PROGRAM

MINERALOGICAL SOCIETY OF AMERICA MEETING
BOZEMAN, MONTANA - JULY 26-31, 1964
JOINT MEETING WITH THE AMERICAN CRYSTALLOGRAPHIC ASSOCIATION

Monday Morning - July 27, 1964

9:00 a.m. Welcoming Remarks
Dr. Leonard G. Berry, President of MSA
Dr. Howard T. Evans, Jr., President of ACA

9:15 a.m. A unique occurrence of uranium minerals at Marshall Pass, Saguache Co., Colorado.
Eugene B. Gross, Division of Mines and Geology, San Francisco, Calif.

A new, Baringer Hill-type, rare-earth pegmatite from the Central Mineral Region, Texas.
A. J. Ehlmann, J. L. Walper, Texas Christian University, Fort Worth, Texas, and J. Williams, The Texas Architectural Aggregate Company, San Saba, Texas.

The origin of some native lead-pyrochroite parageneses.
Kurt Bostrom, Scripps Institute of Oceanography, La Jolla, Calif.

The mineralogy of the Butte District, Montana.
John Guilbert and Lester G. Zeihen, The Anaconda Company, Butte, Mont.

Xanthophyllite from the Tobacco Root Mountains, Montana.
R. G. Stevenson and Carl W. Beck, Indiana University, Bloomington, Ind.

Regressions of optical properties and density on the composition of orthopyroxene.
Horace Winchell and Bernard E. Leake, Yale University, New Haven, Conn.

The origin of tincalconite at Searles Lake, California.
Carl J. Bowser, The University of Wisconsin, Madison, Wisconsin.

*Deerite, howieite and zussmanite, three new minerals from the Franciscan of the Laytonville district, Mendocino Co., California.
Stuart O. Agrell, University of Cambridge, Cambridge, England.

Seven new barium minerals from eastern Fresno County, California.
John T. Alfors, Melvin C. Stinson, Robert A. Matthews, and Adolf Pabst, California Division of Mines and Geology, San Francisco, Calif.

Fluorapatite and sphene from Crystal Lode Pegmatite, Eagle, Colo.
Edward J. Young and John W. Adams, U.S. Geological Survey, Denver, Colorado.

Mineralogy of the Kalkar Quarry, Santa Cruz, California.
Charles W. Chesterman and Eugene B. Gross, Division of Mines and Geology, San Francisco, Calif.

* *Invited paper — given at May 27, 1964 meeting of the Mineralogical Society of Great Britain.*

Monday Afternoon - July 27, 1964

2:00 p.m. Geology of the Crazy Mountains, Montana--Alkaline dikes, sills, and laccoliths; northern part.
Frederick E. Simms, Jr., University of Cincinnati, Cincinnati, Ohio.

Geology of the Crazy Mountains, Montana--Clay minerals of the upper Livingston formation; northern part.
John D. Sims, Univ. of Cincinnati, Cincinnati, Ohio.

Geology of the Crazy Mountains, Montana--Big Timber Stock.
John Tappe, Univ. of Cincinnati, Cincinnati, Ohio.

Zircons of the Boulder Batholith near Helena, Montana.
Leonard H. Larsen, Univ. of Cincinnati, Cincinnati, Ohio.

Pyroxene relations in experimentally crystallized 1887 Mauna Loa basalt.
Myron G. Best, University of Ottawa, Ottawa, Canada.

An occurrence of abundant chiastolite, Sawtooth Mountains, Alaska.
Robert L. Foster and Clayton H. Johnson, University of Missouri, Columbia, Missouri.

Mineral orientation in slates and argillites - a comparison.
Ronald B. Parker, The University of Wyoming, Laramie, Wyoming.

Skarns in the preCambrian of Denver Mountain Parks, Colorado.
Margaret Fuller Boos, Geologic Consultants, Denver, Colorado.

Zeolite zones in volcanic rocks, Nevada Test Site.
D. L. Hoover and A. O. Shepard, U.S. Geological Survey, Denver, Colo.

Groundwater leaching of quickly cooled volcanic rocks.
Donald C. Noble, U.S. Geological Survey, Denver, Colorado.

Tuesday - July 28, 1964

Field Trip - Butte Hill.

Wednesday - July 29, 1964

A.M. Field Trip - Bozeman Area Geology

P.M. Field Trip - Asbestos Mine in Gallatin Canyon

Evening Picnic

Thursday - July 30, 1964

9:00 a.m. The crystal structure of the decavanadate $K_2Zn_2V_{10}O_{28} \cdot 16H_2O$, chemical analog of hummerite and pascoite.
Howard T. Evans, Jr., U.S. Geological Survey, Washington, D.C.

Crystal structure of the sodium-calcium borate mineral, ulexite.
Joan R. Clark and Daniel E. Appleman, U.S. Geological Survey, Washington, D.C.

Structure and twinning of synthetic lithium-fluor micas.
Hiroshi Takeda and J. D. H. Donnay, The Johns Hopkins University, Baltimore, Maryland.

The crystal structure of turquoise, $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$.
Hilda Cid-Dresdner, Massachusetts Institute of Technology, Cambridge, Mass.

Layer structures in secondary copper minerals.
Abraham Rosenzweig, The University of New Mexico, Albuquerque, New Mexico.

Observations on the crystal chemistry of fossil bone and the carbonate apatites.
J. Thomas Nash and Gerald P. Brophy, Amherst College, Amherst, Massachusetts.

Polytypism in biotites.
Malcolm Ross and David R. Wones, U.S. Geological Survey, Washington, D.C.

The crystal structure of alunite.
Rong Wang, W. F. Bradley, and H. Steinfink, University of Texas, Austin, Texas.

The crystal structure of a marialite scapolite.
James J. Papike and Tibor Zoltai, University of Minnesota, Minneapolis, Minnesota.

Temperature parameters of silicate crystal structures.
Charles W. Burnham, Geophysical Laboratory, Washington, D.C.

The shape of misoriented reciprocal lattice planes as recorded by precession photography.
M. J. Buerger and W. A. Dollase, Massachusetts Institute of Technology, Cambridge, Mass.

A slide rule for choosing precession camera settings.
Seymour F. Kaplan, 603 Charles Place N.W., Albuquerque, New Mexico.

2:00 p.m. Quantitative prediction of mineral stability.
M. Slaughter, University of Missouri, Columbia, Mo.

The relationship between the mean sound velocity and the mean index of refraction for oxide minerals.
Orson L. Anderson, Lamont Geological Observatory, Palisades, N. Y.

A. N. Winchell's observations on plagioclase, 1900; an historical note.
A. Pabst, University of California, Berkeley, Calif.

New specific refractive energies ($\underline{n}$-1/$\underline{d}$=K) for CuO and Sc_2O_3.
Mary E. Mrose, U.S. Geological Survey, Washington, D.C.

Diamond disc preparation of polished thin sections for the electron microprobe.
Donald E. Cadwell and Paul Weiblen, Minnesota Mining and Manufacturing Company, St. Paul, Minnesota.

The origin of the term "nuée ardente".
Marjorie Hooker, U.S. Geological Survey, Washington, D.C.

Solubility and growth of sphalerite under hydrothermal conditions.
R. A. Laudise, E. D. Kolb and J. P. De Neufville, Bell Telephone Laboratories, Murray Hill, New Jersey.

*Zeolite Type X equilibria with trivalent cerium and yttrium cations.
Lloyd L. Ames, Jr., General Electric Company, Richland, Washington.

Evening - Banquet

Friday - July 31, 1964

Field Trip - Yellowstone National Park

Saturday - August 1, 1964

Field Trip - Geology East of Butte

* *By title.*

ABSTRACTS

of papers presented at
meeting of the
Mineralogical Society of America
Bozeman, Montana
July 26-31, 1964

DEERITE, HOWIEITE AND ZUSSMANITE, THREE NEW MINERALS FROM THE FRANCISCAN OF THE LAYTONVILLE DISTRICT, MENDOCINO CO., CALIFORNIA

S. O. Agrell, M. G. Bown and D. McKie
University of Cambridge, Cambridge, England

Deerite, howieite and zussmanite are essential minerals in some of the metamorphosed shales, siliceous ironstones and impure limestones of the Franciscan formation.

These minerals occur in various associations with ferro- and ferri-stilpnomelane, spessartine-rich garnet, riebeckite, crocidolite, quartz, aegirine, grunerite, aragonite, oligonite and ferroan-kutnahorite.

Deerite occurs in black acicular crystals, amphibolelike in cross section, just transparent on thin edges. Cleavage (110) good. $\gamma = c$, α 1.840 ± .01, γ 1.870 ± .01, pleochroism slight: α dark brown, $\beta\gamma$ dark brown black. Sp. Gr 3.837. Monoclinic, cell dimensions a 10.755 Å ± .002 Å, b 18.87 Å ± .006 Å, c 9.568 Å ± .002 Å (fiber axis), pseudo c ∿ 3.2 Å. β 107.12° ± .04°, space group $P2_{1/a}$, twin [001] submicroscopic. Deerite a, b, c approximately equals clinoamphibole 2c, b, a.

½ unit cell contents for 0 = 55.

$$(Mg_{.09}Mn_{.95}Fe^{II}_{11.99})_{13.03}(Fe^{III}_{6.48}Al_{.42})_{6.9}Si_{13.04}O_{43.94}(OH)_{11.06}$$

Howieite occurs in dark green to black bladed crystals. Cleavage (010) good, (100) fair, $(2\bar{1}0)$ weak. α 1.701, β 1.720, γ 1.734, biaxial - 2V 65°, dispersion strong v > r, pleochroism marked: α pale golden yellow, β dark lilac grey, γ dull green. Sp. Gr 3.378. Triclinic, cell dimensions a 10.17 Å, b 9.72 Å, c 9.56 Å (all ± .05 Å), α 91.3°, β 70.7°, γ 109°. Unit cell contents for 0 = 44.

$$(Na_{1.03}Ca_{.02})_{1.05}(Mg_{.45}Mn_{2.98}Fe^{II}_{6.41})_{9.84}(Fe^{III}_{1.57}Al_{.62})_{2.19}(Si_{11.96}Ti_{.40})_{12.00}O_{31.3}(OH)_{12.69}$$

Zussmanite occurs in pale green tabular crystals. Cleavage (0001) perfect. ω 1.643, ε 1.623, uniaxial, pleochroism weak: ω pale green, ε colorless. Sp. Gr 3.146. Rhombohedral lattice. Hexagonal cell dimensions a 11.66 Å ± .02 Å, c 28.69 Å ± .02 Å. Rhombohedral cell dimensions 11.69 Å, α 59.8°. Laue group $\bar{3}$, space group R3 or R$\bar{3}$. Rhombohedral unit cell contents for 0 = 56.

$$(Na_{.07}K_{.92})_{.99}(Mg_{1.33}Mn_{.46}Fe^{II}_{10.85}Fe^{III}_{.11}Al_{.34}Ti_{.01})_{13.10}(Si_{16.6}Al_{1.4})_{18}O_{42.2}(OH)_{13.8}$$

SEVEN NEW BARIUM MINERALS FROM EASTERN FRESNO COUNTY, CALIFORNIA

John T. Alfors, Melvin C. Stinson, Robert A. Matthews,
California Div. of Mines and Geology, San Francisco, California

Adolf Pabst,
University of California, Berkeley

Seven new barium-bearing silicate minerals have been found in eastern Fresno County, California. The minerals occur in sanbornite-bearing metamorphic rocks which crop out in a narrow zone 2½ miles long near a granodiorite contact.

Macdonaldite [$BaCa_4Si_{15}O_{35} \cdot 11H_2O$] is biaxial (- or +), 2V = 90°, α = 1.518, β = 1.524, γ = 1.530, colorless, X = c, Y = b, Z = a, G (meas.) = 2.27. It is orthorhombic, Bmmb or $Bm2_1b$, a_o = 14.06, b_o = 23.52, c_o = 13.08, Z = 4.

Krauskopfite [$BaSi_2O_5 \cdot 3H_2O$] is biaxial (-), 2V = 88°, α = 1.574, β = 1.587, γ = 1.599, colorless, X = b, Y ∧ a = 6°, Z ∧ c = 10½°, a ∧ c = 94° 32', G (meas.) = 3.14. It is monoclinic, $P2_1/a$, a_o = 8.460, b_o = 10.622, c_o = 7.837, β = 94° 32', Z = 4.

Walstromite [$BaCa_2Si_3O_9$] is biaxial (-), 2V = 30°, α = 1.668, β = 1.684, γ = 1.685, colorless, G (meas.) = 3.60. It is triclinic, P$\bar{1}$ or P1, a_o = 6.743, b_o = 9.607, c_o = 6.687, α = 69° 51', β = 102° 14', γ = 97° 6½', Z = 2.

Fresnoite [$Ba_2TiSi_2O_8$] is uniaxial (-), ω = 1.775, ε = 1.765, 0 = colorless, E = yellow, G (meas.) = 4.23. It is tetragonal, P4/mbm, P4bm, or P$\bar{4}$b2, a_o = 8.52, c_o = 5.210, Z = 2.

Verplanckite [$Ba_2MnSi_2O_6(OH)_2$] is uniaxial (-), ω = 1.683, ε = 1.672, O = orange-yellow, E = colorless, G (meas.) = 3.62. It is hexagonal, P6/mmm,

$\underline{P}\bar{6}2\underline{m}$, $\underline{P}\bar{6}\underline{m}2$, $\underline{P}6\underline{mm}$, or $\underline{P}622$, $\underline{a}_o = 16.35$, $\underline{c}_o = 7.17$, $Z = 7$.

Muirite [$Ba_5CaTiSi_5O_{15}(OH)_6$] is uniaxial (+), $\omega = 1.697$, $\varepsilon = 1.704$, O = orange, E = colorless, G (meas.) = 3.86. It is tetragonal, $\underline{P}4/\underline{mmm}$, $\underline{P}4\underline{mm}$, $\underline{P}422$ or $\underline{P}\bar{4}2\underline{m}$, $\underline{a}_o = 13.942$, $\underline{c}_o = 5.590$, $Z = 2$.

Traskite [$Ba_5FeTiSi_6O_{18}(OH)_4$] is uniaxial (-), $\omega = 1.714$, $\varepsilon = 1.702$, O = brownish-red, E = colorless, G (meas.) = 3.71. It is hexagonal, $\underline{P}6/\underline{mmm}$, $\underline{P}\bar{6}2\underline{m}$, $\underline{P}\bar{6}\underline{m}2$, $\underline{P}6\underline{mm}$, or $\underline{P}622$, $\underline{a}_o = 17.88$, $\underline{c}_o = 12.30$, $Z = 6$.

ZEOLITE TYPE X EQUILIBRIA WITH TRIVALENT CERIUM AND YTTRIUM CATIONS*

L. L. Ames, Jr.
Hanford Laboratories, General Electric Company
Richland, Washington

Cerium equilibria were determined with several natural and synthetic zeolites including Linde 4A, 13X, AW-400, AW-500, Norton Zeolon, and natural erionite, phillipsite and clinoptilolite. Only Type X (Linde 13X) showed favorable mass action quotients at relatively high fractions of cerium on the zeolite. Further, only with Type X was the cerium capacity the same as the strontium or sodium capacity, 3.6 meq/g. The exchange data for Type X is given in the table. κ is a rational thermodynamic equilibrium constant and ΔG^o is a standard Gibbs free-energy change for the reaction given.

Reaction	κ, 25°C	ΔG^o, 25°C, cal/mole
$3Na_z \longrightarrow Ce_z$	45.6	- 2300
$2Na_z \longrightarrow Sr_z$	19.9	- 1800
$3Sr_z \longrightarrow 2Ce_z$	0.759	+ 200
$3Na_z \longrightarrow Y_z$	6.61	- 1100

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* Abstract to be read by title and published in the proceedings of the Mineralogical Society of America meeting, July 26 through 31, 1964, at Bozeman, Montana.

PYROXENE RELATIONS IN EXPERIMENTALLY CRYSTALLIZED 1887 MAUNA LOA BASALT

Myron G. Best,
University of Ottawa, Ottawa, Ontario, Canada

Experimental investigation of the kinetics of crystallization of the 1887 Mauna Loa, Hawaii basalt reveals significant time dependent phase relations of a similar nature as those found in natural basalts and andesites which are conventionally interpreted as resulting through changes in temperature and composition of the crystallizing magma. The experimental method employs a stack of two large quench furnaces and, to minimize oxidation of Fe, 8 gm. charges contained in very thin platinum foil tubes and heated in an atmosphere of argon. Runs of several days duration starting with powdered basalt (with all phases present as potential seeds) show that augite, hypersthene, and plagioclase all crystallize stably between 1170°C and 1090°C. In other runs where the charge is first completely liquefied at about 1200°C and then quickly introduced into the other furnace at a lower constant temperature no self-nucleating hypersthene forms at any temperature. Augite self-nucleates at temperatures less than 1140°C. Pigeonite (O P // (010); $2V_z$ 20°) nucleates from 1170°C to at least 1135°C; as these crystals become larger with time at any particular constant temperature the optic angle appears to increase, greater inhomogeneity is evident, and finally, after about four days, each grain clearly becomes composite, consisting of exsolved hypersthene and augite. The latter commonly forms irregular jackets and patchy cores or, rarely, thin (100) lamellae in the host hypersthene.

SKARNS OF THE PRECAMBRIAN, DENVER MOUNTAIN PARKS AREA, COLORADO

Margaret Fuller Boos,
Denver 10, Colorado

Skarns developed by polymetamorphism of 3 closely folded calcite-rock, calc-silicate and quartzitic members of the Idaho Springs sequence, crop out in separate, subparallel, well-defined belts within a wide northwest-southeast trending arc of metasedimentaries that border an antiform of at least 4 generations of Precambrian granites at the southwest.

Regional dynamothermal metamorphism of calcareous and associated sedimentary strata, was followed by multiple granite contact metamorphism. Retrograde metamorphism imposed additional modifications, especially of the calc-silicate minerals.

Field investigations located minor endomorphic (autometasomatic) and contact skarns in the outer marble - marmorite belt. The light colored skarn with white quartz bodies developed where the calcite-rich strata are intensely crumpled and dislocated by faulting.

The marble relics of the intermediate belt are enveloped by massive skarn, calc-silicate gneiss and black silexite. The mantle is a half to a mile wide. Discrete pods and strike-aligned lenses of marble and continuous calcite-rich layers are confined to the heart of the calc-silicate envelop. Skarn and marble-marmorite bodies do not merge.

Contact and endomorphic skarns of the intermediate and inner belts, produced by dynamothermal metamorphism, are invaded by mirocline-rich pegmatite and black silexite bodies loaded with innumerable pyrite grains of probable granite contact origin.

Retrograde metamorphism has modified all the calc-silicate minerals of the inner and intermediate belts but has had little effect on the outer one, and the mineralogy of the outer belt is well preserved. Exceptions are marble relics in fault and shear belts, where magnesia-rich and hydrothermal minerals occur.

THE ORIGIN OF SOME NATIVE LEAD-PYROCHROITE PARAGENESES

K. Bostrom
Scripps Institute of Oceanography, La Jolla, Calif.

Systems containing PbS, Mn_3O_4, $CaCO_3$, and $BaCO_3$ in various quantities are discussed. It is found that under certain conditions minerals like native lead, pyrochroite, and hydrocerussite can be formed by redox processes in these systems. The models are compared with native lead-pyrochroite occurrences at Långban, Sweden, and Franklin, New Jersey.

THE ORIGIN OF TINCALCONITE AT SEARLES LAKE, CALIFORNIA

C. J. Bowser
University of Wisconsin, Madison, Wisconsin

Tincalconite ($Na_2B_4O_7 \cdot 10H_2O$) occurs at Searles Lake as coarse-crystalline, commonly euhedral, crystals within the salts of both the upper and lower salt structures. Textural relations indicate it has grown as a reaction product directly from the saturated lake brine. Lake brine temperatures range from 20 to 25°C. The occurrence is unusual inasmuch as tincalconite is generally formed as a dehydration product of borax when exposed to the air.

In pure $Na_2B_4O_7$-water solutions the borax-tincalconite transition temperature is at 60.8°C, however it is lowered by addition of other salts to the solution. Borax converts to tincalconite at 39.6°C in saturated $NaCl-Na_2B_4O_7$ solutions. Van't Hoff determined a transition temperature of 35.5°C in solutions saturated with halite, sylvite, and aphthitalite. Teeple determined solubilities in salt systems which approximate the composition of Searles Lake brines over temperatures ranging from 20°-35°C. Borax was apparently the stable sodium borate phase in all these experiments.

On the basis of existing experimental solubility determinations, it is concluded that the tincalconite at Searles Lake did not form under present brine temperature conditions, except possibly the tincalconite that occurs near the salt flat surface, but that it must have formed earlier under warmer brine conditions. Apparently the tincalconite is kept from hydrating to borax by a surrounding permeability seal of either fine-grained trona or clay.

Data from the system $Na_2B_4O_7-NaCl-H_2O$ suggest that tincalconite is a metastable phase at Searles Lake. Had equilibrium been maintained only borax and kernite should have formed.

THE SHAPE OF MISORIENTED RECIPROCAL LATTICE PLANES AS RECORDED BY PRECESSION PHOTOGRAPHY

M. J. Buerger and W. A. Dollase
Massachusetts Institute of Technology, Cambridge, Massachusetts

The shape of reciprocal-lattice planes in precession photographs is a function of the orientation of these planes relative to the precessing axis. The exact equation of the perimeter of central planes is derived in terms of the lengths of the reciprocal lattice vectors, i.e. $\xi = f(\bar{\mu}, \tau, \varepsilon)$ in the usual notation. Qualitatively one may say that the shape passes from a circle to a curtate cardioid, to a cardioid and finally to a prolate cardioid as the error $\varepsilon = 0$, $\varepsilon < \bar{\mu}$, $\varepsilon = \bar{\mu}$, and $\varepsilon > \bar{\mu}$ respectively.

The precession orientation methods presently in use are shown to be special cases or approximations of the general equation. In addition other methods of orientation, which extend and complement the present methods are suggested by the general equation.

The perimeter of the recorded region may also be characterized by an angular measurement, viz. the angle between the radius vector and the tangent to the perimeter. The relation of the orientation error to this angle is given by an equation which is directly soluble for the error in contrast to the most generally used method which requires graphical solution. Furthermore this method is unlimited in allowing an error of any size to be evaluated as long as the reciprocal lattice plane in question can be discerned.

TEMPERATURE PARAMETERS OF SILICATE CRYSTAL STRUCTURES

Charles W. Burnham,
Geophysical Laboratory, Washington, D. C.

Analysis of experimentally determined temperature factors for ten refined silicate crystal structures with R values less than .06 affords a meaningful comparison of thermal models for oxygen, silicon, and aluminum atoms. Vibration ellipsoids for these atoms in varying structural environments provide guides to temperature factors expected in other silicates, and demonstrate that structural disordering furnishes significant non-thermal contributions that lead to abnormally high thermal parameters.

The rms displacements of 29 three- and four-coordinated oxygen atoms associated with pure Si and Al tetrahedra range from .065Å to .084Å; the mean is .075Å, corresponding to an isotropic temperature factor, B, of .44. When oxygen is only two-coordinated, rms displacements normal to the cation-anion vectors increase to .11-.15Å. In disordered tetrahedra containing mixtures of Si and Al, the rms displacements of oxygen atoms toward the cations increase to .10-.12Å. These increases parallel to bonds represent superposition of positional disordering effects, directly related to cation substitutional disordering, onto the true oxygen thermal vibrations.

Eleven Si and Al atoms have rms displacements ranging from .05Å to .07Å; the mean value is .06Å, corresponding to B = .31. For Si plus Al in six disordered tetrahedra, rms displacements increase to .08-.09Å, representing an increase of mean B to .60.

Other structural factors, such as the existence of defect sites of substitutional disorder in octahedral coordination polyhedra, will also induce anomalously high temperature factors. These non-vibrational contributions, when recognized in detailed anisotropic refinements, may provide crystal-chemical information not available from interatomic distance comparisons.

MINERALOGY OF THE KALKAR QUARRY, SANTA CRUZ, CALIFORNIA

Charles W. Chesterman and Eugene B. Gross
California Division of Mines and Geology,
Ferry Building, San Francisco, California

A suite of more than 50 minerals has been found in the Kalkar Quarry of the Pacific Limestone Products Company, near Santa Cruz, California. Represented are sulfides, sulfosalts, oxides, carbonates, sulfates, phosphates, antimonates and silicates. Sulfide and sulfosalt mineralization is adjacent to faults and occurs in irregular patches within fine-grained, recrystallized magnesian limestone. Interbeds of siliceous and pelitic limestone contain sulfides whereas the sulfosalts are confined principally to the purer limestones. Silicate minerals are developed in the siliceous and pelitic limestones. All secondary minerals are the result of near-surface alteration of the metallic minerals.

Paragenetic studies indicate an overlapping sequence of deposition in the sulfide and sulfosalts with molybdenite, loellingite and gersdorffite forming earliest and at temperatures possibly above 600°C., followed by arsenopyrite, pyrrhotite, pyrite and sphalerite, perhaps below 550°C. The sulfosalts formed last at temperatures below 400°C. The mineralization appears to be related to the intrusion of coarse-grained Mesozoic granite into interbedded magnesian limestone and siliceous and pelitic limestones of the Sur Series (pre-Cretaceous).

THE CRYSTAL STRUCTURE OF TURQUOIS, $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$

Hilda Cid-Dresdner
Massachusetts Institute of Technology, Cambridge, Massachusetts

Turquois is triclinic, space group $P\bar{1}$, with cell dimensions $\underline{a}$ = 7.424 Å, $\underline{b}$ = 7.629 Å, $\underline{c}$ = 9.910 Å, α = 68.61°, β = 69.71°, γ = 65.08°. This cell contains one formula of $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$, so that the Cu atom is fixed in an inversion center. Three-dimensional intensity data were collected on a single-crystal diffractometer using a proportional counter as detector, and were corrected for Lorentz-polarization factors and absorption. The interpretation of a three-dimensional Patterson function and of a three-dimensional electron-density function based on signs due to the Cu contribution only, gave a trial structure that was refined by Fourier methods and then by least-squares methods to = 7%.

The structure can be described in terms of planes of approximately close-packed oxygen atoms oriented parallel to (001). Planes containing the Al in octahedral coordination and planes containing the Cu in a 4 + 2 octahedral coordination alternate between oxygen layers. The octahedral groups of anions around the aluminum are single and double; two phosphorus tetrahedra link each double group to its translational equivalent, forming a tetrahedra-octahedra chain parallel to the $\underline{b}$ axis. The PO_4 tetrahedra together with the single aluminum octahedra constitute a zig-zag chain in the direction of the $\underline{c}$ axis. The water content has been determined to be four molecules per cell.

CRYSTAL STRUCTURE OF THE SODIUM CALCIUM BORATE, ULEXITE

Joan R. Clark and Daniel E. Appleman
U. S. Geological Survey, Washington, D. C. 20242

Ulexite, $NaCaB_5O_9 \cdot 8H_2O$, is triclinic $P\bar{1}$, $\underline{a} = 8.809 \pm 0.02$, $\underline{b} = 12.86 \pm 0.04$, $\underline{c} = 6.678 \pm 0.002$ Å, $\alpha = 90^\circ 15' \pm 05$, $\beta = 109^\circ 10' \pm 05$, $\gamma = 105^\circ 25' \pm 05$, cell volume 687.0 Å, density (calc.) 1.959, (obs.) 1.955 ± 0.001 g cm^{-3} (data from Clark and Christ, Am. Mineral. 44, 712, 1959). The crystal structure was solved by standard three-dimensional Patterson and Fourier methods. Visually estimated three-dimensional data have been used in least-squares refinement of coordinates and individual isotropic temperature factors for the 24 atoms of the asymmetric unit, reducing the residual from an initial value of 0.52 to a present value of 0.16.

The structure contains the isolated borate polyanion $[B_5O_6(OH)_6]^{3-}$ predicted by Christ (Am. Mineral. 45, 334, 1960), consisting of the pentaborate polyanion originally found by Zachariasen (Zeits. Krist. 98, 266, 1937) modified by addition of one hydroxyl group to each of two opposite B-O triangles. The ulexite polyanion is thus composed of three tetrahedra and two triangles, linked at corners to produce two six-membered alternating B-O rings in approximately perpendicular planes. The polyanions are hydrogen-bonded into sheets that are cross-linked by bonds to Na and Ca cations. Each Ca is coordinated by two water molecules and six polyanion oxygen atoms and hydroxyls. Each Na is surrounded by an octahedron of four water molecules and two hydroxyls; these octahedra share edges to form chains along the $\underline{c}$ direction. Polymerization of the ulexite polyanions, according to Christ's fourth rule, produces the $[B_5O_7(OH)_4]^{3-}$ chains found in probertite, $NaCaB_5O_9 \cdot 5H_2O$, by Kurbanov et al. (Doklady Akad. Nauk SSSR, 152, 1100, 1963). The structural formula of ulexite is $NaCaB_5O_6(OH)_6 \cdot 5H_2O$.

A NEW, BARINGER HILL-TYPE, RARE-EARTH PEGMATITE FROM THE CENTRAL MINERAL REGION, TEXAS

A. J. Ehlmann and J. L. Walper
Texas Christian University, Fort Worth, Texas
J. Williams
Texas Architectural Aggregate Company, San Saba, Texas

The discovery of a new rare-earth pegmatite, the Rode Ranch pegmatite, in the Central Mineral Region of Texas has made possible the detailed study of an occurrence quite similar to the famous Baringer Hill pegmatite, now flooded by the waters of Buchanan Lake.

The dominant mass of the Rode Ranch pegmatite consists of bodies of milky quartz and large masses and crystals of microcline perthite.

The primary rare-earth minerals have been found in three general associations. Allanite and fergusonite are found along a quartz-albite contact but, generally, within the albite. The albite is a soft, red feldspar apparently similar to the "red rock" of the Baringer Hill pegmatite. Cyrtolite and fergusonite occur disseminated in the massive microcline perthite. Cyrtolite, fergusonite and gadolinite occur interlaminated with large sheets of biotite along a microcline perthite-quartz contact.

Metamictization is complete in the allanite, fergusonite, and gadolinite and partial in the cyrtolite. Heating causes recrystallization of fergusonite and cyrtolite but dissociation occurs in the allanite and gadolinite before recrystallization.

Thus far, the following minerals, including many alteration products, have been identified from the pegmatite: quartz, albite, microcline, biotite, allanite, fergusonite, gadolinite, cyrtolite, bastnaesite, thorogummite, nontronite, sericite, magnetite, hematite, pyrite, garnet, beta beryllium hydroxide, and hyaline opal.

THE CRYSTAL STRUCTURE OF THE DECAVANADATE, $K_2Zn_2V_{10}O_{28} \cdot 16H_2O$, THE CHEMICAL ANALOG OF HUMMERITE AND PASCOITE

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When vanadium oxide ores of the Colorado Plateau are leached with ground waters, rather acid (pH 4-6) orange solutions are formed containing the isopoly complex decavanadate ion $V_{10}O_{28}{}^{6-}$. Bright orange crystals of pascoite, $Ca_3V_{10}O_{28} \cdot 16H_2O$ and hummerite, $K_2Mg_2V_{10}O_{28} \cdot 16H_2O$ are often deposited by these solutions in cracks or on exposed surfaces. The complex has been well-established chemically to be a 10-nucleate molecular group, but its structure is now revealed for the first time in the crystal structure analysis of the isostructural zinc analog of hummerite, $K_2Zn_2V_{10}O_{28} \cdot 16H_2O$.

The crystals are triclinic, space group $P\bar{1}$, with $a = 10.778 \pm 3$ Å, $b = 11.146 \pm 3$ Å, $c = 8.774 \pm 3$ Å, $\alpha = 104°57' \pm 1'$, $\beta = 109°32' \pm 2'$ and $\gamma = 65°2' \pm 2'$ ($Z = 1$), as determined by least squares analysis of x-ray powder data. 5,143 intensity data for all reflections with $(\sin\theta)/\lambda < 0.7$ were collected by the Weissenberg, multiple-film method, using MoKα radiation. The structure was solved from the three-dimensional, sharpened Patterson map in which the Zn-V vectors gave a clear image of the 10 vanadium atoms in the $V_{10}O_{28}{}^{6-}$ group. Structure factors for the six atoms, Zn + 5V, gave the phases for 2, 959 terms for the first electron density map. This map revealed all 29 non-equivalent atoms as well-shaped peaks of proper height, with no extra or spurious detail above ordinary background irregularities.

The decavanadate group consists of a cluster of 10 condensed VO_6 octahedra: 6 are arranged in a 2 x 3 rectangle by sharing horizontal edges, and 2 pairs of octahedra are inserted above and below the rectangle by shring sloping edges. The complex group, which may be thought of as a portion of a rocksalt type of structure, has orthorhombic <u>mmm</u> symmetry, and is completely isolated from other groups by the intervening cations and water molecules. The zinc ion is coordinated in a regular octahedron to 6 water molecules, and the potassium ion is in contact with 10 oxygen atoms: 3 water molecules from 2 $Zn(H_2O)_6^{2+}$ groups, 5 oxygen atoms from 3 neighboring $V_{10}O_{28}^{6-}$ groups, and 2 further H_2O molecules that fill the remaining space in the crystal.

AN OCCURRENCE OF ABUNDANT CHIASTOLITE, SAWTOOTH MOUNTAIN, ALASKA

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The occurrence of classically developed chiastolite porphyroblasts in a thermally metamorphosed slate in Alaska yields information on reaction rim formation and possibly information on unusual distortion of foliation in slate and of rotation of porphyroblasts. Regionally metamorphosed sedimentary rocks on Sawtooth Mountain, approximately 35 miles southwest of Livengood, Alaska, have been intruded by a stock. Near the igneous metamorphic contact, slates contain thinly armored chiastolite porphyroblasts which formed at the expense of the slate and apparently without initially distorting the foliation during their growth.

Drag of foliation occurs across many chiastolite prism faces which are nearly normal to the foliation. However, relict foliation within the porphyroblasts shows no effect of this sort of disturbance. Foliation is bulged adjacent to chiastolite prism faces which are nearly parallel to the foliation. The drag and the bulge of foliation are interpreted to have resulted during the latter part of porphyroblastic growth. These occurred when the growing crystals pushed out graphitic and minor phyllosilicate impurities which accumulated unevenly before the advancing crystal faces. The stress thus caused is believed to have rotated the porphyroblasts.

The thin armor on the porphyroblasts is interpreted to have been caused by marginal replacement of chiastolitic andulusite by the removed phyllosilicates which were more stable under the existing stress-temperature conditions than was the chiastolitic andulusite.

A UNIQUE OCCURRENCE OF URANIUM MINERALS, MARSHALL PASS, SAGUACHE COUNTY, COLORADO

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In 1956 several unusual uranium deposits were uncovered in the Marshall Pass district, Saguache County, Colorado. Two of the ore bodies occurred in alluvium at about 10,000 feet elevation. The largest of these, on the Lookout No. 22 claim, produced about five tons of "high grade" uranium ore.

The bedrock at the deposit is a quartz-biotite-feldspar schist which has been altered adjacent to a fault zone. Small areas of the schist have been completely replaced by uranium and sulfide minerals producing "rich" ore bodies that have been found *in situ* in the alluvium above the fault.

Ore specimens are tabular to rounded yellow masses measuring from a few inches in diameter to large slabs 2' x 1' x 8" thick and weighing as much as 140 pounds. All samples contained a yellow oxidized coating rimming a black interior of uraninite and sulfides.

Geochemical sampling of soils surrounding the deposit indicated that the uranium migrated less than 100 feet downslope from the ore body.

Radioactive minerals of the deposit included uraninite, schoepite, epi-ianthinite, becquerelite, soddyite, boltwoodite, uranophane, zeunerite, metazeunerite, and a hydrated autunite. Other minerals were tetrahedrite, chalcopyrite, sphalerite, chalcocite, covellite, galena, pyrite, and marcasite.

Uraninite occurs in concentric banded and colloform masses showing fractures and microfaults that have been rehealed by later uraninite. Secondary uranium minerals and sulfides transect the uraninite and occur interstitially between banded masses.

The uranium deposit is probably mesothermal and of late Cretaceous to early Tertiary age.

THE MINERALOGY OF THE BUTTE DISTRICT, MONTANA

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Continuing intensive study of the geologic environments integral to the Butte ore deposits has confirmed the occurrence of over 130 minerals, many previously unreported from Butte. Grouped according to environment, the mineral suites are found to support, refine, and extend existing theories concerning chronology of the district geology and zonation of the hydrothermal mineralization. Environments mineralogically described are: the Tertiary Boulder Batholith Butte quartz monzonite host rock, including its pegmatite-aplite segregations and quartz porphyry dikes; the late-magmatic--pre-Main Stage hydrothermal phases of quartz-molybdenite veinlets and Early Dark Micaceous alteration-mineralization; the Main Stage hypogene mineralization and its contemporaneous wall rock alteration; post-ore rhyolite dike intrusion and ore metamorphism; and supergene alteration of ore minerals and wall rock in both pyrite-rich and pyrite-poor assemblages. The list of verified minerals at present includes 3 native metals, 19 sulfides, 14 sulfosalts, 18 oxides, 2 halides, 12 carbonates, 15 sulfates, 15 phosphate-arsenate-tungstates, and 35 silicates. A few reliably reported but unverified species are described, new occurrences, habits, and assemblages are cited, and minerals ascribed to Butte in the literature but found to be of unlikely or restricted occurrence are noted. Of particular interest to mineralogists is the reporting of the minerals aikinite, wittichenite, and djurleite in the Butte ores. Of general interest are preliminary descriptions of a pyrophyllite-topaz-zunyite alteration assemblage; of the pre-Main Stage, feldspar-destructive, sericite-biotite Early Dark Micaceous alteration-mineralization; and of a recently defined Deep Level Zone of Main Stage sulfide mineralization.

ORIGIN OF THE TERM NUÉE ARDENTE

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Nuée ardente, the term in use to designate the glowing, gaseous, ash-laden, avalanching cloud characteristic of certain volcanic eruptions, has long been assumed to have originated with A. Lacroix in his writings on the 1902 eruption of Mt. Pelée on the island of Martinique. In actual fact, it was introduced into the geologic literature in 1873 in an article by F. Fouqué describing the volcanic eruptions in 1580 and 1808 on the island of San Jorge in the Azores. Fouqué derived it from the Portuguese _nuvem_ _ardentem_ which was used in early Azorean accounts to describe the fiery-cloud phenomenon accompanying the eruptions. In his first on-the-spot reports from Martinique,

Lacroix, believing that the clouds he observed were a phenomenon as yet undescribed, designated them as nuages denses. In later reports and in his full, final report, convinced that the clouds were similar to those that had occurred on San Jorge, he decided to adopt the name given in the old Azorean records and translated by Fouqué as nuées ardentes. Since that time, the term, retained in its French form, has become well established in volcanologic terminology, in part from general usage but more particularly, perhaps, from its use by F. Perret in a vivid description and a discerning analysis of the 1929-1932 eruption of Mt. Pelée.

A SLIDE-RULE FOR UPPER-LEVEL SETTINGS FOR THE PRECESSION CAMERA

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By changing the equation $S = r_s \mathrm{Cot}\, \mathrm{Cos}^{-1} (\mathrm{Cos}\, \bar{u} - d^*)$ to $\mathrm{Cos}\, \bar{u} = d^* + \mathrm{Cos}\, \mathrm{Cot}^{-1} S/r_s$ a circular slide-rule for determining upper-level settings for the precession camera can be constructed. It is possible with this slide-rule to achieve the twin objectives of maximizing the precession angle and remaining within the physical limitations imposed by the motion of the camera. The slide-rule permits one to choose between a number of possible settings, and/or to vary the settings quite rapidly. The slide-rule has been constructed with a 60 mm film-to-crystal distance in mind, so that $Fd^* = 60\, d^*$. Other slide-rules of the same type can easily be constructed for any film-to-crystal distance. From cone photographs, d^* can also be quickly determined on this slide-rule.

SOLUBILITY AND GROWTH OF SPHALERITE UNDER HYDROTHERMAL CONDITIONS

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The solubility of sphalerite (cubic ZnS) was studied between 300° and 450°C, between 270 and 1360 bars, in a variety of mineralizer solutions. In particular, 0.5-10.0 N KOH was found to have a large effect on solubility, and solubilities as high as 10 wgt. % were obtained. The temperature dependence of solubility is shown to follow the Van't Hoff equation and the dependence of solubility upon $(OH)^-$ concentration leads to information concerning the species present. The solubility was found to be nearly independent of

pressure. The results are compared with previous solubility studies of quartz, sapphire and zincite under similar conditions.

The solubility data were used to find suitable conditions for the hydrothermal crystallization of ZnS. Growth rates as high as 15 mil/da were obtained in < 110 > in 10 molar KOH at 550 bars when the crystallization temperature was in the neighborhood of 350° and the temperature difference between dissolving and growth zones was $10\text{-}20^{\circ}$. The effect of growth conditions on rate is discussed as is the optical quality of the crystals.

NEW SPECIFIC REFRACTIVE ENERGY VALUES FOR CuO AND Sc_2O_3

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Large deviations between calculated and experimental mean indices of refraction (n), obtained when the Gladstone and Dale relation ($\underline{n} - 1/\underline{d} = K$) was applied to several copper-bearing minerals under investigation, led to the determination of a new specific refractive energy value (k) for CuO, using the chemical, optical, and density data of dioptase, $CuSiO_3 \cdot H_2O$. New newly derived $\underline{k}_{CuO}$, 0.173, replaces the previously accepted $\underline{k}_{CuO}$ value 0.191. Using the new $\underline{k}_{CuO}$ value, the rule of Gladstone and Dale was applied to 49 minerals in which copper is an essential constituent. Of these, 23 were found to have deviations within 0.010 between mean calculated n and mean measured n. Those for which the deviation calculated is greater than 0.010 are believed to contain inaccuracies in the data for their chemical or optical properties.

On the basis of new optical determinations, specific gravity measurements, and spectrographic and chemical analyses of kolbeckite and sterrettite, both of which are now known to have the composition $ScPO_4 \cdot 2H_2O$ (Mrose, Meyrowitz, and Wappner, unpublished data, 1964), the specific refractive energy for Sc_2O_3 has been determined to be 0.264, replacing the value 0.248 previously derived from thortveitite, $(Sc,Y)_2Si_2O_7$. The new k for Sc_2O_3 (0.264) is considered more reliable because of the simplicity of the analytical results and the close agreement of the optical and specific gravity measurements obtained on kolbeckite and sterrettite (= kolbeckite) from two localities. Analyses of thortveitite from Iveland, Norway, show such variation in the scandium and rare-earth oxide contents that the homogeneity of the analyzed samples as well as the analytical procedures used in determining these constituents are suspect. Use of thortveitite to determine the specific refractive energy value for Sc_2O_3 is complicated by the fact that the specific refractive energies for the rare-earth oxides have not been rigorously established.

OBSERVATIONS ON THE CRYSTAL CHEMISTRY OF FOSSIL BONE AND THE CARBONATE APATITES

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The crystal chemistry of the carbonate apatites is being reviewed in the light of new X-ray diffraction, chemical, infrared, and thermal analyses of apatites and fossil bones. Infrared spectra give more critical information on the role of carbon in the apatite structure than any other method employed to date. The spectra indicate that carbon is present as CO_3^{--} and is substituted in essentially the same manner for all apatites regardless of surface area, CO_2 or H_2O content. The presence of tridentate peaks in the v_3 region for CO_3^{--} in fossil bone and some apatites suggests that there are non-identical carbonate sites. Infrared spectra of heated and analyzed samples confirm the two site structure as one group of peaks in the v_3 region is reduced in intensity before the other. Structural calculations by the method of McConnell on a typical analysis (sum 100.40%) of fossil bone produces a formula

$$(Ca_{8.79}\ Mg_{0.32}\ Na_{0.68}\ K_{0.12}\ C_{0.28})\ (P_{4.75}\ C_{0.57}\ H4_{0.68})\ O_{24}\ (F_{1.68}\ OH_{0.38})$$

but with 3.57 excess H. Calculations on 7 other fossil bones and 2 phosphorites lead to the same problem of excess H if C is assigned preferentially. The failure of proposed structures to accommodate all components in these francolites which are high in F, CO_2 and H_2O+ indicates that present models for the carbonate apatite should be altered to allow some CO_2 or H_2O+ to be assigned to sites not recognized in the fluor-apatite structure or to a tightly absorbed pseudo-molecular position.

GROUND-WATER LEACHING OF SODIUM FROM QUICKLY COOLED VOLCANIC ROCKS

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Quickly cooled silicic volcanic rocks are highly susceptible to ground-water leaching of Na_2O. Various workers have previously recognized that natural glasses, if hydrated, are particularly susceptible to leaching. Rocks with vitric groundmasses, particularly highly porous tuffs, may lose as much as 3 percent Na_2O.

In addition, analytical data obtained during recent work on rocks from southern Nevada show that 0.5 to 1 percent Na_2O has been leached from both porous and densely welded ash-flow tuffs that have devitrified during cooling (primary devitrification) and from quickly chilled devitrified lavas. These rocks appear fresh and unaltered in both hand specimen and thin section. Cristobalite is the dominant groundmass silica mineral in the leached rocks. More slowly cooled lavas and tuffs having primary quartz instead of cristobalite in the groundmass are not leached; they have the same sodium content as rocks from the same stratigraphic unit which have groundmasses of non-hydrated glass.

It is known (Buerger, 1935; 1954) that the composition of natural cristobalite and tridymite typically departs appreciably from pure SiO_2. In particular, Al^{+3} replaces Si^{+4}, the charge balance being maintained by the incorporation of alkali and alkaline-earth ions in interstitial positions. A high degree of such replacement can be expected in cristobalite formed at the relatively high temperatures of primary devitrification. Tuffs with groundmass cristobalite typically contain 0. 3 to 0. 7 percent H_2O plus. It is inferred that H_3O^+ very slowly replaces Na^+ ions in the "stuffed" cristobalite and tridymite by ion exchange with ground-water. In addition, it appears that in some cases soda is also lost during secondary low-temperature recrystallization of primary cristobalite to quartz.

K_2O usually is not leached, possibly because of the large size of the potassium ion.

A. N. WINCHELL'S OBSERVATIONS ON PLAGIOCLASE, 1900; AN HISTORICAL NOTE

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A. N. Winchell's doctor's dissertation (Paris, 1900), "Étude minéralogique et petrographique des roches gabbroiques de l'État de Minnesota, États-Unis, et plus spécialement des anorthosites," was soon republished in English (American Geologist 26, 151-188, 197-245, 261-306 and 348-388, 1900). A chemical analysis and detailed observations on a labradorite from Carlton Peak were reported and a difference of about 6° noted in the optic angle from that of similar labradorite studied by Fouqué. Winchell wrote: "Since his (Fouqué's) measures were all made on feldspars from the volcanic rocks, it seems probable that the optic angle is distinctly greater in labradorite of the deep-seated rocks than in the corresponding labradorite of the volcanic rocks. It will at least be interesting to examine this question further as the measures of the optic angle on material of known composition increase in number." Winchell was fully aware of the significance of these relations for he recurred to them thrice in the same chapter and again in his conclusions. Unfortunately he did not "examine this question further" and 40 years passed before others took it up.

If the indices and optic angles of Winchell and Fouqué are interpreted from the best modern data (J. R. Smith, 1958), compositions more anorthitic by 6 to 8% than those shown by their analyses are indicated. However, Winchell was correct in stating that the differences in indices and birefringence are negligible, whereas those of optic angle are significant, for in the range An 58-70 the optic angle of low plagioclases is larger by 5 to 7 degrees.

THE CRYSTAL STRUCTURE OF A MARIALITE SCAPOLITE

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The crystal structure of an 80.6% marialite scapolite, with a = 12.060 Å ± .003, c = 7.572 Å ± .003, and space group I4/m was determined and refined. Three-dimensional intensities were collected with an equi-inclination, single-crystal diffractometer from a spherical crystal of scapolite from Gooderham, Ontario.

After several unsuccessful attempts at refining the model proposed by Pauling (1930), and Schiebold and Seumel (1932), the three-dimensional Patterson function was computed and solved for an approximation of the structure with the minimum function method. This model was completed and refined by Fourier and least squares methods. The refined structure is similar to that of Pauling, Schiebold and Seumel; however, most of the atomic coordinates have been shifted substantially:

	x	y	z	B
(Na, Ca, K)	.1340 ±.0003	.2113 ±.0002	0	2.65
Si-1	.3388 ±.0001	.4104 ± 0001	0	.82
(Si, Al)-2	.3374 ±.0001	.0851 ±.0001	.2060 ±.0002	.76
0-1	.4587 ±.0005	.3483 ±.0004	0	1.60
0-2	.3066 ±.0006	.1206 ±.0004	0	2.14
0-3	.0517 ±.0003	.3500 ±.0002	.2148 ±.0006	1.55
0-4	.2293 ±.0003	.1289 ±.0002	.3281 ±.0006	1.37
Cl	0	0	0	

The average T-0 distances are 1.608 Å in the first and 1.665 Å in the second tetrahedron. Comparison with known Si, Al-0 distances indicates that Al must be restricted to the second tetrahedral position.

LAYER STRUCTURES IN SECONDARY COPPER MINERALS

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Strong lines with spacings near 7.2 and 3.6 Å appear in the powder patterns of several secondary copper minerals having a single perfect cleavage. The minerals contain hydroxyl ion and tetrahedrally coordinated anions. The patterns bear a resemblance to that of kaolinite and suggest possible analogous structures.

Copper can be accommodated in modified trioctahedral layers by distortion of the cation coordination. Sites on trigonal axes are forbidden to copper but may have cations such as aluminum or be voids. Hypothetical trigonal layers are proposed as follows: (1) seven sites, one having trigonal symmetry; (2) nine sites, three trigonal; (3) twelve sites, three trigonal. Layers involving no trigonal sites may be of trigonal or lower symmetry. Layers with less than seven sites require that all or none be trigonal. Layers with more than twelve sites are possible.

Two seven-site layers normal to the 14.34 Å hexagonal axis are established by partial determination of the spangolite structure. The cation composition is Cu_6Al per layer. The nine-site layer is suggested for an undescribed, rhombohedral copper silicate having three layers, possibly Cu_6Al_2 (one site vacant), normal to the 21.27 Å trigonal axis. The twelve-site layer, with composition Cu_9Al (two sites vacant), is suggested for chalcophyllite. Six layers normal to the 57.4 Å trigonal axis require a different linkage to anions than that in spangolite.

Devillite may have layers of eight non-trigonal sites. Clinoclase has a 7.12 Å spacing but requires more sites than a single layer can accommodate. Antlerite has ribbon-like units related to sheet structures.

POLYTYPISM IN BIOTITES

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Single-crystal studies, by means of the Buerger precession camera, of 42 individual crystals of an oxybiotite from the brecciated margin of a rhyodacite lava flow at Ruiz Peak, New Mexico, show that the specimen contains approximately one-third 1M, one-third $2M_1$, and one-third more complex polytypes. Among the complex forms, 4- and 20-layer monoclinic, 8- and 14-layer triclinic, a probable 10-layer monoclinic, and probable 3-, 23-, and 25-layer triclinic polytypes were found. Three of the multilayer types are excellent examples of structures with a periodic stacking fault.

These structures are based on a 1M sub-cell with probably every n-th layer (n = 8, 14, and 25) faulted. Biotite samples from Idaho, Alaska, Canada, and N. Ireland, of both igneous and metamorphic occurrence, show a similar mixture of polytypes. A well-crystallized 3-layer triclinic form was found in the specimen from Newcastle Co., N. Ireland. The apparent continuous or semi-continuous streaking parallel to $\underline{c}^*$ which appears in the precession photographs of some of the biotite crystals can be explained by the presence of a number of periodic stacking faults or by a stacking fault having a very large repeat distance. These studies suggest that, in general, biotite specimens may be composed of more than one polytype or a complex mixture of many polytypes. The identification of biotite polytypes by X-ray powder techniques may thus be invalid. Crystal structure analyses of the 1M, $2M_1$, and 4M oxybiotite polytypes are in progress as well as interpretation of probable stacking sequences and twinning relationships of the more complex forms.

HYPABYSSAL ALKALINE BODIES AND STRUCTURE OF PART OF THE NORTHWESTERN CRAZY MOUNTAINS, MONTANA

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The Crazy Mountains have been studied by Weed, Iddings, Pirsson (1894-98) and Wolff (1938). They include calc-alkalic stocks (?) plus other intrusives and alkaline sills, laccoliths, phacoliths, dikes and other discordant bodies. The present area of 55 square miles was mapped (1:20,000) in 1962-63 as typical for the alkaline bodies. Rock types include malignites, lamprophyres, nepheline syenites, monzonites, andesites and their variants. Principal minerals are aegerine-augite, augite, anorthoclase, sodic plagioclase, nepheline, analcite, sodalite, sodic amphiboles and micas. Pseudoleucite is associated with malignites.

Maximum intrusion occurred with folding and faulting, followed by an andesite-trachyandesite dike swarm. From west to east are a south-plunging syncline, and anticline with a steep eastern flank followed by a south-east-dipping homocline. Alkaline microsyenites and malignites occur as concordant bodies, north-trending dikes and other discordant bodies in the syncline and anticline. The microsyenites were intruded later than the associated malignites. Phacolithic bodies and other features indicate that folding occurred with successive intrusion. On the homocline a sill series strikes southwest. The sills are predominantly porphyritic microsyenites to micromonzonites, often with interstitial quartz. Toward the northern stock (?) sills are more numerous and sedimentary septa thinner.

In the central and eastern parts of the area a radiating dike set curves north to northwest. The dikes in the north center have petrological affinities with the alkaline rocks to the west (with exceptions). To the southwest radiating dikes include, in order of intrusion, camptonites, basaltic andesites and trachyandesites and focus on the southern stock. One camptonite dike is cut by the southwest-trending sill-set and was offset along bedding planes as folding and sill intrusion occurred. This sill set, in turn, is cut by composite andesite-trachyandesite dikes. Field and petrologic studies are being continued.

QUANTITATIVE PREDICTION OF MINERAL STABILITY

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Relations between chemical bond type and configuration and expected physico-chemical behavior of the silicates are outlined. It is suggested as a first approximation that the covalent bond energies, except for small differences, are independent of the silicate and other partially covalent mineral phases. Covalent and overlap repulsive energies may be largely ignored when deducing stability relations of minerals.

Combining Coulomb energies with appropriate corrections makes possible quantitative prediction of stability relations of minerals. Melting and decomposition temperatures of some minerals including corundum and quartz have been calculated from the binding energies. Agreement between calculated and observed melting points is exceptionally good when covalency, radius-ratio, and coordination effect corrections are made to the Coulomb binding energies. Employing the binding energies of four minerals: pyrophyllite, talc, montmorillonite, and muscovite-like pyrophyllite, it was found that the agreement between calculated energies, and the energies inferred from observed chemical behavior, was good only when the charges on the ions were reduced to account for covalency. Thermal stabilities of some phyllosilicates are predicted semiquantitatively. Calculated energies show that the stability of montmorillonite with respect to other phyllosilicates in most low-temperature geochemical environments is probably the result of hydration of the interlayer space. Also, when small amounts of magnesium are in a silicate system montmorillonite is the phase which minimizes the total energy of the system.

First results of energy calculations on an investigative level are very encouraging, and efforts should be made to improve the quality of the approximations.

XANTHOPHYLLITE FROM THE TOBACCO ROOT MOUNTAINS, MONTANA

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Xanthophyllite is found as large, deep green, tabular, pseudohexagonal crystals directly associated with diopside, serpentine, spinel, and calcite. In addition, the deposit contains idocrase, grossularite-andradite, and vermiculite. The xanthophyllite-bearing deposit comprises predominantly an irregularly-shaped body of light-green, aphanitic serpentine, 22 feet by approximately 42-50 feet, enclosed within a diorite stock. The x-ray powder data agree with published data except that this material shows a good (001) reflection not reported previously. The unit cell constants are: $a = 5.19$, $b = 9.00$, $c = 9.80$ A, $\beta = 100^{\circ}08'$; $a : b : c = 0.577 : 1 : 1.089$. Measured specific gravity (pycnometer), 3.15; hardness, 4½ on cleavage (001), 5½ on (hk0). $\alpha = 1.647$, $\beta = 1.659$, $\gamma = 1.660$; 2V range = 6-18°; optically negative. The formula calculated from a chemical analysis is $Ca_{1.19}Mg_{2.94}(Al_{2.30}Si_{1.61})_4O_{10}(OH)_2$.

STRUCTURE OF A SYNTHETIC LITHIUM-FLUOR MICA*

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Taeniolite, $K(Mg_2Li)Si_4O_{10}F_2$, was synthesized by the Mycalex Corporation of America for Dr. H. S. Yoder, Jr., who kindly provided the sample. The bulk composition of a fraction consisting of only clear hand-picked crystals is $K_{0.86}(Mg_{2.26}Li_{0.54}Al_{0.08})(Si_{3.83}Al_{0.17})O_{10}F_{2.03}$ (J. L. Miller, Jr., U. S. Bureau of Mines, Norris, Tennessee). The crystal structure has been determined in space group C2/m, using counter data for 62 OKL reflections and photometer data of integrated Weissenberg photographs for 512 observed HKL reflections. The cell dimensions are $a = 5.31$, $b = 9.21$, $c = 10.13$ Å ± 0.3%, $\beta = 100^{\circ}1' \pm 10'$, rather close to those of fluophlogopite. Lease-squares refinement (using Busing et al.'s program) letting multipliers for atomic scattering factors vary, indicates more Mg than shown by the chemical analysis and some Li enrichment in position 2c. Using the bulk composition and all HKL reflections, R = 0.094 and the temperature factor of (Mg, Li) in position 4h is 0.18; whereas, with the derived chemical formula R = 0.085 and the above temperature factor increases to 0.65. The average (Si, Al) -0 distance is then found to be 1.65 Å. This value is large enough to give support to the increased Al/Si ratio for the tetrahedral sites, which is

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necessitated by the raise in Mg content, since the total cation charge is kept constant. The distance (Mg, Li) -F is 2.03 Å, only 2% shorter than the distance (Mg, Li) -0 which is 2.07 Å. The two sets of K-0 bond lengths average 2.99 and 3.28 Å.

THE CRYSTAL STRUCTURE OF THE ZEOLITE FERRIERITE

Philip A. Vaughan
Rutgers, The State University, New Brunswick, New Jersey

Ferrierite is a zeolite mineral which occurs at Kamloops Lake, British Columbia. I have determined the crystal structure of this mineral. The unit-cell dimensions are $\underline{a}$ = 19.156 Å, $\underline{b}$ = 14.127 Å, and $\underline{c}$ = 7.489 Å, and the space group is Immm. An analysis of the sample (by the Norton Company) shows that the unit-cell content is very nearly $Na_{1.5}Mg_2Si_{30.5}Al_{5.5}O_{72}\ 18H_2O$.

Refinement consisted of three 3-dimensional Fourier syntheses and six cycles of least squares. The part of the unit-cell content which is established as having crystallographic periodicity is $Si_{30.5}Al_{5.5}O_{72} \cdot 2Mg(H_2O)_6$. The sodium ions and remaining water molecules are located somewhat randomly in the large channels which exist in the structure parallel to the $\underline{c}$ axis. These channels are formed by rings of ten tetrahedra, and, with allowance for the van der Waals radius of oxygen, are roughly elliptical in cross section, with major and minor diameters of 5.4 and 4.3 A.

As expected, the $M_{36}O_{72}$ framework consists of corner-sharing tetrahedra. The average (Si, Al) -O distances in the four crystallographically distinct tetrahedra are 1.615, 1.623, 1.597, and 1.596 Å. Thus, the Al atoms are presumed to be randomly distributed.

The $Mg(H_2O)_6^{++}$ ions are located in cavities in the structure centered at 00½ and ½½0. These cavities are connected to the main channels by 8-membered rings which are perpendicular to the $\underline{b}$ axis. These windows have dimensions of 4.6 by 2.8 Å and do not permit passage of the $Mg(H_2O)_6^{++}$ ions.

THE CRYSTAL STRUCTURE OF ALUNITE*

Rong Wang, W. F. Bradley, and H. Steinfink
University of Texas, Austin, Texas

A single crystal diffraction analysis of alunite, $KAl_3(SO_4)_2(OH)_6$, yields an internally consistent set of bond lengths and angles which include significant revisions of previously determined values. The sulfate group includes one unique oxygen more strongly bonded to sulfur than are the other three.

DIAMOND DISC PREPARATION OF POLISHED THIN SECTIONS FOR THE ELECTRON MICROPROBE

Paul Weiblen and Donald E. Cadwell
Minnesota Mining and Manufacturing Co., St. Paul, Minnesota

Photomicrographs are presented of polished thin sections of: (1) Sudbury, Ont., ore, (2) Duluth gabbro, (3) Minnesota granulite gneiss with magnetite-ilmenite, (4) friable volcanic rocks, (5) Ajo porphyry copper ore, and (6) Homestake quartz-gold ore.

Preparation of the sections begins with diamond core-drilling of the rock specimen, grinding a circular cross section of the core with Diamond Discs, then vibratory polishing in two stages, the first with 6-micron diamond, and the second with 0.1-micron alumina. We cement the polished face to a ground slide, then saw off the thin section and grind it to final thickness on the Ingram thin section saw and grinder respectively. The standard wheel of the grinder is replaced by either Coarse or Extra Fine grade Diamond Discs, and the drive modified to provide variable speed in order to optimize performance of both grades. The finished section must be transferred to a transparent slide.

This method routinely and relatively quickly produces low-relief sections of the high quality required for electron probe microanalysis.

* Acknowledgement is made to the donors of the Petroleum Research Fund, administered by the American Chemical Society, for support of this research.

REGRESSIONS OF REFRACTIVE INDICES, DENSITY, AND LATTICE CONSTANTS ON THE COMPOSITION OF ORTHOPYROXENES

Horace Winchell and Bernard E. Leake
Yale University, New Haven, Connecticut

Regression formulas probably yield the best estimates now available for the properties of end-members and of other interesting compositions!

Regression-estimates of properties for some interesting compositions

	ENSTATITE			HYPERSTHENE			ORTHOFERROSILITE		
	$Mg_2Si_2O_6$	+Al[a]	+Al, Ca[b]	$FeMgSi_2O_6$	+Al[a]	+Al, Ca[b]	$Fe_2Si_2O_6$	+Al[a]	+Al, Ca[b]
n_x	1.6518±.0049	1.6505	1.6506	1.7115	1.7102	1.7085	1.7725	1.7682	1.7665
n_y	1.6562±.0031	1.6596	1.6607	1.7268	1.7302	1.7292	1.7840	1.8746	1.7836
n_z	1.6621±.0017	1.6662	1.6671	1.7269	1.7310	1.7299	1.7926	1.7935	1.7924
G	3.2160±.0110	3.2240	3.2320	3.6020	3.6090	3.6060	3.9880	3.9760	3.9720
a	18.2448±.0071	18.2344	18.2344	18.3297	18.3193	18.3167	18.4637	18.4466	18.4441
b	8.8328±.0088	8.8084	8.8084	8.9374	8.9130	8.9099	9.1600	9.1245	9.1214
c	5.1834±.0023	5.1815	5.1823	5.2134	5.2114	5.2113	5.2575	5.2533	5.2532

NOTES: [a]0.10 Al; [b]0.10 Al and 0.03 Ca

These estimates agree with published values for similar compositions, but regression-estimates, for which standard errors can be calculated, are probably the best because they take into account all data (not just the Fe/Mg ratio, for example, assuming all other elements constant) for a large number of analyzed samples. Tables of the regression coefficients have been prepared for preliminary distribution. They show, for example, the amounts to be added to the above estimates for $Mg_2Si_2O_6$ to allow for substitutions of the several elements (Al, Fe''', Ti, Fe'', Mn, Ca, Na) in appropriate positions of the pyroxene formula ABC_2O_6.

ANNOUNCEMENT OF A SUMMER MEETING

MINERALOGICAL SOCIETY OF AMERICA

Bozeman, Montana - July 26-31, 1964

A summer meeting of the Mineralogical Society of America will be held in conjunction with the annual meeting of the American Crystallographic Association in Bozeman, Montana, July 26-31, 1964. The decision to hold a summer meeting was made by the Council at its November 1963 meeting in New York City, as a result of a suggestion made by the Board of Past Presidents.

A summer meeting of an informal nature, in an area where interesting field trips can be planned, should be a welcome relief from the hectic pace of the winter meeting held with the GSA and other societies. It is hoped that the idea will be enthusiastically received by the membership and that as many as possible will attend. Non-members are also invited to attend the meeting and present papers.

PLACE:

Montana State College, Bozeman, Montana.

HOUSING:

Individual and family housing will be available on campus. The rooms are suitable for two people per room and family groups will be accommodated with adjoining rooms. Room charges for Sunday through Friday night will be $19.50 per person for singles and $16.50 per person in doubles. Prices include maid service and fresh towels daily.

Motels, hotels, and trailer courts are also available. A listing will be included in a second circular so that those desiring these accommodations may make arrangements directly. Prices range from $7.00 to $10.00 per bed.

MEALS:

Meals will be available on an "ACA Menu" basis for five days, Monday through Saturday morning, at $18.50. A special price of $13.00 has been granted for children 11 and under.

REGISTRATION:

Preregistration is encouraged and will be handled for the MSA by the ACA local committee. The registration fee will be $5.00. Student registration will be $3.00. Only those preregistered can be guaranteed dormitory space and meals on the ACA menu.

Forms for preregistration will be included in the second circular.

TRAVEL:

Bozeman is served by Northwest Airlines, Northern Pacific Railroad, and Greyhound Bus lines. Because North-South connections with these carriers may be poor, charter buses will be used to meet appropriate Western Airlines and Frontier Air Lines flights into Billings and Butte. Further details on this will be in the second circular.

Bozeman is on highways 10 and 191. Parking facilities will be available to anyone traveling by car. Scenic camping areas are in the near vicinity for those that may wish to combine the meeting with a mountain vacation trip.

SCIENTIFIC SESSIONS:

Titles of papers to be presented must be submitted to the Secretary by May 15, and abstracts by June 15. Abstracts must be submitted in standard GSA format, i.e. double spaced on a single sheet, not to exceed 250 words in length, in duplicate.

FIELD TRIPS:

Two or three days of field trips are being planned. Tentative plans call for a full-day trip to Butte, a half-day trip to an asbestos mine near Bozeman, a half-day trip to examine the geology of the Bozeman area, and a full-day trip to Yellowstone National Park. Detailed information about the field trips will be sent with the second circular.

SECOND CIRCULAR (IMPORTANT - READ CAREFULLY):

A second circular with additional information and preregistration form will be sent in April. In order to save mailing costs the second circular will be sent only to those members living in the United States and Canada. Members living in other countries wishing to receive the second circular check the appropriate box on the attached form and return it to the Secretary.

In order to help in the planning for this summer meeting, which will be a new experience for all concerned, it will be greatly appreciated if those who are planning to attend the meeting, or who think they might, would fill out the coupon below and return it to the Secretary as soon as possible.

George Switzer, Secretary
Mineralogical Society of America
U. S. National Museum
Washington, D. C. 20560

March 9, 1964

Detach here and mail to George Switzer, U. S. National Museum, Washington, D.C. 20560

I (plan) (do not plan) (hope to but not certain yet) to attend the Bozeman meeting of the MSA.

I will (will not) present a paper.

I will (will not) participate in the field trips.

I am resident in a foreign country -- please send second circular ☐.

____
Signature