emulsion (films) of a type PT, FO-5, AP-3. The coefficients of a distribution of gold and silver were determined on a relation of a density of blackening of a photoemulsion above quartz or pyrite.

As a result of the conducted investigations were established the series of the minerals according to a degree of the sorption of gold and silver from the solutions (pH-2; 10 mkg/g Au 5 Ag) which have the next form:

for gold

Mineral	Gold-Bornite-Galenite-Arsenopyrite-Sphalerite
K	39.6 36.8 5.8-28.6 7.4-10.3 5.7-7.4
min.-qu.	Chalcopyrite-Antimonite-Faded ore-Pyrite-Quartz
	1.8 - 2.2 1.9 1.3 1.1-1.51

for silver

Mineral	Gold-galenite-Bornite-Sphalerite-Arsenopyrite
K	38.8 20.7-37.4 8.1 6.0-9.3 4.3-11.0
min.-qu.	Chalcopyrite-Antimonite-Faded ore-Pyrite-Quartz
	4.7-7.6 6.5 3.5 2.8-4.31

K - the coefficient of the distribution of gold (silver)
min.-qu. mineral-quartz

A quantity of sedimentary gold and silver decreases from metallic gold in the direction of pyrite. The established sequences do not agree with the known series of the electrode potentials of the sulphides, in this connection the process of the sorption of the studied elements cannot be explained by the electrochemical sedimentation. The process of the sorption of the elements with their subsequent reestablishment on the surface of the sorbent (mineral) is more real. This conclusion corresponds to thermodynamic calculations (Letnikov, Vilor,1981) and direct experimental measurings carried out by a method of photoelectron spectroscopy (Bancroft, Gille,1982). The interaction of the auriargentiferous solutions with the sulphide minerals in the natural conditions, with the higher concentrations of silver, must result into the formation of mostly gold-silver compounds (custerite, electrum, low-standard gold).

IMPROVEMENTS IN METHODS OF EVALUATION AND EXPLORATION OF COMPLEX SILVER-BASE METAL DEPOSITS ACCORDING TO THE DATA OF MINERALOGICAL-GEOCHEMICAL INVESTIGATION

B. F. Zlenko, A. M. Gubanov
Institute of Mineralogy, Geochemistry and
Crystallochemistry of Rare Elements, Moscow, USSR

The prospecting works are performed at specific units with proved commercial value. In all deposits geologo-mineralogical studies are carried out to determine forms of occurrence of ore components productive associations, technological grades of ores, evaluation of flanges and deep horizons of the known ore deposits and detection of new ore bodies.The experience in investigation of complex silver-base metal deposits at the stage of search and evaluation and prospecting shows that mineralogical and geochemical data provide valuable information on some other problems:

1) well-grounded selection of main and accompanying components which should be considered during delineation of ore bodies or by group samples in the calculated outline;
2) delineation of separate ore intersections and their space interrelation with determination of commercial outlines of ore deposits;
3) study of distribution of maximum concentrations of some elements, which is important for substantiation of density of sampling grid and determination of a necessary number of cuts for the reliable quantitative evaluation of main calculation parameters (average thickness and concentration);
4) determination of mechanisms of elements distribution and forms of their occurrence in veins, salvages and halos for substantiation of different kinds of work (e.g. drilling) for exact evaluation of mean content of particular elements.

Application of mineralogical-geochemical data for solution of the above mentioned problems significantly increases the quality of prospecting, provides complex use of mineral resources and decreases quantity of costly trials.

48A

PATTERNS OF ELEMENT DISTRIBUTION IN POST-MAGMATIC FORMATIONS OF THE DARASUN ORE-MAGMATIC SYSTEM

L.D.Zorina, Z.I.Kulikova, Institute of Geochemistry, Irkutsk, USSR

The deposits of the Darasun ore-magmatic system refer to gold-sulphide formation. The host rocks include gabroids, which underwent an intensive granitization, and granitoids. The mineralization was preceded by the intrusion of stock-like bodies and dykes diorite and quartz diorite porphyrites, granite-porphyries, plagiogranites and plagioporphyries, felsites and felsite-porphyries. The above rocks underwent to some extent pre-ore propylitization: replacement by albite, sericite, carbonate, actinolite, epidote, chlorite. The similar zonal metasomatic columns are present in the vicinity of ore bodies, mineralized (ore zones) and non-mineralized tectonic dislocations. The absolute age of propylites is 149±8 mln. years (Rb-Sr method). Ore bodies are rimmed by zonal listvenites(quartz, carbonate, chlorite, sericite, pyrite) in gabbroids and berisites (quartz, pyrite, sericite± chlorite) in granitoids, which as though "complete" metasomatic propylite columns. The age of listvenites-berisites is 144±9,6 mln. years. The mineralization proper developed throughout 4 stages: tourmaline (tourmaline, pyrite), pyrites (pyrite, arsenopyrite, chalcopyrite) polymetallic (pyrite, galenite, sphalerite) and sulphosalt (sulphosalts Ag, Bi, Cu, Sb, As, Pb), veined-quartz and carbonates. The ore process terminates by the post-ore quartz-carbonate stage.

The following distribution patterns of several element groups are studied in the granitized gabbroids, propylitized rocks, listvenites, berisites, ore veins, ore zones and non-mineralized tectonic dislocations: alkaline (K, Na, Li, Rb, Cs), rare-alkaline-earth (Ba, Sr), Fe group (Co, Ni, Ti, V, Cr, Mn) and forming ore bodies (Au, Ag, Bi, As, Cu, Sb, Pb, Zn, Hg, B). The levels of element concentrations are normalized after background and are expressed by contrast coefficients (CC). This permitted the geochemical fields of concentration (GFC), removal (GFR) and fields of dispersion (GFD) to be classified.

The following trends should be indicated. Potassium in the processes of pre-ore and syn-ore alteration of the host rocks tends to accumulation and formation of GFC. It is removed from the zones of maximum sulphide deposition (ore veins). Sodium on the contrary is characterized by the stable removal, which is observed from the propylitization process. Rare alkalies and Ba, as well as K tend to accumulation. Along with it, in some metasomatic zones of granitized gabbroids, propylitized rocks and berisites, alkalies and Ba remain at the background level. Strontium and the elements of Fe group form GFR, which are connected with GFC of ore and alkaline elements. GFD of Co, Ti, Mn, Ni and V may occur only in the propylitized granitoids and berisites. Such ore elements as Au, Ag, Bi, Pb start accumulating in the process of propylitization. Their contrast being low (CC up to 10). The spectrum of elements is extended in listvenites and berisites and corresponds to that of ore veins (Au, Ag, Pb, Zn, Cu, As, Bi, Sb, Hg, B), the contrast increasing up to 100. It is maximum (CC>> 100) in the ore veins from which all petrogenic and associated rare elements are removed. The ore zones are characterized by average and high contrast GFC of ore elements, which are associated with K, Li, Rb, Cs, Ba, Mn and connected with GFR of other elements studied. Geochemical field of concentration of Li amd low-contrast geochemical fields of concentration of ore elements, associated in some cases with GFC of K, Rb, Cs, Ba, Mn, Co, Ni, Ti, V, are the markers of tectonic dislocations.

The analysis of GFC, GFR, GFD of the Darasun ore-magmatic system indicates the juvenile supply of ore elements, B, K, as well as displacement of Na and Fe group elements and redistribution and possible juvenile supply of Ba and rare alakalies. The above features are proposed to be applied in practice of prospecting.

APPLICATION OF THE METHODIC BASES DEVELOPED IN THE USSR FOR GEOCHEMICAL EXPLORATION AND EVALUATION OF GOLD-ANTIMONY MINERALIZATION IN SLOVAK DEPOSITS

M. A. Zubov (USSR), E.Dryznik (CzSSR),
Institute of Mineralogy Geochemistry and
Crystallochemistry of Rare Elements, Moscow, USSR

Multifactor models of ore objects at different hierarchic levels (ore bodies, deposits, ore fields) serve as the base for interpretation of geochemical data. Generalization and additional study of occurrences of Au-Sb mineralization in Slovakia allowed to reveal similarity and/or difference with soviet standard objects of the analogous type and to create a generalized exploration-interpretational geologic-geochemical model of Au-Sb mineralization. The interpretation methods of geochemical components and model characteristics-chemical composition, geochemical zoning, proportionality of parameters of halos and ore bodies.

In the applied interpretation technique, specific features of chemical composition are used to distinguish geochemical anomalies and evaluate their possible formation type: the geochemical zonality is the criterion for estimation of the erosion level of anomalies. The size of mineralization is forecasted on the basis of quantitative dependence of parameters of geochemical halos and ore bodies.

The application of the developed technique in the districts of Au-Sb mineralization in Little Carpathians, Low Tatras Mountains and Spishsko-Gemersky Ore mountains demonstrated its efficiency and allowed to obtain interesting practical results.

49A

GLACIAL DISPERSAL OF CHROMITE FROM THE KEMI CHROMITE ORE IN NORTHERN FINLAND

Tuomo Alapieti. Lars Forsström and Vesa Peuraniemi
Department of Geology, University of Oulu, 90570 Oulu, Finland

A considerable number of chromite ore boulders had been found in the area east of Oulu, Northern Finland, even by the mid-1960's, and thungsten and sulphide ore prospecting was carried out by Rautaruukki Oy Exploration in the same area in the early 1980's using heavy mineral till geochemistry. It was then decided to employ this method to reconsider the source of the old chromite ore boulders.

Samples were taken from a surficial part of the till and the heavy fraction was concentrated by sluicing and panning for chemical analysis by XRF. Selected samples were investigated mineralogically with the aid of scanning electron microscopy and an electron microprobe.

As a result, a glacial dispersal train of chromite was found which is exceptionally long by Finnish standards. The source rock turned out to be the Kemi chromium ore, already discovered in1959, one of the largest chromite deposits in the world, which is situated over 100 km northwest of the chromite ore boulders. The chromite anomaly in the heavy till fraction extends in a coherent form for 80-90 km to the southeast, the direction of ice movement, and up to 120 km in a discontinuous form. The dispersal train is so long that it must have been generated during several successive glaciations. The fact that the sub-outcrop of the Kemi chromium ore is broad will also have contributed to the length of the dispersal train, as has high resistance of chromite to chemical and mechanical weathering.

The results of the survey also showed that the last ice flow phases were highly important for the dispersal of surface boulders, although the average direction of successive ice movements is the most important factor when considering the transport of the whole till material.

ORE-RELATED ALTERATION AS A GUIDE IN BOULDER PROSPECTING

William O. Karvinen
W.O.KARVINEN & Associates Ltd., 32 Lakeland Pt. Dr., Kingston, Ont. K7M 4E7 Canada

Ore-boulder prospecting, particularly in glaciated terrains, has been successfully used in locating ore deposits especially in Scandinavia and Canada. But, because economic concentrations of mineralization tend to be relatively small compared to other rock-types and generally have limited exposure to mechanical/chemical weathering, the representation of ore material in the overburden, especially on or near surface, is restricted. To expand the effectiveness of boulder prospecting, methodology has been developed which makes use of the unique alteration assemblages associated with hydrothermal ore deposits. Such alteration zones are a few magnitudes greater in volume than the associated ores and therefore are represented in greater abundances in transported overburden.

Several alteration types which are intimately associated with Archean base and precious metal deposits in the Canadian Shield of Ontario and Quebec have been documented and used with varying degrees of success in locating areas of mineralization. Examples are presented from existing mining camps as well as case histories of new discoveries.

5CA

Some pros and cons of using the heavy fraction of overburden in geochemical exploration

by: Y.T. Maurice

Geological Survey of Canada
Ottawa, Canada

Because it requires more time to collect and to prepare for analysis, the heavy mineral fraction of overburden is more costly on a unit sample basis than the equivalent unseparated sample material (soils, glacial till, alluvium, etc) commonly used in geochemical exploration. Yet mining companies and prospectors increasingly include heavy mineral sampling in their exploration programs. This is partly the result of the shift, in the mid-80s, in the then current and forecasted long term demand for mineral substances, away from base metals and more towards precious, strategic, and high-tech materials. Another likely cause is the realization that the heavy mineral approach has a number of distinct advantages over more conventional techniques and provide a more sensitive mean of detecting the increasingly-difficult-to-find ore deposits. This paper is based on nearly ten years of accumulated experience on heavy mineral geochemistry, mostly in the Canadian Appalachians.

Most of the advantages of using heavy minerals in geochemical exploration can be summarized as follows.
Heavy minerals provide:

1. a substantial lowering of the detection limits for all the elements that make up the heavy mineral suite,
2. greater representativity of the samples due to the larger volume of original material processed,
3. geochemically less complex samples which facilitates data interpretation,
4. more opportunities to study anomalous samples using a wide range of follow-up techniques based on mineralogy and mineral chemistry.

Some of the drawbacks include:

a. higher cost per sample,
b. requirements for more elaborate field and sample preparation procedures and facilities,
c. interferences when using certain techniques of analyses (e.g. XRF, INAA) which often result in a loss of sensitivity,
d. limited usefulness for certain important metals types (including some base metals) and pathfinder elements,
e. loss of potential information resulting from a geochemically simpler sample.

Other often-cited problems with heavy minerals, such as greater sensitivity to metallic contaminants and insufficient heavy minerals due to low heavy mineral content of overburden in some areas, rarely constitute serious impediments to the technique and can generally be overcome by simple means.

51

GEOCHEMICAL FEATURES OF SCHEELITES FOR PROSPECTING OF TUNGSTEN DEPOSITS

J.L.Nikolaev, A.G.Gurbanov, V.J.Rekharsky.

Institute Ore Deposits Geology, Petrography, Mineralogy and Geochemistry,
USSR Academy of Sciences, Moscow, USSR.

Scheelites of the North Caucasus Bolshoy Blib deposit of quartz-scheelite type related to diorite-plagiogranite association presumably of Precambrian age, are higher in Cr, Mo, Sr, Pb, K and Rb than scheelites of the same type North Caucasus Kti-Teberda deposit related to diorite-granite association of Late Paleozoic age enriched in Sb.

Scheelites of the North Caucasus Djimidon polymetallic deposit are related to diorite-granite association of uncertain age (PZ3- I1?) and concentrations of Cr, Mo, Sr, Pb, K and Rb in them are decreasing with the increase of Sb contents. Geochemical features of scheelites of the Jasenie-Cista deposit in Czechoslovakia (quartz-scheelite type) resemble those of Kti- Tebera deposit.

In vertical section of Kti-Teberda deposit scheelites of the upper units are enriched in Mn, Sn and Pb while those of the lower units in Cr, Fe, Na, Bi, Ba, Li and K.

These results can be used for prospecting and search of scheelite and scheelite-bearing deposits of different age and origin and also for estimation of their erosion level.

GEOCHEMICAL METHODS FOR SHELF PLACERS SEARCHING

Patyk-Kara N.G.
Institute of Ore Deposit Geology, Petrography, Mineralogy and Geochemistry of the USSR Acad. of Sci.,
Moscow, USSR

Geochemical methods make it possible to get a direct express information about ore mineral accumulation in coastal shelf zones. They are based on the study of elements of lithologic-geochemical background and elements of ore paragenesis proper. It was noted that buried and submerged placers in the coastal shelf zone are associated with contrast geochemical anomalies. The composition, length and stability of the anomalies is determined by the nature of primary feeding sources and the evolution of sediments. Being a variation of mechanical flows belonging to a slime class, the shelf placers are associated with disperse aureoles and flows in aleuritic, pelitic and subcollodial fraction of the sediment. In the destruction zone, for example, on the abrasive platforms, the aureoles primarily have a mechanical nature; over buried placers salt, sorbtion and some other aureoles are formed. They all have a vertical development. In the both cases the nowadays active layer is an important geochemical barrier zone to intensify a signal about buried ore accumulations.

The geochemical study of the nowadays active level of the bottom placers allows us to discover potential placer (ore placer) joints with buried and submerged placers and fields of deposits. In the cut of metal bearing sediments by means of geochemical methods we can draw an outline of placers. We can also determine the type of the cut and level of primary source cut according to the composition of the associated complex lithologic-chemical anomalies.

GEOLOGICAL EVOLUTION OF PLACERS

Patyk-Kara N.G.

Institute of Ore Deposit Geology, Petrography, Mineralogy and Geochemistry of the USSR Acad. of Sci.,
Moscow, USSR

Placers are traditionally regarded as a product of simple mechanical differentiation. But the modern theory of placers is about diffusion and concentration processes of ore substance on the geochemical level. You cannot avoid studying the geochemical level to develop the theory of placers and to improve methods of prospecting and searching of placers.

From the point of geochemistry all the placers are divided into two big groups: near drift placers (having a local primary source) and far drift placers (they appear after numerous residementation processes of regional source substance). The main tendency for the occurrence of the first group can be formulated as "Concentration on the way to diffusion". As far as the second group is concerned, an absolute concentration of raw components takes place in relation to primary rocks.

The geochemical evolution of placers has several aspects. The first one deals with the level of ore-formation processes. It comprises the analysis of transformation of ore substance of placers depending on a tectonic-geomorphologic evolution of the region with the consideration to cyclicity and irreversibility of placers formation processes from stage to stage. The second aspect covers the problem of concentration and diffusion of the substance in placers under the influence of various factors, that determine the level of source cut(a reflected geochemical zonality of placers). The third aspect is the study of geochemistry of placer formation processes in definite sedimentation environment. The fourth aspect concerns the analysis of placers from the point of various mechanical flows of diffusion. Here local facies, lithologic-dynamic and structural environments act as gravitation geochemical barriers that can change migration conditions and raw mineral concentration. The fifth aspect is the study of secondary aureoles and diffusion flows, appearing in the process of postsedimental changes in metal-bearing sediments and used as most important measures for prospecting and searching of buried and submerged placers.

52A

ON THE MODE OF OCCURRENCE OF ZINC IN GLACIAL TILL AND ITS APPLICABILITY TO THE USE OF HEAVY MINERAL GEOCHEMISTRY TO SEARCH FOR ZINC ORES

Vesa Peuraniemi, Department of Geology, University of Oulu, 90570 Oulu, Finland

Economically the most important zinc-bearing mineral in zinc ores is zinc sulphide, or sphalerite, which is readily decomposed in a surficial, oxidizing environment to release zinc ions into the circulating water. In glaciated terrain, till samples taken from deep down near the bedrock surface, often below the groundwater table, can contain glacially dispersed primary sphalerite. Since it is usually the fine fraction rich in phyllosilicates and secondary iron hydroxides that is most often analyzed in till geochemistry, the hydromorphically dispersed zinc can also be identified.

On the other hand, heavy mineral geochemistry, in which the samples are usually taken from the surficial part of the till, is not regarded as a reliable means for searching for zinc or other sulphide ores. It is widely believed that the glacially dispersed sphalerite has decomposed in the oxidizing surficial parts of the till deposits during postglacial times. The present survey deals with the mode of occurrence of zinc in till in four areas in Finland where anomalous zinc concentrations have been encountered in the surficial parts of the till.

A primary sphalerite has been found in the surficial part of the till in the Ylikiiminki area, the reason for this being that the area is flat and the groundwater level high, so that also the surficial parts of the till are quite moist in places and postglacial weathering has not caused decomposition of the glacially dispersed sphalerite.

In the Leteensuo area a zinc anomaly fan was found in heavy mineral samples from the surficial parts of the till, but no sphalerite was identified. The samples also contained iron and manganese anomalies. The interpretation is that glacially dispersed sphalerite was decomposed and the zinc ions liberated by this immediately became bound to Fe-Mn hydroxides.

A zinc anomaly in the surficial part of the till in the Saajanmäki area led to the discovery of a sphalerite mineralization. Some sphalerite was also found in till samples, but some had evidently been decomposed, generating secondary iron sulphate, melanterite, as a result. Melanterite can still contain some zinc in its lattice.

Heavy mineral samples with zinc anomalies obtained in the Kataloistenjärvi area contained no sphalerite, and the anomaly was found to be caused by a green, entirely fresh mineral identified as zinc spinel, gahnite, which occurs in connection with sulphidic zinc ores, so that it can be regarded as an important indicator mineral.

The sulphide-bound metals Zn, Cu, Pb, Ni, Co should also be analyzed in regional heavy mineral geochemistry surveys, and if anomalous metal concentrations are found it may be rewarding to look into the mode of occurrence of these metals.

HEAVY MINERAL PROSPECTING IN THE NORTH-WEST PART OF BOHEMIAN MASSIF

Šimek J., Geoindustria Praha, Czechoslovakia

Reconnaissance heavy mineral prospecting covered up to this time more than 70 % of the Czech republic /e.g. 53 500 sq.km/. The last project was finished in 1986 and covered the area of the České středohoří /the Czech Midmountains/ and contiguous areas in the north-west part of Bohemian massif.

The area of interest is represented by various types of tertiary volcanites, platform sediments of cretaceous and neogene age, not very large islets of Paleogene System, porphyres of permocarboniferous age and, in lesser extent, the rocks of crystalline complex.

In this area of about 2 600 sq.km the set of 2.654 heavy mineral samples were taken from active recent stream sediments e.g. the density of sampling was about 1 sample/sq.km. Then sieving followed (2 mm sieves) and -2 mm fractions were panned. Next laboratory processing included : sieving into -2 + 0,15 mm and -0,15 subfractions, magnetic separation and separation in heavy liquids of the former and, finally, colouring tests for barite, cassiterite and wolframite. The -2 + 0,15 mm fractions were analysed in mineralogical way, e.g. the contents of present minerals were estimated in grams/cu.m. The fine fractions (-0,15 mm) were pulverized and, using optical emission spectral analysis, the concentrations of 17 elements (Ag, As, Au, Bi, Cu, Hg, La, Mo, Nb, Ni, Pb, Pt, Sb, Sn, W, Zn and Zr) were estimated.

After statistical evaluation the anomalies of cassiterite, scheelite, wolframite, pyrite, chalcopyrite, gold, barite, pyrope and topaz (111 anomalies together) were delineated as probable source areas in the colour-printed distribution maps of 1 : 50 000 scale. In addition, the distribution maps of apatite, perovskite, light-green monoclinic pyroxene and Cr-diopside (in the same scale) were delineated; these minerals (and namely pyrope, picroilmenite, Cr-spinel, olivine etc.) are known as the pathfinder minerals for diamond occurences. Unfortunately, diamonds were not found in any sample.

The distribution maps of selected minerals and/or chemical elements (1 : 200 000 scale) were plotted by means of computer. The most interesting and contrast are extensive anomalies of bloody-red pyrope, some anomalies of scheelite, cassiterite, topaz and barite.

Generally, the pyrope anomalies are associated with higher contents of Cr-diopside, light-green monoclinic pyroxene and/or perovskite. Some of these anomalies are of similar association type as the contrast one in the surroundings of Třebívlice, which reflects the known and mined pyrope gravels.

As for cassiterite-scheelite anomalies, there was very contrast one delineated in the south-east surroundings of Teplice. Its significance is stressed by the presence of coarse-grained and angular cassiterite, high contents of topaz and some elements such as Sn, Mo, Bi, Zn. The mineral association corresponds to the near-by anomaly between well known Cínovec and Krupka deposits.

Barite, in contrast to the other minerals of special-interest, makes up higher number of the more extensive anomalies, which are situated along the fault system of NE-SW direction. It is possible, that some of the barite anomalies reflect the existence of the neoidic barite (∓ fluorite) mineralizations.

The associated anomalies of two types were delineated on the bassis of single elements distribution:

1. Sn - W (± Mo, ± Bi) type of association, which can be stressed by higher concentrations of Zn and/or Pb, Ag; and
2. Pb - Zn (± Cu, ± Ag) type of association, with higher concentrations of Sb, As, but even Bi, Mo in single anomalies.

The distribution maps of single rock-forming minerals (1 : 200 000 scale as well) served among others as the basis for delineation of mineral association fields. The compraring of these maps with the geological situation made possible to delineate four basic mineral associations; each of them characterizes distinct lithological environment:

- association of heavy minerals indicating volcanite occurences
- association of heavy minerals of permocarboniferous rocks
- association of heavy minerals of neogene basins, and
- association of heavy minerals correspoding to the crystalline complex

The map of industrial pollution indications is the final output of evaluation of metal and non-metal human activity fragments in the samples. There were found three subregions with significant pollution of stream sediments, alltogether in the surroundings of the industrial centres. The most signifificant is the relation between non-metal pollution and glass industry, accentuated locally by higher concentrations of Hg and/or Au, Nbm and Pb. These results confirm the applicability of the method also in environmental studies.

References:

Doležalová et al. /1986/: Dílčí závěrečná zpráva úkolu "Severočeské vulkanity". - MS Geoindustria Jihlava

SOME CRYOGENIC GEOCHEMICAL ANOMALIES OF GOLD ORE DEPOSITS IN BALD MOUNTAINS; TAIGA LANDSCAPES IN SIBERIA

T.T.Taisaev
Geological Institute, Buryat Research Center of the Siberian Branch USSR Academy of Sciences,
Ulan-Ude, USSR

Active cryogenic transformation of gold deposits and their preglacial oxidation zones, caused by repeated phase transformations and presence of non-freezing pellicular water, occurs in the cryolithic zone of Bald Mountains - Taiga landscape of Middle Mountains. Moreover, large gold grains separate, but thin-dispersed gold changes into solution. Gold-quartz low-sulphide veins incorporate Archean-Proterozoic gneiss fault and are subjected to post-ore mechanical splintering. Coarse-grained free gold from quartz and sulphides (class -2,5+0,1) accounts for 50-70% of general content in the cryogenic zone of the vein disintegration. Residual concentrations of coarse gold represented by elluvial halos and placer deposits, formed in the upper parts of slopes over vein outcrops by the regular transport of fine products of weathering and fine gold, represent the source of alluvial placers. The gold concentrations in the elluvial halos are 1,5 - 5 times greater than in primary ores. Horizonts of surface gold enrichment are formed in cryogenic and pre-glacial oxidation zones. Fine-grained gold forms secondary aureoles, fluxes and gold-bering sediments in subpond reservoir. Open suffosional gold aureoles are typical in the foot of rock stream slapes. Gold is sorbed from gold-bearing water by clay, ferric hydrate, peat and falls on native gold on platforms of river valleys.

Cryogenic zone of sulphate and oxide oxidation is distinguished over gold-sulphide ore in Paleozoic black schists. Apart of original minerals (pyrite, pyrrhotite, chalcopyrite, galena), goethite, hydrogoethite, jarosite, melanterite, malachite, and azurite occur. In cryogenic zones of fractured sulphide ores, great number of soluble metallic salts transfer to the surface with pellicular water in winter. Oxidized ores are accompanied by cryogenic saline anomalies. Mineralization burried under solifluction sediments is indicated by contrast water, biogeochemical and little-contrasting lithogeochemical gold anomalies. In ferrigenous sediments and peats of low moors and water-bearing fault zones as in arboreous and shrub vegetation on the gold anomalies are informative. Lichen, the predominant kind of vegetation of bald mountain landscapes, concentrates gold drastically.

Thus, the conjugate cryogenic mechanical and saline (lithochemical, water and biogeochemical) gold anomalies are formed in the zone of gold ore deposits cryogenesis. The cryogenic cores of weathered gold-quartz veins are the source of elluvial and alluvial placers in subpond reservoirs. The lithochemical stray fluxes are connected with fundamental sources and Late-Pleistocene gold-bearing glacial and fluvio-alluvial sediments. The weak lithochemical stray fluxes of gold intensify by moss and plants aleurite testing along the river-bed flux and are distinguished by contrasting biogeochemical anomalies.

THE GOLD PANNING EXPLORATION IN THE EASTERN PYRENEES AND CATALONIAN COASTAL RANGES (NE SPAIN)

M. Viladevall*, J. Marturiá*, F. Espiell**, G. Camacho * and A.Llobet *
(*) Dept. of Geochemistry, Petrology and Geological Prospecting. Zona Universitaria de Pedralbes 08028 Barcelona, Spain. (**) Dept. of Chemical Engineering and Metalurgy. Zona Universitaria de Pedralbes 08028 Barcelona, Spain.

The panning surveys covered an extension of 9500 km2 in the Hercynian materials and were made in 1986, 1987,1988 and 1989. A total of 450 panning concentrates were made in the Catalonian Coastal Ranges (CCR) with the support of the Geological Survey of Catalonia; 73 in the CCR and 280 in the Pyrennes with support provide by the "Comisión Asesora de Investigación Científica y Técnica (CAICYT)", Ref.PB86-0023 .

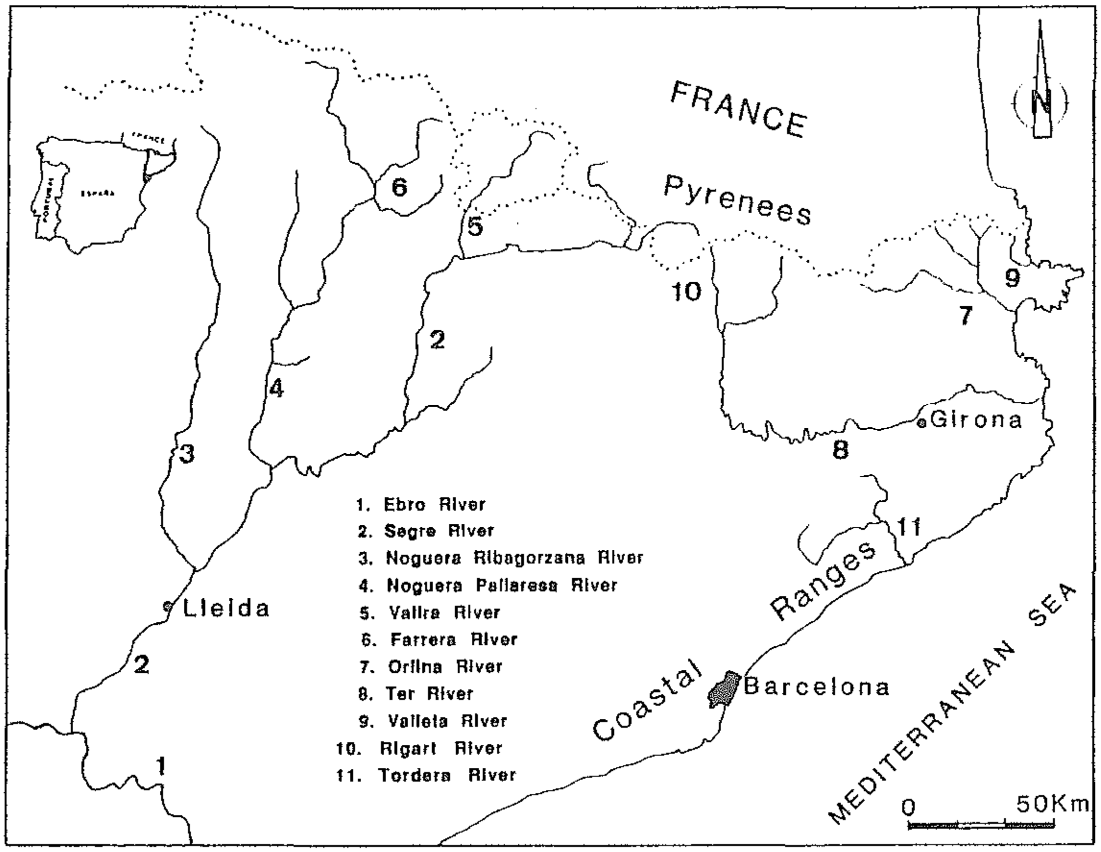
The major content of gold comes from the rivers draining from the Axial Pyrenees (fig.1), principally the Segre River (Viladevall, et. al.,1989); the Ter River; and the Orlina River. However, in the CCR, the most important area is the Tordera River in the Montseny Massif.All these were very likely workered in the Middle Ages and possibly already in the Roman period.

The primary source of gold proceeds from the Cambrian-Ordovician siliciclastic rocks, paleoplacers of the Silurian and Devonian age, epithermal volcanogenic gold deposits of the Permian age, Hercinian As-Au lodes or/and Hercynian skarns deposits. The secondary sources proceed from the Quaternary tills.

The average particle content in 10 litres ranges from 2 to 3. The richest zone found is in the Segre River with a maximum of 3g per m3. The silver content in the gold particles varies from 13.9 pct to 3 pct on SME-EDS (Vaquer, et. al., 1989) in the Axial zone and the Tordera River . In the lower parts of the rivers the silver content varies from 6pct to 3 pct on SME-EDS.

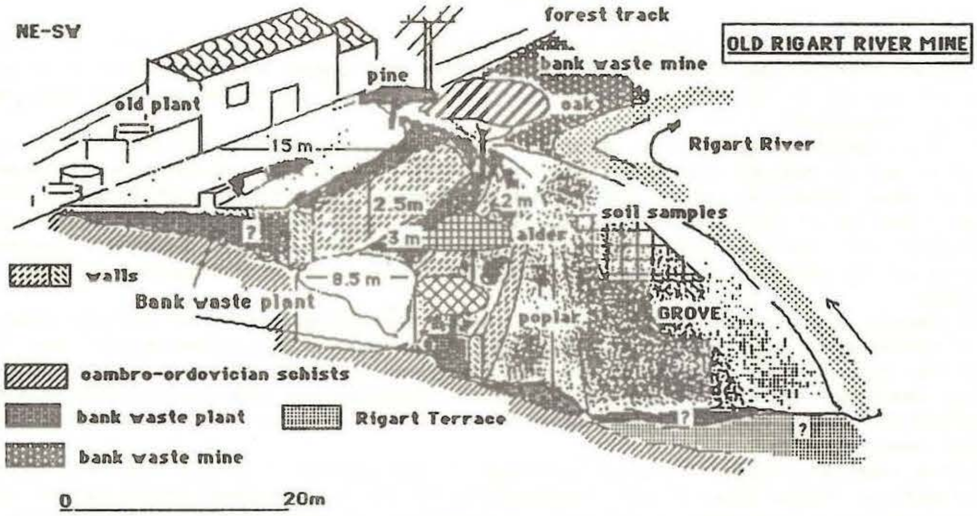
References:

Viladevall, M., Serra, J., Espiell, F., Colombo, F., Canals, M., Camacho, G. & Marturiá, J./1989/: "The gold placer of the Segre River (Catalonia, NE Spain)". *4th International Conference on Fluvial Sedimentology.* Barcelona. October 1989, pp.237.
Vaquer, R., Espiell, F., Viladevall, M. and Camacho, G./1989/. "Determination of the Au/Ag ratio in gold particles by SME-EDS". *Gold 89 in Europe.* Toulouse Mai 1989.



BIOGEOCHEMICAL GOLD EXPLORATION IN THE OLD RIGART RIVER MINE IN THE PYRENEES (CATALONIA.NE SPAIN)

G, Camacho *, F, Espiell** and M, Viladevall .
(*) Dept. of Geochemistry, Petrology and Geological Prospecting. Zona Universitaria de Pedralbes 08028 Barcelona, Spain. (**) Dept. of Chemical Engineering and Metalurgy. Zona Universitaria de Pedralbes 08028 Barcelona, Spain.



Recent research in the old As-Sb-Cu (Au,Ag) mine in the Oriental Pyrenees (Catalonia, NE Spain), shows an anomalous content of silver and gold in the plant waste and mine waste. Fig.1.

Samplings were from the bank waste plant, bank waste mine, the soil forest track, the terrace of the Rigart River which is beside the bank waste plant, and leaves from some trees which grow in the bank waste plant.

Results:

The analytical method was the AAs graphite furnace for gold and silver and INAA bay gold and 27 other elements.The gold and silver content in the bank waste plant is 65 ppm and 200 ppm respectively. The gold content in the bank waste mine is 7 ppm and the gold content in the soil forest track beside the old mine range from 1.5 ppm to 21 ppm. (Fig.1.)

The gold content in the oak leaves varies from 260 ppb to 6 ppb in three samples taken in November, July, October and November (1988-1989); the pine varies from 26 to 21 ppb; the poplar from 125 ppb to 4 ppb; and the alder between 58 ppb to 15 ppb. (Table 1.)

METALLIC CONTENTS IN LEAVES OF OAK, PINE, POPLAR AND ALDER TREES (Table 1)

	November1988				July1989				November1989				October 1989
	oak	pine	poplar	alder	oak	pine	poplar	alder	oak	pine	poplar	alder	oak
Au ppb	260	26	125	51	6	16	4	15	94	21	10	28	24
As ppm	226	36	75	41	4	36	5	11	88	37	7	19	12
Sb ppm	39	9	44	12	2	6	2	4	15	7	3	7	6
Zn ppm	60	54	198	63	22	35	89	55	32	38	65	63	33
Co ppb	540	280	141	460	-	380	560	200	-	-	900	-	-
La ppb	600	360	81	850	180	600	170	380	-	550	-	-	-

The most constant gold contents, in the biogeochemical samples studied are found in the pine and the alder leaves. The oak and poplar show very unstable contents varying sharply according to season and weather.

Full support was provied by "Comisión Asesora de Investigación Científica y Técnica (CAICYT)", Ref.PB86-0023

ON THE GEOCHEMISTRY OF HEAVY METALS IN THE GEOMICROBIAL BARRIER SYSTEMS

V.V.Demidov, B.S. Kogan,
Institute of Mineralogy, Geochemistry and
Crystallochemistry of Rare Elements,
Moscow, USSR

It is accepted now that biogenic factors belong to the most effective ones for halo and ore formation process. At the same time however the mechanism of biogenic differentiation of metals in the barrier systems and the selectivity of biochemical interactions of microorganisms with heavy metals are insufficiently investigated.

Our investigations of peculiarity of metallotransformation activity of autochthonous microorganisms of geomicrobial barrier systems discovered that the biochemical interactions are selective ones not only to the sort of metal associated anions. The estimations display high efficiency of dissolved heavy metals by selective formation of precipitated metalloorganic flocculs. Thus, the discovered selective bioflocculation together with their earlier displayed processes of electoral colloid-biogenic aggregation and biocoalescence are the powerful mechanisms for differential concentration of dissolved and colloidal forms of heavy metals.

The results obtained make the frame work for quantitative physic-chemical and physicomathematical modelling of processes of geochemical differentiation of metals on such biochemical barriers. They allow to estimate the role of metallophility of microorganisms for formation of complex geochemical halos in metalliferous sediments. Selectivity of interactions of microorganisms with the concrete metals explains zonal deposition of cobalt, nickel, copper, cadmium and other heavy metals in organometallic fractions of organomineral beach deposits.

We have modelled experimentally the processes of autocleaning of waters from heavy metals on the river-marine barrier. Regularities of this mechanism may be used for the governing of barrier geochemical processes and serve as a test-signs in the geomicrobiological and ecogeochemical investigations.

Several ecological aspects of microbial-metal interactions in geomicrobial barrier systems are also discussed. The possible consequence of environmental pollutions by heavy metals, for example, the increase of the beach abrasion and the raise of pathogenity of marine microorganisms as the results of violation of ecological equilibriums on the level of microbial population are drawn.

BIOGEOCHEMICAL EXPLORATION FOR NOBLE METALS IN WESTERN CANADA

Colin E. Dunn, Geological Survey of Canada

Much of western Canada is rugged, mountainous, and heavily forested with coniferous trees characteristic of temperature latitudes. Exploration for the noble metals is hampered by both the physical environment and a cover of glacial deposits. Recent studies have attempted to characterize the efficiency of these trees in absorbing metals derived from deposits of the noble metals, and thereby established the value of each plant species in helping to discover mineralization.

To date there has been only limited success in applying biochemical methods to the exploration for the platinum group metals (PGM). The Tulameen mineralization comprises mainly Pt and Ir associated with pods of chromite contained within serpentinized dunite. Weak enrichments of Pt (up to 30 ppb in ash) have been observed in the bark and twigs of Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta), and in the foliage of western cedar (Thuja plicata). The small flower Eriogonum ovalifolium also contains slightly elevated levels of Pt. Data on Pd, Rh, and Ir indicate lower concentrations than Pt with no consistent patterns of enrichment in the species studied.

Considerably more success has been obtained in studies of Au. In general the twigs and outer bark of the conifers contain appreciably more Au than other tissues. Levels of up to 3000 ppb Au in ash have been found near zones of Au mineralization, demonstrating that there is significant enrichment with respect to the 10 - 20 ppb Au that represents background concentrations in ash.

Around the Nickel Plate mine, contained in skarn-hosted Au mineralization in southern British Columbia, Au concentrations are enriched in outer bark of lodgepole pine throughout an area of 100 sq. km. Distinct patterns of metal enrichment (notably As and Bi) in the bark appear related to the mineralogy of the deposits. The area of enrichment of each element is different, and tests indicate that the patterns observed are not a result of air-borne contamination.

In the central part of the Province a survey was undertaken to examine the feasibility of exploring for Au by collecting tree tops for analysis. The procedure, which involved leaning out of a helicopter to snip off the top 1 m of Douglas-fir trees, proved a practical and cost-effective method of quickly screening rugged of heavily-forested terrains for the mineral potential of the ground. Results indicated a 10 to 100-fold enrichment of Au in tree tops near the undeveloped zone of mineralization.

Another study compared biogeochemical and lithogeochemical data and showed a considerably larger zone of Au and As enrichment in western hemlock (Tsuga heterophylla) and Pacific silver fir (Abies amabilis) than in the bedrock. In the steep terrain of this survey area, groundwaters caused significant dispersion of metals down-slope from the deposit, providing a much larger biogeochemical target than that of the bedrock chemistry. This phenomenon of large biogeochemical haloes of metals around mineral deposits provides a sound reason for including biogeochemistry as an integral part of an exploration program.

RELATIONS BETWEEN THE HYDROCARBON GENETIC FEATURES OF KEROGENS AND THEIR BIOLOGICAL PRECURSOR MATERIAL

M. Hetényi and M. Kedves, A. József University, Hungary

Hydrocarbon genetic features of organic rich sediments derived from different biological precursor materials were studied on some Hungarian fossil fuels (oil shales and low-rank coals).

Type and thermal maturity as well as hydrocarbon potential of the kerogens were determined by Rock Eval pyrolysis. Immaturity of organic matter of the investigated samples offered a possibility to simulate their catagenesis and to measure their liquid hydrocarbon potential by laboratory thermal degradation.

Alginites formed in Upper Pannonian maar-type volcanic crater lakes and the organic rich sediments deposited in Upper Triassic lagoons (Solti, 1985; Knutson et al., 1989), contained kerogen very favourable to produce hydrocarbons. Their biological precursor material was mainly Botryococcus braunii algae of different preservation. Absence of the benthic organism in the anoxic bottom water permitted a good preservation of algae. It led to kerogen of type I with very high hidrogen index (HI $>$ 750mgHC/TOC) and good conversion ratio of organic carbon (PC/TOC=65-70%) as well as an excellent liquid hydrocarbon potential ($>$750 mg/gTOC). At the same time the kerogens originating from Botryococcus braunii algae which was extensively reworked by microorganism proved to be of type II (HI=500-600 mgHC/TOC; PC/TOC=45-50 %), and their liquid hydrocarbon potential (290-450 mg/g TOC) seemed to be a moderate one.

Kerogen of type II with lower hidrogen index (350 mgHC/gTOC), PC/TOC ratio (33 %) and liquid hydrocarbon potential (290 mg/gTOC) filled in a maar-type volcanic crater lake of special biological activity. Its organic material consisted of a mixture of land derived higher plants and algal material. In addition to the considerably reworked Botryococcus braunii algae sporomorph assemblages were identified in good preservation.

Kerogen of type III and type II were found in low-rank coals made essentially of plants of terrestrial origin. Miocene lignites (HI$<$150 mgHC/gTOC, PC/TOC$<$15%) derived from subtropical swamp vegetation produced a small yield of liquid hydrocarbons ($<$100 mg/g TOC). Eocene brown coals(HI=150-320 mg HC/gTOC; PC/TOC=19-30 %) originating from tropical vegetation had fairly high liquid hydrocarbon potential (100-310 mg/gTOC). Comparing the parameters measured by Rock Eval pyrolysis and the yield of pyrolysate to the results of other works (Mukhopadhyay et al. 1989; Teichmüller et al., 1983) the studied Miocene lignites could be classified as humic coals and the studied Eocene brown coals as mixed ones.

Due to the dissimilar depositional environments kerogens could have different hydrocarbon genetic features. Brown coals deposited in periodically inundated Fagaceae semiterrestric swamp seemed to be very similar to the kerogen derived from a mixture of algal material and terrestrial higher plants (yield of pyrolysates=309 mg/gTOC). Whereas, brown coals formed in a swamp rich in Ericaceae shrub were nearly as unfavourable for liquid hydrocarbon generation (105 mg/gTOC) as Miocene lignites.

References:

Knutson C.F., Dana G.F., Solti G., Qian J.L., Ball F.D., Russel P.L. Piper E.M., Vaino Paura, Vello Kattai and Kaarli Urov (1989):Developments in oil shale in 1988. Am. Assoc. Pet. Geol. Bull. 73/108. 375-384.

Mukhopadhyay P.K., Gormly J.R. and Zumberge J.E. (1989): Generation of hydrocarbons from the Tertiary coals of Texas - Coal as potential source rock for liquid hydrocarbons in a deltaic basin? - Org. Geochem. 14, 351-352.

Solti G. (1985): Alginite (oil-shale) exploration and utilization possibilities in Hungary. Földtani Kutatás. XXVIII, 11-20. (In Hungarian).

Teichmüller M. and Durand B. (1983): Fluorescence microscopical rank studies of liptinites and vitrinites in peat and coals, and comparison with results of the Rock Eval pyrolysis. - Int. J. Coal Geology, 2, 197-230.

57A

BIOGEOCHEMICAL METHOD OF TIN ORE DEPOSIT SEARCHINGS IN THE FAR EAST

IVASHOV P.V.
Institute of Water and Ecological Problem of the Far East Branch of the USSR Academy of Sciences
USSR, Khabarovsk

For the purpose of establishing a possibility of biogeochemical indication of tin mineralization many practice and methodic tests were carried out at various tin deposits and tin ore manifestations having different genetic types in the Far East such as: 1) quartz-cassiterite, 2) sulphide-cassiterite, 3) sulphide-stannite-cassiterite, 4) cassiterite-polymetallic, 5) cassiterite-skarn, 6) cassiterite-pegmatite, 7) cassiterite-greisen, 8) cassiterite-placer.

It was found that in all cases tin ore manifestations represented generally by cassiterite were fixed by biogeochemical aureoles of tin dispersion according to data obtained by analysis of plant ash. Biogeochemical tin anomalies corresponding spacely to epicenters of tin ore bodies or mineralization zones are distinctly marked out among some dispersion aureoles. Contrast of biogeochemical tin anomalies ranges from 2 to 300 when the content of this metal is equal to 0,001% and contrast coefficients are dependent upon deposit genetic types and intensity of tin mineralization.

Tin content of plant ash in the Far East species spread in the places of tin deposits in comparison with plants clark equal to 0.0005% (Vinogradov, 1954) is 4-600 times greater which is indicative of a high degree of accumulation of this metal by plant species. Such lower plants as Bryophyta, Cladonia, Lycopodium and some species of higher vascular plants as Carex, Pteridium and Artemisia have the greatest tin content. Coefficients of tin biological absorption vary from 0.1 to 16.6. It must be that tin absorption by plant is the greatest one in deposits with fine-dispersed and microcrystalline cassiterite and also in such tin ore manifestations where tin mineralization contains except cassiterite, the other mineral - stannite.

Tin capacity of accumulation by plants at all climatic zones of the Far East seems to be indicative of unknown yet biogenic features of this chemical element - heavy metal which is not influenced by biological systems regardless of literature information.

The experience of working out scientific foundations and practical ways of biogeochemical method for indication of tin mineralization testifies the fact that: 1) as a rule natural tin mineralization is fixed by biogeochemical aureoles of tin dispersion and its associated chemical elements-indicators, in particular lead, copper, zinc, silver, bismuth, scandium, boron, beryllium, arsenic, antimony, fluorine, tungsten, gallium, lithium, 2) biogeochemical tin anomalies are characterized by high contrasts and also on such ore manifestations, where mineralization is completely represented by primary hypogenic cassiterite which is very stable to chemical erosion in hypergenesis zones, 3) tin does not make false biogeochemical anomalies not connected with tin mineralization, 4) biogeochemical tin anomalies on the steep slopes of mountains covered by vegetation fix more exactly epicenters of tin ore bodies than lithogeochemical (edaphic) anomalies.

THE MAIN MODELS OF THE BIOGEOCHEMICAL EXPLORATION FOR MINERAL DEPOSITS

Kovalevskii A.L.

Geological Institute of the Buryat Scientific Center, Siberian Division, Academy of Sciences
Ulan-Ude, USSR

It is offered to distinguish 3 main models of exploration by indicator elements in plants: litho, hydro- and atmobiogeochemical exploration (Kovalevskii, 1985, 1988). This division is based on the facts that in the concrete conditions the main sources of the biogeochemical haloes may be litho-, hydro- or atmogeochemical haloes of mineral deposits. These models have solid, liquid or gaseous phases of indicator elements in the root-inhabited zone of soils and rock as the main sources of the biogeochemical haloes. The intensity of absorption of chemical elements by plants from these three phases may differ in hundreds and thousands times. The average intensities of this adsorption are related between themselves approximately as 1:3000:300000 (Kovalevskii, 1973-1989).

The practical advisability of the division of these three biogeochemical exploration models is stipulated by the various depth of mineral deposits, first. This depth is 1-20 to 70 m for lithobiogeochemical, 20-200 to 1000 m for hydrobiogeochemical and from tens of meters to 1-2 km for atmobiogeochemical exploration (Kovalevskii, 1984-1989). In accordance with the various sources of indicator elements in their biogeochemical haloes and also with the various depth of mineral deposits' revealing which is determined by the distance of the upward migration of chemical elements in a corresponding phase, methods of carrying out and especially interpretation and detailization by complex investigations of the revealed biogeochemical anomalies of these three types, have significant peculiarities.

In the conditions when roots reach ore bodies and their primary and residual eluvial haloes, and the mineral composition of ores and their primary haloes in the various parts of deposits show no significant changes, lithobiogeochemical haloes of some ore elements (Mo, Au, Ag, Be, Pb) in nonbarrier plant species and parts may be interpreted quantitatively. With the help of corresponding quantitatively informative bioobjects the probable contents of ore elements in native rocks and ores can be determined (Kovalevskii, 1979-1988). At the same time it is established that under conditions we have studied, the quantitative interpretation of the presumed ore lithobiogeochemical haloes of easily leaching ore elements (Zn, Cu, for example) is not possible. The principal possibilities of the results of lithobiogeochemical exploration quantitative interpretation in the practice of prospecting for minerals need to reveal and to investigate the conditions under which a close quantitative connection between haloes in the nonbarrier bioobjects and the ore bodies takes place. According to the factual data the quantitative interpretation of lithobiogeochemical haloes is possible when ecraning loose covers have thickness up to 5-20 m. It is evident that the list of elements, lithobiogeochemical haloes of which may be interpreted quantitatively, will be significantly enlarged in the future. Methods of this quantitative interpretation demand elaboration for concrete geological and landscape conditions. The spheres of the practical application of these quantitative methods need special investigations.

The quantitative interpretation of atmobiogeochemical haloes is considered to be unsuitable for the quantitative interpretation of the atmogeochemical haloes even for the direct indicators of corresponding deposits: Hg,F, S, Se, Rn, methane and other elements and the compounds which are gaseous migrants. The possibilities of the semiquantitative interpretation of atmobiogeochemical haloes are limited. They require special investigations. In the last years mercury-biogeochemical exploration for ore, nonmetal, oil and gas deposits achieved some practical significance (Kovalevskii, 1981-1989; Lukashev, 1986; Radchenko, 1982). Atmobiogeochemical exploration for oil and gas deposits by hydrocarbon gases in plants (Stadnik, 1984) can be considered very prospective.

In real conditions the main sources of biogeochemical haloes may be complex. It is relatively often observed the simultaneous influence of the solid and liquid phases of the indicator elements in a root-inhabited zone, i.e. the model of lithohydrobiogeochemical exploration.

BIOGEOCHEMICAL HALOES OF GOLD IN VARIOUS SPECIES AND PARTS OF PLANTS

Kovalevskii A.L., Kovalevskaya O.M.

Geological Institute of the Buryat Scientific Center, Siberian Division, Academy of Sciences
Ulan-Ude, USSR

Our results (Kovalevskii,1973-1989; Kovalevskii, Kovalevskaya,1982; Kovalevskii, Prokopchuk,1978) and the summarizing of numerous publications show that the intensity of gold haloes in plants and the effectiveness of biogeochemical exploration and prospecting for gold deposits depend upon quantitative barrier characteristic (QBC) species and parts of the plants which are used for sampling.

The determinations of 194 Siberian biological objects QBC show that only 33 bioobjects (17% from investigated ones) are quantitatively-informative, nonbarrier to high concentrations of gold in the root inhabited zone of soils, rocks and ore bodies. This first group of bioobjects includes cork of outer and middle cork layers of almost all the investigated species of trees and also some shruby and grassy plant shoots and floor litter of some forest types. This group of bioobjects is recommended for the first turn sampling in biogeochemical prospecting for gold ore deposits. It is very important that biogeochemical haloes of gold in nonbarrier plant species and parts may give quantitative information about gold content in ore bodies and their primary lithogeochemical haloes which are ecraned by various allochthonous or slope loose covers of small (2-20 m) thickness (Kovalevskii, Kovalevskaya, 1982).

The majority (99 from 194 or 51%) of the investigated Siberian plant species and parts are included into the second group of practically nonbarrier of hectabackground-barrier bioobjects. They are recommended for sampling when bioobjects of the first group are absent. It is necessary to remember that the quantitative interpretation of gold ore biogeochemical anomalies and haloes is impossible when they are registered in the practically nonbarrier bioobjects.

The revealing of not numerous (14 from 194 or 7%) background-barrier plant species and parts with low, close to local background limiting contents of gold above its ore bodies situated in the root-inhabited zone (Kovalevskii, Kovalevskaya, 1982) indicates the importance of the bioobjects' choice in exploration prospecting for gold ore deposits. Sampling of background-barrier uninformative plant species and parts is useless waste of time and money. That is why we do not recommend to use them for sampling in prospecting works. Such uninforamtive bioobjects must be "forbidden" for using in exploration and prospecting for gold ore bodies and deposits. It should be noted that according to Dunn's (1985) data such a background-barrier bioobject uninformative to high concentration of gold in the root-inhabited zone of soils, rocks and ores are twigs of alder (Alnus crispa) sampled from mid June to mid September, 1984 and 1985, when they have stable gold contents from 6 to 23 ppb. At the same time in mid April, 1984 these alder's twigs were informative with content of gold up to 250 ppb on the background of approximately 20-30 ppb. These data show that the QBC of gold in the young growing parts of plants and correspondingly the intensity of gold ore bodies' biogeochemical haloes in them may significantly change with time. At the same time in our investigations it was established that in "old" suberinized and lignificated plant parts the contents of gold, the QBC and the intensity of biogeochemical haloes are stable in time. It is evident that preference should be given to the old nonbarrier parts of plants in sampling for biogeochemical exploration for gold ore bodies and deposits. Gold is represented in mineral form as particles of native gold in the outer suberinized tree cork layers (Kovalevskii, Prokopchuk, 1978). This is the main cause of the stability of its contents in these old parts of trees. It is established that in the green parts of plants gold is represented in water soluble ionic forms (Kovalevskii, 1976). Mineral forms of gold were not found in them by our special investigations.

Biogeochemical haloes of separated gold ore bodies in nonbarrier bioobjects of plants are usually very local. Their width is comparable with the width of industrial gold ore bodies' outcrops and seldom is more than 10-20 m. Sometimes they are accompanied by the near-ore biogeochemical haloes of gold with the width up to the first hundred meters. These near-ore haloes are stipulated by wide ore-containing zones of hydrothermally-altered rocks, which are enriched by mobile - fluid forms of gold.

For the choice of the most informative bioobjects in concrete conditions it is necessary to determine the QBC of the dominant plant species' various parts in well investigated deposits and gold ore occurrences with rich ore bodies. The recommended methods of QBC determinations are published (Kovalevskii, 1976; Kovalevskii, Kovalevskaya, 1979).

BIOGEOCHEMICAL PROSPECTING FOR SILVER ORE LODE BODIES AND DEPOSITS

Kovalevskii A.L., Kovalevskaya O.M.

Geological Institute of the Buryat Scientific Center, Siberian Division Academy of Sciences
Ulan-Ude, USSR

At the first stage of investigations the bioobjects nonbarrier in relation to the high concentrations of silver in the soil and rock root-inhabited zone were revealed. They are: the wood of old (including rotten) stubs of Pinus silvestris and Larix dahurica with the relative content (RCBO) taken as standard - 1.0 and suberized pine cones from forest litter (RCBO=0.1 correction x 10).

Detailed biogeochemical survey was done on the area about 1.2 km2 with two known silver ore occurrences. The net of crossed profiles was used and the interval between probes along the profiles was 1-5 m. In order to secure such a small interval plant probes were sampled with the deviation from profiles to 10-30 m, i.e. in the stripes of 20-60 m width. About 10500 plant probes and more than 2100 soil, rock and ore probes were investigated. The survey of plant pathology was done.

A very intricated biogeochemical silver field in nonbarrier bioobjects was revealed and was partly contoured. Maximums of silver concentrations in stub wood ash were unique - to 1000-3000 ppm on the background of 0.5-1.0 ppm. After standardization with the help of plant-rock (PRC) and plant-ore (POC) coefficients this anomalous field became significantly simple and interpreted. More than 130 supposed near ore biogeochemical anomalies (SNOBA) of silver and 89 supposed ore ones (SOBA), mainly of the before unknown north-north-east direction, were revealed in it. They were divided into 9 geochemical types. The most investigated are the tree types: lead-rich (Pb:Ag=3-30 to 100), lead-poor (Pb:Ag=0.4-2.5) and lead-free (Pb:Ag=0.03-0.35, without statistically trustworthy lead anomalies). In the north zone of thickening of 42 silver SOBA 330 m wide these three geochemical types form approximately symmetric zonality. The lead-rich SOBA of silver are situated in the center and the leadless SOBA of silver in the periphery of this zone. Poor quartz-galena, quartz-galena, and quartz, sulphide-poor mineralization was consequently revealed during their ditching.

SOBA with the silver concentrations of 70-3000 ppm are very local. In ditching of SOBA under them practically without dislocation 3-6 silver ore bodies or the mineralized zone divided by oreless intervals were revealed. According to the preliminary data the biogeochemical probes of stub wood correspond to the channel probes of rocks and ores 2 m long.

In the east zone of thickening all of 35 revealed silver SOBA were displaced between 6 bulldoser ditches of 3-6 m depth which were made for opening the soil-geochemical anomalies of silver and lead. The example of this zone revealing shows that by the detailed biogeochemical prospecting on the 1:500 - 1:5000 scale may be revealed not only lode silver ore bodies, but even silver ore deposits on the areas where the rare net of ditches and drilling cores has been made before.

The majority of revealed SOBA is not accompanied by the soil anomalies (SA) of silver. In the revealed rare SA contents of silver were tens and hundreds time less than in SOBA. In contrast SOBA soil anomalies of silver cannot be interpreted quantitatively with the geological prognostic resources evaluation.

The studied part of the still uncontoured completely biogeochemical silver field may be pictured as a model of a distinctive wavy field. In one of the cross sections three zones of silver SOBA thickenings are interchanged and contoured by the zones of their absence. This wavy structure is seen more exactly when the complex of halo-forming elements (Ag, Pb, Cu, Zn, Hg, Cd, Na, Fe, Mn) is examined. This biogeochemical field model is similar to the wavy field of thickenings and dischargings of tectonic breaks which was described by V. V. Bogatskii (1986).

The data described testify that revealing and contouring the lode silver ore bodies and the evaluation of geological prognostic silver resources in the mapped SOBA with the help of the non-barrier bioobjects in the studied conditions are possible. This method may be named as the nonbarrier biogeochemical prospecting (NBP) of the known and supposed silver ore deposits and silver ore fields. The concrete methods of NBP must be elaborated for various landscapes, geological and metallogenic conditions. By NPP it is possible to make the preliminary mineralogical conditions. By NPP it is possible to make the preliminary mineralogical and technological mapping of silver ore deposits when the various geochemical types of silver SOBA are presented as it takes place on the area explored.

BRIOGEOCHEMICAL METHOD - THEORY AND PRACTICE

Gennady P. Lapaev, Buryat Geological Institute, USSR

In the nearest decades the realization of the International Geochemical Mapping Project (IGSP 259) proposed by A.G.Darnley can play an appreciable role in the life of mankind and in particular for solving ecological tasks. For geochemical mapping of humid areas of the Earth briogeochemical method can become a basic geochemical survey method.

The main point of briogeochemical method is studying chemical elements abundance in surface-waters by sampling bryophytes available in them. The following phenomena are the basis of the method:

I. Aquatic bryophytes having no roots absorb the dissolved chemical elements from their water surroundings through their entire surface and accordingly an element content of plant ash depends on chemical element content of mineral substance dissolved in water.

2. Both geographic and ecological distributions of the aquatic bryophytes are wide. The bryophytes occupy abundantly practically all the streams and fresh lakes, lakelets and various basins, wells and sources in all humid areas of the Earth from the humid tropics to the arctic and antarctic zones.

3. Aquatic bryophytes are very tolerant to the high content of the trace elements in the environment and can exist even in mine waters.

4. The bryophytes concentrate many trace elements very well. From the 26 elements studied only Cd, Li, Sr and Sn have been concentrated poorly or haven't been concentrated at all.

5. Aquatic bryophytes are practically "non-barrier" plants. Anomalous trace elements content in bryophyte ash can be many hundred and thousand times higher than their back - ground including such elements, as As, Sb, U, Cd, Tl and Pb considered to be toxic for higher plants.

6. % ASH of aquatic bryophytes has a wide range of values (from 2-3 to 25-30%) and depends on water temperature, but does not depend on the level of water mineralization.

The briogeochemical survey can be used for solving the following tasks:

I. to locate mineral occurences and to estimate their range and chemical element composition;

2. for ecological aims - to estimate surplus/lack trace elements in the landscapes; to map technogene pollution; to create the basis for bryogeochemical monitoring of environmental pollution;

3. to map the Earth crust substances on atomic level.

The aquatic bryophytes are almost always more effective than the stream sediments. The bryophytes can be successfully made use of for geochemical surveys even of the areas overlayed by loose deposits of thickness up to 200-300 m where stream sediments are practically useless. In general case, however, to receive the most complete and trustworthy information as the result of geochemical survey it is better to collect the samples of both the bryophytes and the sediments, the latter should be optimized and unified.

The method is practically simple enough. The technique of collecting and processing the bryophyte samples were worked out. The stock of the water migration of the elements is taken into account in the interpretation of the briogeochemical data.

In the USSR the briogeochemical method has been made use of since I972 only in Siberia and in the Far East. The first practical usage of the method dates back to I965-I966. In Yakutiya the briogeochemical surveys have been made of the area of more than I00000 km^2. The sample density was from 2-4 samples per I km^2 up to I sample per 6-I5 km^2. The contrasting briogeochemical anomalies of As, Sb, Cd, Pb, Zn, Au, Sn, W, REE and other elements have been mapped. The ore mineralization of Au, Sn, W, REE has been revealed. The results of some briogeochemical surveys made under conditions of various landscapes are demonstrated.

STUDY OF THE BACILLUS CEREUS-MYCOIDES-THURINGIENSIS COMPLEX PRESENT IN AURIFEROUS SOILS

Neybergh H.(1), Moureau Z.(2), Remacle J.(3), Swings J.(4), Verraes G.(5), Sulten E.(2),
Champenois B.(2), Hambuckers-Berhin F.(3), Kersters K.(4), Vanhonacker K.(4) et Verdonck L.(4).

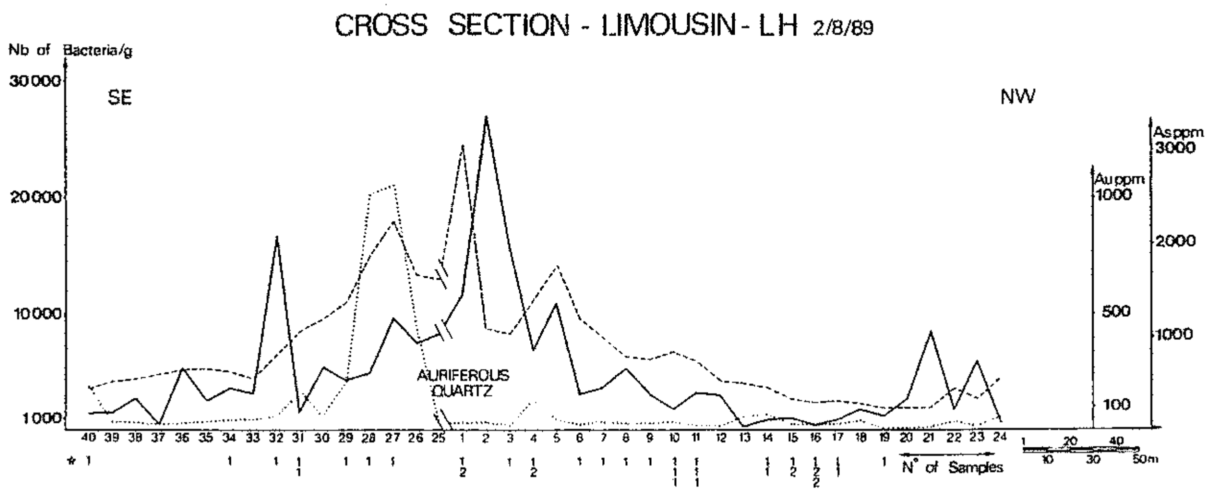
In previous articles, a relationship between gold bearing zones and their Bacillus cereus content has been noted (Pardhun and Watterson 1984, Watterson 1985). This was confirmed by Neybergh and al.(1989).

The aim of the present study has been to investigate this relationship further, focusing on the following topics :

- The distribution of positive bacilli lecithinase and the Au-As content in soils collected along profiles crossing auriferous quartz bearing veins. One profile studied in detail is presented in the graph below ; it illustrates the distribution of bacilli, gold and arsenic in relation to the auriferous vein.
- The identification of bacilli by fatty acids analysis and API 50 CHB system.
- The resistance of the same bacilli against toxic ions (Au, Co, Zn, As and Sb) and 14 different antibiotics.

These methods will allow a better understanding of bacterial populations in mineralized soils.

The first results show a good correlation between the number of bacilli and the gold-arsenic content of the soils. Furthermore they seem to indicate that the Bacillus cereus-mycoïdes-thuringiensis complex contains several populations characterized by a particular antibiotics resistance pattern and a particular fatty acid fingerprint type.



✱ Assignment of the isolates to one of the 2 fatty acid groups distinguished within the Bacillus.
// Between 1 and 25, shift of the profile.

References :

-Pardhun N. and Watterson J. 1984 : Preliminary studies of B.cereus distribution near a gold vein and a disseminated gold deposit.- Open-file Report 84-509. United States of the Interior. Geological Survey.
-Watterson J. 1985 : A procedure for estimating B.cereus spores in soil and stream sediment samples. A potential exploration technique.-Journal of Geochemical Exploration,23 : 243-252.
-Neybergh H., Moureau Z., Gérard P., Verraes G. and Sulten E. 1989 : Biochemical Prospection : Application to gold deposits research. Study of the relationship between the Bacillus cereus content and gold content in the soil.-Terra Abstracts 1.

(1) Service Géologique de Belgique, 13 rue Jenner, B-1040 Bruxelles
(2) Institut royal des Sciences naturelles de Belgique, Laboratoire de Bactériologie, Rue Vautier 29
B-2040 Bruxelles.
(3) Université de Liège, Laboratoire d'Ecologie microbienne, Sart Tilman, B-4000 Liège.
(4) Rijksuniversiteit Gent, Laboratorium voor Microbiologie and Microbiële Genetica. Ledeganckstraat 35,
B-9000 Gent.
(5) Ecole Nationale Supérieure des Techniques Industrielles et des Mines, avenue de Clavières 6, F-30107 Alès.

EXPERIENCE IN BIOCHEMISTRY METHOD APPLLIED TO PROSPECTING UNDER PERMAFROST

Marina G. Opekunova, University of Leningrad, USSR

Secondary biochemical zones developed under permafrost show several peculiar features. The chemical composition observed from 18 species of plants from the Norilsk Plateau reflects underlying rock pattern, regular features of heavy metal lateral migration and specific characteristics caused by their systematic position. Mean Ba, Cr, Sr, Zr concentrations adopted as the regional background are half again as little, whereas those of Ag, Pb, Zn, Y are 8 to 10 times less than the floral clarc according to R.Brooks (1976). Ga and Mo contents are close to the latter, whereas those of Cu, Co and Mn are 2 to 5 and that of Ni is 10 times as much. Within copper-nickel ore occurences all plants are enriched in Cu, Ni Co and Mn, reaching in some samples 271,180, 5 and 904 mg per kilogram of dry matter, respectively. The strongest concentration capability is shown by Betula nana L., Salix lanata L., S.glauca L. shrubs and Vaccinium uliginosum L., Ledum palustre L. small shrubs. Heavy metal concentrations in the leaves of these plants are 2 to 4 times as high as in their branches. Among herbaceous plants high indicating capabilities are reported by Saussurea alpina (L.) DC (Asteraceae), Silene paucifollia Ledeb. (Caryophyllaceae), Delphinium elatum L. (Ranunculaceae). However, paucuty and rare occurences of the latter prevent from their overall use in exploration biochemistry. Lichens are enriched in Cu, Cr, Ni. Statistic parameters have estimated unusual concentrators of heavy metals to exhibit higher dispersion and higher variation factor. A close correlation has been revealed in Cu, Ni, Cr, Co, Zn accumulations on one hand, and Ti, Ba, Zr, Ga, La, V on the other. Multiple correlation technique has confirmed subdivision into elemental groups above causing the ore and rocks associations. Major component technique in factor analysis has revealed 3 to 6 signidicant factors. The most versatile factoral structure is reported from leaves of shrubs. All the samplings investigated contain along with elemental biogenic accumulation the ore factor manifesting an antogonism in Ni, Cu, Zn, Cr, Co vs. Ti, La, Mo, V, Zr accumulations. Its average weight reaches 40 to 45 %. In branches of shrubs the ore-forming process is usually determined by only one factor whereas in leaves it is caused by two factors showing on one hand Cu, Ni, Zn accumulations and those of Mn on the other, which may be attributed to a specific physiological development in leaves. Mapping the major ore factors has indicated that positive values fall on ore-enriched sites and tectonic fracture zones. However a displacement of secondary biogeochemical zones take place due to lateral migration causing the restriction of some anomalous values to the negative topographic forms .

Therefore, the studies conducted have confirmed the possibility of applying biogeochemical exploration for comprehensive geochemical sampling under permafrost.

References:

Brooks R.R. /1983/ Biological methods of prospecting for minerals. - New York, J Wiley and sons, USA.

BIOGEOCHEMICAL EXPLORATION IN LOESS ENVIRONMENT IN CHINA

Gao Ping

Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849 People's Republic of China

China's loess leads the world with its vast area and great depth. The loess terrain which mainly distribute along the middle and lower reaches of the Yellow River cover up to 632 000 km^2. The sediment thickness is from 10 m to 100 m with the maximum of 200 m.

The loess areas have long been taken as the forbidden zone for geochemical exploration because the conventional geochemical methods can not detect element distribution and geochemical anomalies related to mineralization under the loess. Biogeochemical orientation survey in two loess areas found very valuable geological information and mineralization below the thick loess. The results show that it entertains high hopes that biogeochemical exploration is able to break through the forbidden zone using deeprooted plants.

Jiaolong Zhang stratabound pyrite-type polymetallic deposit in Gansu Province, which was hosted in the Ordovician clastic rocks, is totally covered with loess. Tertiary red clay-layer is commonly developed under the loess, the total thickness of the overburden is from 30 m to 120 m. Vegetation is sparse, Salix Matsudana Koidz (Hankow willow), one of the predominant species, grows mainly along arroyoes in the area. Its root system is at the lesat ten meters. Biogeochemical orientation survey revealed that iron, V, Ti, Mn, Mo, P, K, S, Zn, Cu, As and Ba have anomalous concentration in Salix matsadana Koidz over the Jiaolong Zhang deposit. The element distribution pattern is similar to the primary halo of the deposit. According to this orientation survey, biogeochemical survey was carried out in an area of 140 km^2 on outskirts of the Jiaolong Zhang Mine. Twig and fresh bark were taken from Salix matsadana Koidz. Analyses discovered three biogeochemical anomalies. The significance of the anomalies were proved by drill geological information.

About 70% of Xinzhang Gold Mine in Shanxi Province was covered with loess of a few to 50 meters in thickness, which makes prospecting and follow-up difficult. Vegetation is scarce, and Wikstroemia pampaninii Rehd alone is common in this area. Biogeochemical section displays a strong anomalous concentration of gold, As, Sb, Bi, Cu, and Hg in Wikstroemia pampaninii Rehd above the gold vein under ten-meter thick loess, which clearly delineate the location of the gold vein.

The two case histories show that biogeochemical methods can provide mineralization information for buried ore and will become an effective prospecting tool in loess terrain.

GEOBOTANICAL AND BIOGEOCHEMICAL ZONATION IN TERMITE MOUNDS

E.A.V.Prasad[1], M.Jayarama Gupta[1], and Colin E. Dunn[2]

1 Department of Geology, Sri Venkateswara University, Tirupati - 517 502 (A.P), India
2 Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A 0E8, Canada

An ancient scientific Sanskrit text of Jyotiśśāstra (astronomy/astrology), called **Brihat Saṁhita** (master collection), considered the termite (Termitidae) mound as an ideal example of microcosm constantly maintaining homeostatic equilibrium[1]. This scientific text described it as an important tool in exploration and exploitation of ground water[2] and mineral resources[3]. In recent years such mounds have been employed in geochemical exploration for gold[4] and other ore deposits[5].

This study deals with biogeography and geochemistry of the termite mounds occurring on the campus of Hyderabad University (Lat. 17° 26' - 17° 28' N; Long. 78° 18' - 78° 21' E), Andhra Pradesh, South India. In this semi-arid tract, underlain by granites of Archaean complex, three types of termite mounds are recognised. These are (1) barren mounds', i.e.; the mounds devoid of any vegetation; (2)'monophytic mounds', i.e., the mounds colonised exclusively by one particular taxonomic plant species; and (3)'polyphytic mounds', i.e., the mounds colonised by more than one plant species. These mounds are further categorised into the following five types. (1) Conical mounds (height 0.9-2.2 m, base diameter 0.8-2.0 m) built by Odontotermes mathadi generally developed on dry sites. Some of them exhibit horizontal or vertical zonation, each zone being reflected by the development of a particular vegetation type. (2) Low curvature mounds (height 0.6-1.5 m, base diameter 0.9-2.6 m) developed by Trinervitermes biformis on seasonally water-logged sites. These mounds, like the mounds of O. mathadi, also exhibit horizontal or vertical zonation. (3) Subconical mounds (height 1.1-1.5 m, base diameter 1.4-1.75 m), constructed by O. redemanni on dry sites; (4) Small, barren, conical mounds (height 0.20-0.40 m, base diameter 0.15-0.30 m) built by Macrotermes estherae developed in shady, moist sites., and (5) Subterranean termite (?) nest system, with a well-defined circular patch (diameter 3.5-4.5 m) on dry ground surface, demarcated by a particular, profusely developed, plant species consisting of either Hyptis suaveolens or Kirganelia reticulata.

In this study, the details of two types of zoned termite mounds, located in seasonally water-logged sites have been recorded. In one case, a huge conical mound of O. mathadi conspicuously exhibits six, well-defined, horizontal layers. Starting from base upwards, 1st, 2nd, 4th, and 5th layers are occupied by different species of grass; 3rd layer is barren, while the top layer 6 is colonised by Digitaria Sp.-a grass species, associated with Lantana camara. The vegetation on the ground surface surrounding the mound consists of an admixture of all these different grass species.

In another case, certain mounds of T. biformis are divided vertically into two parts,and each is colonised with distinctly different plant species; and these two parts of the mound show preferred north-south or east-west orientation. In some cases, one part of the mound is colonised by vegetation while the other remains barren.

For different soil layers of these zoned mounds, the pedological properties (bulk density, organic matter, sand-silt-clay ratios, grain-size parameters, pH, and conductivity) were determined; and thirty elements, viz., Mo, Cu, Pb, Zn, Ag, Ni, Co, Mn, Fe, As, U, Au, Th, Sr, Cd, Sb, Bi, V, Ca, P, La, Cr, Mg, Ba, Ti, B, Al, Na, K and W were analysed by inductively coupled plasma emission spectrometry (ICP). This data reveal biogeochemical differentiation of the mounds by termite activity.

These pedological, geobotanical, and biogeochemical charecteristics reflect the extraordinary capacity for genetic innovation of the termites with necessary adaptation to modify the climatogenic, pedogenic, and biogenic processes within the microenvironment of these mounds to maintain ecological equilibrium.

The mound with different tiers of vegetation is considered as a microcosm representing the altitudinal zonation of vegetation, due to variation in bioclimatology, on a global scale (macrocosm).

This study throws light on termite mound in arid or semi-arid regions as an extremely significant tool in: (1) geochemical and agricultural reconnaissance surveys; (2) biological monitoring of the environmental pollution; (3) reclamation and revegetation of adversely affected environments; and (4) the study of adaptations and evolution of life forms.

References:

1. Prasad, E.A.V. /1980/: Ground Water in Varahamihira's Brihat Samhita, Sri Venkateswara Univ., Tirupati, p.351.
2. Prasad, E.A.V. /1989/: Tropical Ground Water Hydrology in Varahamihira's Brihat Samhita, 28th Int. Geol. Cong., Washington, D.C.
3. Prasad, E.A.V., Nagaraju, A., Raghu, V., Jayarama Gupta, M., and Motooka, J. /1989/: Biogeochemistry of Termite Ecosystem, 28th Int. Geol. Cong., Washington, D.C.
4. Prasad, E.A.V., Jayarama Gupta, M., and Dunn, C.E. /1987/: Significance of Termite Mounds in Gold Exploration. - Curr. Sci. 56, 1219-1222, Bangalore.
5. Prasad, E.A.V., and Vijayasaradhi, D. /1984/: Termite Mound in Geochemical Prospecting. -Curr. Sci. 53, 649-651, Bangalore.

HIGH-SELECTIVITY ATOMIC ABSORPTION ANALYZERS FOR THE DETERMINATION OF THE MERCURY CONCENTRATION IN GAS, LIQUID AND SOLID SAMPLES

Alexander A. Ganeyev, Nicolaj R. Mashjenov, Sergey E. Sholupov, Gleb B. Sveshnikov
Leningrad State University, USSR

At present geochemists and ecologists pay attention to the problem of the mercury detection in the various media. This attention can be explained by two reasons: mercury is a pathfinder of different kinds of deposits and mercury is a toxic element, which concentration in air, water, foods must be kept under control.

In the Leningrad State University two high-selectivity atomic absorption analyzers for the express determination of the atomic mercury concentration in the broad range are elaborated. Using commercial atomizers or barbaters and our instruments one can detect mercury in gas, liquid and solid samples without any preliminary treatment procedure. Both analyzers are based on the differential atomic absorption spectrometry, but they differ in the manner of realization of two-wave scheme. In the first instrument the source of light is in the constant magnetic field, as a result the resonance mercury line is splitted on several components (it is a direct Zeeman effect). One of these components takes place on analytical line and other - reference line. By means of the polarization modulator the radiation of the Zeeman components penetrates the analyte cell in turn and then it is detected by PMT. In another analyzer the discharge in the spectral lamp with the mixture of two mercury isotopes is excited by the high-frequency generator which is modulated by radiofrequency voltage. Due to spectral-phase effects it is possible to detect the radiation corresponding each component. In this case the radiation of one isotope component takes place on analytical line and another-frequency line. Further treatment of signals is carried out in traditional algorithm for differential techniques.

Due to differential technique we can guarantee high selectivity and decrease the limit detection and now it is limited only by drop noise of the PMT. Both analyzers have similar analytical parameters: limit detection 10ng/m^3, time of one analysis - 15s, they can suppress the interference of the matrix up to 3 a.u.

By means of our instruments in the geological and ecological objects we carried out the determination of the mercury concentration in 1) ambient air using moving platform (airplane, helicopter, car, ship) and in the back-pack version 2) natural gas in the USSR and SFRYu 3) liquid and solid samples. Everywhere we've got good agreements of our results and the results got by other analytical techniques.

62A

PROGRESS IN THE APPLICATION OF ICP-MASS SPECTROMETRY TO ANALYTICAL GEOCHEMISTRY

Gwendy E.M. Hall

Geological Survey of Canada,

ABSTRACT

The extremely variable composition of geological materials, particularly that of rocks and soils, poses an immense challenge to the accurate and precise multi-element determination of trace and ultra-trace level constituents. Hence, it is not surprising that numerous geoanalytical laboratories leapt with both feet into ICP-MS in its early days, with promises of such features as simple spectra with few interferences, wide linear dynamic range and detection limits in solution in the order of 0.01-0.1 ng ml^{-1}. Inevitably, we have since learned to temper enthusiasm with caution, as fundamental and applied studies of matrix-induced interferences have evolved. However, new doors have been opened in geoanalysis by this technique whose ultimate power is yet to be fully exploited.

Undoubtedly two of the most significant achievements to date lie in the determination of two groups of elements: precious metals and the REEs. The collective determination of Au and the PGEs (Pt, Pd, Rh, Ru, Ir, Os) by commercial laboratories has been the sole domain of NAA. Application of ICP-MS in this field offers the advantages of superior sensitivity for Pt, Pd and Ru and rapid turnaround time without the necessity of lengthy decay periods. This technique has also found a niche in the determination of Au, Pt and Pd following Pb fire assay where previously ICP-AES and AAS have dominated. As in other applications the critical factor affecting detection limits is the purity of the reagents used, not the sensitivity of ICP-MS. Biogeochemical exploration for Pt and Pd has now become a practical tool, owing to the reasonable quantity of sample required to attain adequate detection levels. This technique now reigns supreme in its proven ability to determine all REEs down to 1 ng g^{-1} if a separation step is incorporated into the procedure. This capability together with abundance level detection of high field strength elements (e.g. Nb, Hf, Ta) is greatly facilitating tectonic interpretation studies.

The application of surface and ground waters in geochemical exploration is yet to be thoroughly evaluated but the ability of ICP-MS to analyse waters directly and adequately for many trace elements assures it a key role. Research is active currently into the introduction of gaseous hydrides into the ICP mass spectrometer in an effort to improve detection limits over those offered by ICP-AES.

These comprise some of the accomplishments reviewed in this presentation. Progress in the use of alternative sample introduction techniques and calibration strategies is also discussed.

USE OF OPTIMIZATION PROCEDURES FOR THE QUANTITATIVE DETERMINATION OF MINERALS AND FOR THE DISTRIBUTION OF Cr, Ni AND Co IN LATERITES.

Zdenek Klika, Ivan Kolomazník, Technical University of Mining and Metallurgy, Czechoslovakia

The chemical quantitative phase analysis (CQPA) was for the first time used for calculation of mineral concentrations for clastic sediments (Klika et al./1986/, Chmielová et al./1986/). The chemical composition of rocks may be described by a set of simultaneous equations:

$$y_i = \sum_j x_{ij} c_j \tag{1}$$

where x_{ij} and y_i are percentages of the oxides of i-th elements in mineral j-th phases and the bulk rock respectively, and c_j are the percentages of j-th phases present in the rock. The determination of the concentration of c_j-th phases is based on the internal optimization procedure

$$\sum_i (y_i - \sum_j c_j x_{ij})^2 = \min \tag{2}$$

The results of CQPA and optical methods were tested on 21 samples of laterites from Cuba. They show very good agreement. Three of the samples (1A, 3D, 1F) with very different mineral composition are presented in Table 1.

Table 1. RESULTS OF MINERAL CONCENTRATIONS (%) DETERMINED BY OPTICAL (a) AND CQPA (b) METHODS.

	1A		3D		1F	
	a	b	a	b	a	b
kaolinite		2.5		9.6		6.7
clay minerals	1.0		13.3		8.4	
gibbsite	17.2	15.8				
psilomelane	1.0	1.1	0.4	0.4	0.2	0.3
chromite	3.1	3.9	1.6	1.6	1.2	1.2
magnetite			4.1	3.1	4.2	4.3
serpentine	1.3	1.7	56.7	59.6	80.5	81.0
goethite + + hematite	74.6	72.5	21.0	23.6	4.8	4.7
pyroxene			1.0	1.0	1.0	1.0

The optimization method was also used for the calculation of Cr_2O_3 , NiO and CoO concentration dependences on mineral concentrations. The following equations were found out:

$$\%Cr_2O_3 = 0.453(\%\text{chromite}) + 0.018(\%\text{goethite}) + 0.017(\%\text{hematite}) \tag{3}$$

$$\%NiO = 0.013(\%\text{serpentine}) + 0.017(\%\text{goethite}) + 0.015(\%\text{hematite}) \tag{4}$$

$$\%CoO = 0.0019(\%\text{goethite}) \tag{5}$$

The chromium is bonded predominantly on chromite and dependence (3) has a very high correlation coefficient. Nickel and cobalt are probably bonded predominantly by sorption and their dependences (4) and (5) have a low correlation coefficient.

References:

Klika Z., Weiss Z., Chmielová M./1986/: A Method of Quantitative Mineralogical Analysis of Rocks from their Elementary Chemical Analysis.-Tenth Conference on Clay Mineralogy and Petrology, Ostrava, 11 - 18

Chmielová M., Klika Z., Weiss Z./1986/: Quantitative Mineral Analysis of Carboniferous Sedimentary Rocks.-Tenth Conference on Clay Mineralogy and Petrology, 19-29, Ostrava.

63A

CONCENTRATION OF RARE EARTHS BY VARIOUS CATION EXCHANGE RESIN TYPES FOR ICP-AE ANALYSIS OF GEOCHEMICAL SAMPLES

N.A.Sorokina, L.B.Efremova

Institute of Lithosphere, USSR Academy of Sciences,
Moscow, USSR

Rare earth elements are widely used for petrogenetic modelling of magma genesis and chemical heterogeneity of mantle and crustal reservoirs. They are also the effective tool for precise studies of geodynamic setting of magmatic series and ore formations. All these applications require an accurate and sensitive analysis of rare earths in geological samples.

One of the rapid and sensitive methods of REE analysis is the ICP-AE spectrometry with preliminary concentration of lanthanides using cation exchange resin chromatography.

The process of evaluation of rare earths on different types of exchange resins was studied using standard solutions. The eluation curves for eight rare earths (La, Ce,Nd, Sm, Eu, Gd, Er, Yb) were measured and compared with existing extraction methods. The proposed technique allows full extraction and concentration of REEs for ICP-AES analysis at ppm levels. The details of concentration process were studied using international references samples.

The accuracy and reproducibility of the method are evaluated and compared with other chromatographic techniques. The standard deviations and misfit corridors for measured and reported values for rare earths in reference samples were calculated. The results of this study are in a good agreement with previously published data. Different types of DOWEX and BIORAD exchange resins were used for extraction and than compared to obtain the best fitting resin type and regime of eluation.

The application of the method for ICP-AES determination of rare earths in geological samples (mafic, intermediate and acid intrusive and volcanic rocks, sedimentary rocks) shows good results available for all types of common geochemical and petrological research.

CHEMICAL-ANALYTICAL PROVISION
OF GEOCHEMICAL WORKS

Yu. P. Sotskov

Institute of Mineralogy,Geochemistry and Crystallochemistry of Rare Elements
Moscow, USSR

At present geochemical works are widely used not only at all stages of geochemical exploration but also for the solution of various scientific and applied problems including the environmental investigations. A study of a matter composition of various materials used in geochemical investigation (bedrocks, soils, bottom sediments, water, air, plants, etc.), a wide range of concentrations under determination (6-7 orders) require such methods and techniques that often differ from those used in other fields of science. Unfortunately there is not any universal method which could help to provide a comprehensive information on the chemical elements content, forms of their existence isotopic composition, physicochemical properties, grain sizing etc. for the material being studied. We have to choose the most promising, reliable and economical complex of the analytical methods for the time being. The following criteria are usually taken into consideration while selecting a complex or a separate method for the solution of a specific problem:

- a type of supposed investigations: scientific or applied;
- a sample phase state: solid, liquid or gaseous
- a set of components necessary for the solution of the problem;
- an expected range of concentrations;
- a number of samples to be investigated, their approximate matter composition;
- a remove of the area being investigated from the base laboratory;
- the necessity of the material preservation for the future investigations, its unique properties;
- the cost of works and some other important criteria.

Based on the generalization of the big actual material an attempt is made to create rational complex for the solution of the specific tasks of the applied geochemistry. Alongside with the traditional methods of analysis (atomic emission, atomic absorbtion, X-ray fluorescence and neutron activation) are also considered the place and significance of chromatographic, electrochemical, mass-spectrometric methods and phase matter composition methods of investigations. Much attention is given to the field and remote methods which allow to increase the expressness of geochemical works and to reduce the time and cost of these investigations also makes it possible for a geochemist to obtain all the necessary information immediately in the process of exploration and evaluation.

Besides the problem of the complex chemical-analytical investigations in the present work are raised the questions of the creation of the quality control system in analytical investigations of the necessary level to solve the tasks of the applied geochemistry and unification of sampling and sample preparation methods for the analysis. The reliability and information quality of the obtained results can be only achieved by the improvement of all stages of the analysis and realization of all possibilities of modern methods.

TEACHING IN GEOCHEMISTRY: INDIA

K.S.Murty

Univ. Dept. of Geology, Law College Compound, Nagpur 440 001, India.

Reviewing the status of Geochemical Prospecting in the World in 1965, Hawkes mentions that 4 publications, out of 225 were from India during the period January 1960 to July 1964. Of these, three were Reports of field observations and location of field areas. However, the year 1922 was noteworthy because K.K.Mathur and Sir S.S. Bhatnagar published their paper "Studien über Bandstrukturen - Die Synthese gebänderter Steine" in German and also because the classic work on the geochemistry of the rocks of Mt. Girnar was also started by Mathur and his team that year, which led to the enunciation of the series of geochemical problems by Mathur in his Presidential address at the Geology section of the Indian Science Congress at Bombay in 1934. It was not until 1954, however, that teaching of geochemistry was formally started at the Benares Hindu University when Mathur and Bhatnagar established a school of geochemical research. The first well-equipped geochemical laboratory was also established by Sinha and his co-workers. A year before this, the Geological Survey of India had launched a programme of geochemical prospecting for base metals in the Singhbhum thrust belt. Subsequently, the Indian Institute of Technology in Kharagpur started a Master's Degree course in geochemistry. In most of the Universities in India, petrochemistry and mineral chemistry formed part of geological teaching in late fifties. From 1962 onwards, both teaching and research in geochemistry was started in the Universities of Patna, Mysore, Osmania, Andhra, Roorkee, Udaipur, Calcutta, and St. Xavier's College in Bombay and IIT, Bombay.

Now, geochemistry forms either an essential part of the curriculum for Master's degree in Geology and/or Applied Geology, or it is offered by many postgraduate geology departments as one-semester course. For instance, Nagpur University postgraduate department of Geology has a one-year course in Exploration Geochemistry since late seventies. The practical work is generally confined to rock and ore analysis by conventional wet chemical methods, colorimetry, spot tests and flame photometers. Few departments have AAS spectrophotometers and fluorimeters. Among other institutions that make significant contribution to research in geochemistry are the Tata Institute of Fundamental research, Physical Research Laboratory, National Geophysical Research Laboratory, and Indian School of Mines respectively, located at Bombay, Ahmedabad, Hyderabad, and Dhanbad. Geological Survey of India, Atomic Minerals Department, and Bhabha Atomic Research Centre (BARC) are equipped with AAS, XRF, FRS, INAA, MSID, electron microprobe etc. The inability of Universities, particularly located in the States, can be attributed to two reasons, if they are not maintaining teaching of geochemistry at high level: 1. Nonavailability of adequate instruments, thus depriving the student of opportunities to aquire laboratory skills, and 2. classroom is purely descriptive and the student does not get the feel of the problem by processing and interpreting stimulated experimental data. In view of this, the University Grants Commission has identified certain departments of the Universities as special centers to be equipped with necessary instruments so that the two problems can be solved.

EDUCATION IN GEOCHEMICAL PROSPECTING

SOLOVOV A.P., Moscow State University, USSR

The contemporary methods of geochemical prospecting for mineral deposits were created in the Soviet Union (1931-32) by N.I.Safronov and based on the scientific conception of primary haloes and secondary dispersion aureoles of such deposits. Similtaneously V.A.Socolov proposed the hydrocarbonate gas surveing for oil and gas prospecting. Now these methods are largerly used over all world.

In the Soviet Union teaching of students in applied geochemistry was started in 1938 on the Geophysical Faculties of the Leningrad and the Moscow Mining Institutes under the name "Physico-chemical Methods of Prospecting" and now is obligatory for the all Soviet Geological Colleges under the name "Geochemical Methods of Prospecting for Mineral Deposits".

The leading role in developing of this discipline now belongs to the Chair of Geochemistry of the Geological Faculty of the Moscow State University (prof. A.A.Saukov and author of this contribution) and to the Chair of Geochemical Prospecting of the Geophysical faculty of the Leningrad Mining Institute (prof. E.M.Kvyatkovsky) and to some other Geological Colleges in Kiev, Irkutsk and Alma-Ata.

After three years of general geological education all students, who belongs to the Geochemistry Chair of MGU, have monthly field practical training on a special Geochemical base near the Sadon polymetalic deposit on the North Caucasus. In this time they studies theory and practice of Lithochemical prospecting for ore deposits by secondary haloes and dispersion trains, including field sampling, preparation of samples for analysis, emission spectrographic analisis of samples for Pb, Zn and Cu, graphical and quantitative interpretation of obtained data. Discovered geochemical anomalies are examined on place by using microchemical tests with KJ and by collection of additional samples for XRRA and ESA. After evaluation of expected Pb+Zn resources the main secondary haloes are investigated by trenching.

After presentation of report about practice, students who will obtaine a specialisation in Geochemical Prospectinig, especially foreign students, have continuation of their field work in the district of Sadon deposit on study of primary haloes and ecological monitoring. Students of other geochemical specialities are leaving for areas of their field practice in other parts of the Soviet Union.

The main course on Geochemical Prospecting is given to the all students of the Geochemical Departament during the 7th (autumn, 72 hours) and the 8th (winter, 28 hours) terms, and followed by passing a special examination. The study of the main course is ensured by special textbooks (A.P.Solovov, M., Nedra, 1985; A.P.Solovov and A.A.Matveev, the 2d edition, M., MGU, 1985) and an English tranlation of the Russian textbook (A.P.Solovov, Mir Publ., M., 1987). For the next summer field practice all students are going as a members of different geochemical teames of the Geological Faculty to Siberia and Kazakhstan. The next two terms they are using in Moscow for analitical work and computer processing of obtained data followed by presentation of graduation thesises for public defence before the State Scientific Counsil with participation of an external opponents.

The post-graduate course on Geochemical Prospecting for a PhD degree in geological-mineralogical science (speciality 04.00.13 - Geochemical Prospecting) takes additional 3 years for the Soviet geochemists and 4 years for foreigners. This time are using for scientific researches in any of chosen theoretical or experimental domain of selected speciality. Presentation of a dissertation for its public defence has take place before the Scientific Counsil of the Geological Faculty of the MGU, consisting by leading geochemists of Moscow Scientific organizations, with participation of 3 external opponents.

65A

For a DSc degree it is necessary to complete additional fundamental investigations and a number of publications on selected field.