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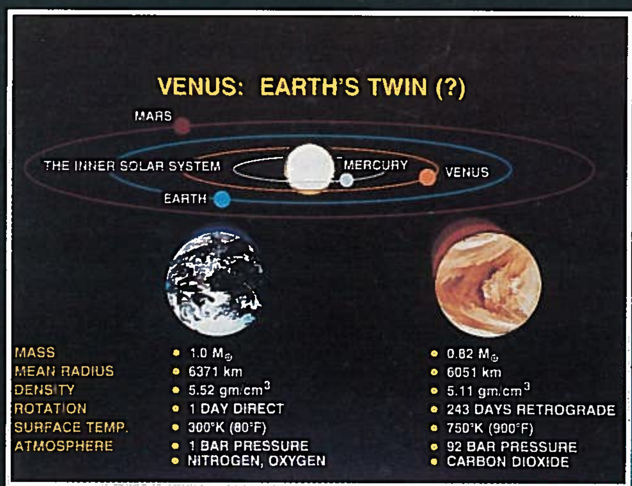
INSIDE



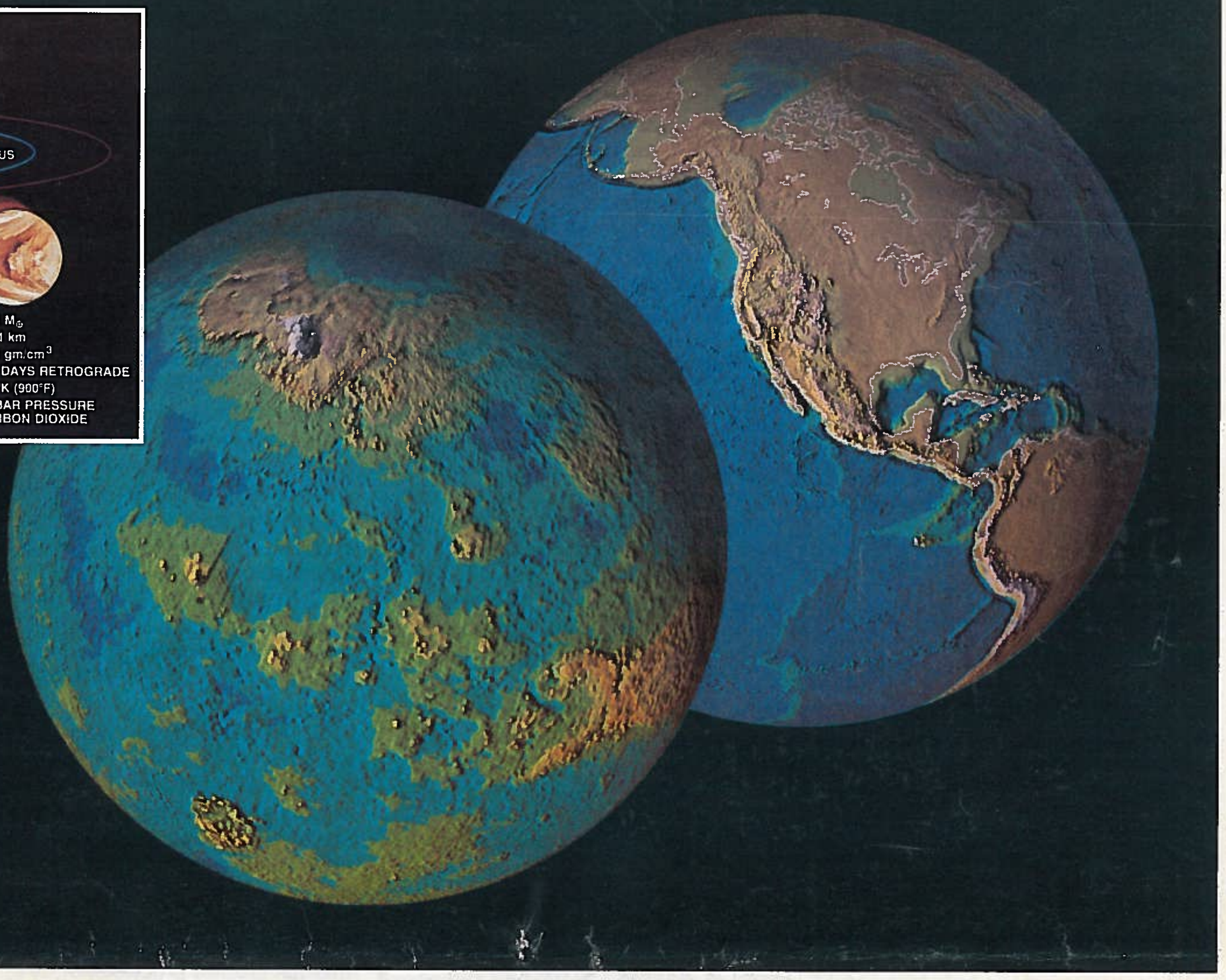


Figure 1. (Upper left) Comparison of major characteristics of Venus and Earth. **Figure 2.** (Right) Computer-generated globes of Venus and Earth. Venus topography is derived from combination of Pioneer-Venus Orbiter altimetry data and Soviet Venera 15/16 altimetry data for northern high latitudes. Darker blue shades are lowest elevations; pink represents highest elevations.

Geology of Venus: A Perspective From Early Magellan Mission Results

James W. Head
Department of Geological Sciences
Brown University, Providence, RI 02912

R. Stephen Saunders
Magellan Project Scientist
Jet Propulsion Laboratory, Pasadena CA 91109

ABSTRACT

The Magellan mission will provide global high-resolution image and altimetry data sets for comparison of geologic processes and history of Venus, Earth, and the smaller terrestrial planets. Images of the first 10%–20% of the surface observed by Magellan show the surfaces to be dominated by volcanic plains, abundant small shield volcanoes similar to seamounts, large local rises capped with volcanic edifices, linear rift zones from which lava flows hundreds of kilometres long emerge, and local steep-sided domes similar in morphology to rhyolite and dacite domes on Earth. Tectonic structures include orogenic belts up to 11 km high, suggestive of extensive crustal shortening and thickening, and a variety of other linear deformation zones showing evidence for shear, shortening, and extension. Circular to elliptical structures 200–1000 km in diameter display concentric zones of deformation and central volcanism, suggesting localized mantle upwelling. The abundance of impact craters is more Earth-like than Moon-like, and the crater ejecta patterns show evidence of fluidized flow. Erosion appears to be of minimal importance relative to Earth because of the lack of water, and the abundance of soils is very low. Where soils exist, there is evidence for eolian activity in the form of streaks and possible dunes. Assessment of global tectonic styles and modes of crustal formation await additional coverage and the acquisition of gravity data.

Introduction

In the past 30 years, exploration of the terrestrial planets has provided us with a perspective on our own planet Earth (Head and Solomon, 1981). Those planetary bodies one-half the diameter of the Earth and smaller (Moon, Mercury, and Mars) are known to be characterized by unsegmented globally continuous lithospheres (one-plate planets), and they have remained largely unmodified since the first third of Solar System history, losing their internal heat by conduction (Solomon and Head, 1982). In contrast to these ancient, relatively unmodified surfaces, Earth presents a dynamic picture of a segmented lithosphere with laterally moving plates and tectonic and volcanic activity linked largely to their creation and destruction. The abundance of water, the significance of aqueous erosion, and the formation of continents also distinguish Earth from these smaller planets. Venus, on the other hand, is very close to Earth in terms of size, density, and position in the Solar System, but it differs in other characteristics, most particularly its atmosphere and surface temperatures and pressures (Fig. 1). What geologic and geophysical processes have formed and modified the surface and interior of Venus, and how do they compare to those of Earth and smaller terrestrial planets? Is Venus Earth's twin, a distant family member, or could it perhaps be similar to Earth as it was sometime in its early history? These are the kind of questions that have motivated the Soviet Union and

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Prepared from contributions from the GSA staff and membership.

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the United States to send spacecraft to penetrate the thick continuous cloud cover of Venus to explore and map the surface by means of orbiting radar experiments and landers. The U.S. Pioneer-Venus and Soviet Venera 15/16 missions provided data on the topography of Venus and revealed that it was unimodal in character, in contrast to the bimodal nature of Earth's global topography (Fig. 2). The Soviet spacecraft also provided images of the northern 25% of the planet (Barsukov et al., 1986), and these data, together with images from Earth-based radio telescopes (e.g., Campbell et al., 1989), showed abundant evidence for volcanic and tectonic activity and surfaces with ages that were more Earth-like (less than about 1 b.y. old; Ivanov et al., 1986) than like the smaller planets. These data resulted in numerous local and regional analyses that set the stage for global questions about Venus and its affinities to Earth (Basilevsky, 1990; Basilevsky et al., 1990; Grimm, 1990; S. C. Solomon and J. W. Head, in preparation).

In response to the obvious need for global coverage with high-resolution images, NASA launched the Magellan spacecraft, which was inserted into orbit around Venus in August 1990, and began systematic global mapping on September 15, 1990. The major instrument on board the spacecraft is a synthetic aperture radar (Saunders et al., 1990; G. H. Pettengill et al., in preparation) that provides images at 120–300 m, considerably better than those obtained previously (Fig. 3). Analysis of the data is being carried out by an international team of scientists from many different institutions.[1] Data returned in the early part of the mission have provided an unprecedented view of the surface. In this article, we describe some of the features and processes that have been revealed.

Volcanic Features

That volcanism is a dominant process in the formation and modification of the surface of Venus is being confirmed by Magellan (Head et al., in preparation). Volcanic plains with a wide variety of surface characteristics make up over 80% of the planet observed thus far. Radar-bright (rough) units with associated flow lobes are seen superposed on dark (smoother) flow units (Fig. 4A; *Note: Figures 4–15 are on p. 58–59*), indicating stratigraphic relations and local sequences of buildup of the volcanic plains. Elsewhere, dark flow units emerge from fractures in the plains, flow downslope, and pond locally in adjacent lows (Fig. 4B). Thousands of small shield volcanoes, generally 2 to 8 km in diameter, with associated summit pits are observed in the plains; local concentrations are quite high (Fig. 4C). These features are similar to terrestrial seamounts and small shields on Hawaii and Iceland. Here too, the sources of the small shields are often linked to structure in the plains, being both superposed on and cut by regional fractures and grabens. Other centers of volcanism are marked by 2–10-km-diameter caldera-like structures with varieties of shapes (Fig. 4D) and evidence for several stages of subsidence and filling (Fig. 4E).

Narrow, sinuous channels about 0.5–1.5 km wide and extremely constant in width have been discovered by Magellan in the volcanic plains of Venus. These sinuous channels commonly do not show evidence for associated flow lobes or lava-flow deposits, and some of them appear to empty into low-lying areas to form widespread plains deposits. In one example (Fig. 4F), a sinuous radar-dark band about 0.75–1.5 km wide extends for hundreds of kilometres and is linked to a fan-shaped area of dark volcanic plains at one end. Details of the rille show what appear to be radar-bright levees and local "breakouts," where the dark material flowing in the interior of the rille has broken through the levees and spilled out to form a new channel. These characteristics are very similar to sinuous rilles on the Moon which are interpreted to have formed when very low viscosity lava or lava emerging at very high effusion rates becomes turbulent and thermally erodes and incises a channel into the preexisting plains deposits. If these structures are of similar origin, the higher surface temperatures on Venus may enhance thermal erosion processes.

In some places volcanism is locally concentrated and edifices have been constructed (Fig. 5A). Sif Mons, a volcano some 225 km in diameter is located on Western Eistla Regio, a broad rise in the Venus equatorial region more than 2000 km across. The volcano itself is characterized by hundreds of radial flow units, which build up an edifice about 1.7 km above the top of the rise. Some of the flows emanating from the vicinity of the summit extend downslope for more than 300–600 km, veneering large parts of the rise and locally flooding radial graben-like fractures (Fig. 5B). This collection of features may indicate the presence of a broad mantle upwelling or hot spot beneath Western Eistla Regio.

In contrast to the Sif Mons shield, an extremely large and deep caldera is observed in the highlands of Ishtar Terra in the northern high latitudes. Located in Lakshmi Planum, a broad volcanic plateau surrounded by orogenic belts, Sacajawea Patera is 200 by 300 km in diameter and 1–2 km deep (Fig. 5C). No shield edifice comparable to Sif Mons is observed in either image or altimetry data, and very few flow features are observed on the rim of Sacajawea. The volume of the depression is between 2.4 and 6.3 × 10^4 km^3, considerably greater than volumes of typical terrestrial calderas. No distinctive single ridge or scarp sharply defines the rim of Sacajawea, and the outer walls are characterized by a wide belt of circumferential, curvilinear grabens, rather than the crests of rotated blocks commonly associated with listric faults on collapsed caldera margins. A rift-zone–like feature extends from the southeast boundary of Sacajawea. Apparently, magma rising from depth reached neutral buoyancy in the upper part of the crust, creating a large magma reservoir. Instead of effusive eruptions contributing to a surrounding edifice as at Sif Mons, magma was predominantly intruded laterally along dikes into the preexisting crust. Continued lateral intrusion caused subsidence of the rim, characterized by broad downwarping which resulted in an annulus of graben structures.

The very high surface atmospheric pressure on Venus will serve to inhibit the exsolution of volatiles as magma rises in the crust. Theoretical calculations (Head and Wilson, 1986) suggest that unless the volatile content exceeds about 2–4 wt%, explosive disruption of the rising magma in the vent will not be favored, and Hawaiian-style pyroclastic activity will probably not occur. In spite of this, there is some evidence for pyroclastic deposits. Dark fragmental materials appear to mantle heavily fractured volcanic plains (Fig. 6) in a few areas. Bright wedge-shaped exposures of underlying plains appear to extend away from small vent-like features within the mantling deposits. These generally are oriented in the same direction and are interpreted to be places where regional Venus winds have encountered areas of local surface roughness (the vent-like areas) causing local turbulence and the sweeping clean of fragmental pyroclastic deposits downrange.

Most volcanic landforms and deposits seen in pre-Magellan image data were interpreted to be related to

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Figure 3. Comparison of resolution of Magellan radar images with previous Venus imaging systems. Magellan resolution is 120–300 m, Venera 15/16 resolution is 1–2 km, and Pioneer-Venus Radar image resolution is 20–70 km. Resolution is simulated using Seasat image of Mount St. Helens.

[1] Raymond E. Arvidson, Washington University; Victor R. Baker, University of Arizona; Alexander Basilevsky, USSR Vernadsky Institute of Geochemistry; Joseph H. Binsack, Massachusetts Institute of Technology; Joseph M. Boyce (Magellan Program Scientist), National Aeronautics and Space Administration; Donald B. Campbell, Cornell University; Merton E. Davies, RAND Corporation; Charles Elachi, Jet Propulsion Laboratory; John E. Guest, University of London; James W. Head III, Brown University; William M. Kaula, University of California, Los Angeles; Kurt L. Lambeck, Australian National University; Franz W. Leberl, Vexcel Corporation; Dan P. McKenzie, Cambridge University; Barry E. Parsons, Oxford University; Gordon H. Pettengill (RADIG Principal Investigator), Massachusetts Institute of Technology; Roger J. Phillips, Southern Methodist University; R. Keith Raney, Canada Centre for Remote Sensing; R. Stephen Saunders (Magellan Project Scientist), Jet Propulsion Laboratory; Gerald G. Schaber, U.S. Geological Survey, Flagstaff; Gerald S. Schubert, University of California, Los Angeles; Laurence A. Soderblom, U.S. Geological Survey, Flagstaff; Sean C. Solomon, Massachusetts Institute of Technology; Manik Talwani, Houston Area Research Center; G. Leonard Tyler, Stanford University; John A. Wood, Smithsonian Astrophysical Observatory; Alexander Zakharov, USSR Institute of Radio Engineering and Electronics.

Penrose Conference Report

Large Lake Systems and Their Stratigraphic Record

Conveners:
Andrew S. Cohen
Department of Geosciences
University of Arizona, Tucson, AZ 85721

Thomas C. Johnson
Duke University Marine Laboratory
Beaufort, NC 28516

Large lakes of the world span all climatic zones and vary significantly in their origin (i.e., tectonic, glacial), chemistry (saline vs. fresh), and response to climatic forcing. Until recently, large lakes have been largely neglected in our analysis of modern environments for the purpose of understanding Earth history or building sedimentological models that can be applied to the study of their ancient analogs. During the past few years however, significant new information has been obtained on the structure and sedimentology of large lakes in Africa, North America, and Asia. Concurrently, there have been exciting developments in the study of ancient lake deposits in such diverse areas as geochronology, basin modeling, Quaternary and pre-Quaternary paleoclimate, and nutrient cycling. A Penrose Conference on Large Lakes and Their Stratigraphic Record was held at North Lake Tahoe, California, Sept. 9–13, 1990, to consider these diverse issues. Our goal was to allow geologists working on ancient lake deposits and geologists, geophysicists, and limnologists working on modern lakes to communicate their interests, problems, and recent results, thus providing a perspective for the formulation of future research directions. The 75 participants (including four students) from nine countries came with a vast array of backgrounds and research interests on lakes and lake deposits, fueling some fascinating discussions between neolimnologists and paleolimnologists.

The meeting was organized around four theme sessions (including keynote addresses, other formal presentations, and poster and discussion sessions) and two field trips. The first day's theme, "Lakes As Small Oceans," addressed the limnological dynamics of modern large lakes and the response observed in their surficial and Quaternary sedimentary records. The diversity of opinion about the extent to which large lakes can even be considered to behave as small, model ocean basins became evident in a provocative keynote address by Dan Livingstone, who voiced the opinion that lakes do not behave like oceans, nor should they necessarily be investigated by means of research methods that emulate those of oceanographers. Lakes record a diversity of environmental conditions and depositional responses which greatly exceeds that of the ocean basins. Furthermore, the relation between the water body and the climate system is completely different in oceans (which largely drive climate) and even the largest of lakes (which primarily *reflect* climate). Livingstone also emphasized the need to generate testable hypotheses of the paleoclimatological signals in lake sediments. Other participants (notably Tom Johnson and Hank Mullins) argued that the geological and geophysical study of modern large lakes must follow the lead of oceanography, albeit at an appropriate scale for interior basins.

The extremely high amplitude and high frequency lake-level fluctuations documented for many African and North American lakes do set them apart from ocean basins, and suggest that stratigraphic modeling of large lacustrine sequences must incorporate somewhat different ground rules from those developed for the continental margins. Lakes are not simply scaled-down ocean basins. They do however, embody many of the depositional processes of oceans in systems that are simplified (and therefore perhaps more easily interpretable) in terms of size and geological history.

Andy Cohen and Tom Johnson discussed the controls on sedimentation in large lakes, mostly from the perspective of the African Rift lakes and the Laurentian Great Lakes. Sedimentation processes and subsequent reworking and erosion conspire to make the stratigraphic record of nearshore environments extremely complex and discontinuous. The transition from nearshore to offshore environments (at approximately 100 m depth in Lakes Malawi, Tanganyika, and Superior, but somewhat shallower in other smaller lakes) involves a profound change in depositional dynamics and facies geometries. However, offshore environments in large lakes can be subject to a wide variety of depositional processes aside from suspension settling (including vigorous turbidity and contour current- and wave-generated deposits, hydrothermal processes, and erosional features), which in many ways resemble those of the continental slope–rise–ocean basin transition. Carbonate depositional processes and the hydrodynamics of anoxia in lakes were covered in posters by Nigel Platt, Paul Jewell, and Bruce Finney. Hans Nelson, Jack Diamond, and Robert Collier reported on recent deep-water investigations of the caldera floor and hydrothermal processes in Crater Lake, Oregon.

Stan Loeb and Bob Osborne discussed their work on physical, chemical, and biological limnology and sediment transport at Lake Tahoe. The research at Tahoe has proceeded against a background of environmental degradation, introduction of exotic species, and general eutrophication within the basin, all the result of basinal development. Numerous point and diffused sources of nitrates along the shoreline can be correlated with excessive benthic algal and (to a lesser extent) phytoplankton growth. A continuous decrease in water clarity over the past 25 years is another manifestation of this problem. Nearshore sediment studies within the lake demonstrate that most sediment movement in this steep-sided basin occurs in an onshore-offshore direction, with little longshore transport or shifting

Penrose *continued on p. 55*

The Congressional Science Fellow Program

Craig M. Schiffries
1990–1991 GSA Congressional Science Fellow

The Congressional Science Fellow Program was created to assist the U.S. Congress in dealing with the growing number of issues it faces with significant scientific and technical components. The program is a cooperative effort of approximately 20 national scientific and engineering organizations. Each organization selects and sponsors one or more professionals who serve as special legislative assistants in congressional offices for one year. The program was begun in 1973, and it is administered by the American Association for the Advancement of Science (AAAS). The Geological Society of America has sponsored a Congressional Science Fellow since 1986.

Congressional Science Fellows serve in the office of a Senator, a Congressman, a congressional committee, or a congressional support agency. The fellows gain firsthand experience about the legislative process, and they make practical contributions to public policy through the application of their scientific and technical knowledge. They communicate to policy-makers the views of scientists, and they communicate to scientists the nature of the legislative process.

The fellowship begins with an intensive orientation program organized by the AAAS. The orientation program, which is highly regarded on Capitol Hill, provides an introduction to the substantive, procedural, and political aspects of public policy. It features meetings with members of Congress and their staffs, as well as briefings at the Congressional Office of Technology Assessment and the Congressional Research Service.

The orientation program is not limited to the legislative branch of government. We met with the Assistant to the President for Science and Technology, the chief of staff of the White House Office of Science and Technology Policy, and representatives from the National Science Foundation, NASA, the Department of Energy, and other executive agencies. We also met with representatives from nongovernmental organizations, including the World Bank and the National Academy of Sciences.

After fellows complete the orientation program, their next step is to secure placement in an appropriate congressional office. The demand for Science Fellows is much greater than the supply. I interviewed with about a dozen personal and committee offices in both the House and the Senate. I considered several attractive opportunities before deciding to serve in the Senate, on the staff of the Subcommittee on Technology and the Law, of the Committee on the Judiciary. The chairman of this subcommittee is Senator Patrick Leahy of Vermont. The subcommittee was created in 1987, and it has never had a scientist or engineer on its staff.

A central goal of the Subcommittee on Technology and the Law is to update our laws so that they keep pace with advances in technology. Many of the subcommittee's activities are designed to promote the competitiveness, technological leadership, and economic growth of the United States. In a future column, I will discuss some of the legislation that is under consideration by the Subcommittee on Technology and the Law.

The Congressional Science Fellows program provides many long-term benefits to the scientific community and to the Federal government. More than 400 scientists and engineers have served as fellows over the past 18 years. Approximately one-third of the fellows have stayed in Washington to continue working in the policy arena. Former fellows currently hold some of the most senior policiy positions in the U.S. Congress. One is chief of staff for Representative Richard Gephardt, majority leader to the House of Representatives. Another is chief of staff for Senator Pete Domenici, ranking minority member of the Senate Budget Committee and the Senate Subcommittee on Energy Research and Development. Former fellows are staff directors—a top policy position—of several of the most important committees in Congress, including the Senate Committee on Energy and Natural Resources, the Senate Committee on Governmental Affairs, the House Committee on Energy and Commerce, and a subcommittee of the House Committee on Science, Space and Technology. Former fellows also hold influential postions in the executive branch. One former fellow is an Assistant Secretary of State, another is an Assistant Secretary of Defense, and a third served as U.S. Ambassador to NATO.

The Congressional Science Fellows program provides an opportunity for scientists to serve in Congress without getting elected. The cost of funding a fellow for a year is easy to measure. The long-term benefits of the program accrue over an extended period of time, and are nearly impossible to measure quantitatively. The fact that many former fellows have pursued highly successful careers in public policy should not be overlooked when evaluating the long-term benefits of the program to the scientific community and to the Federal government. ■

Craig Schiffries is the GSA Congressional Science Fellow for 1990–1991. He is serving in the U.S. Senate, on the staff of the Subcommittee on Technology and the Law, of the Committee on the Judiciary. He can be reached at (202) 224-3406. *The fellowship, which is for a one-year term, is funded by GSA and the U.S. Geological Survey, which supports 47% of the program with a $21,000 grant.*

GSA FORUM

Bruce F. Molnia

Forum is a monthly feature of *GSA Today* in which many sides of an issue or question of interest to the geological community are explored. Each Forum presentation consists of an informative, neutral introduction to the month's topic followed by two or more opposing views concerning the Forum topic. Selection of future Forum topics and participants is the responsibility of the Forum Editor. Suggestions for future Forum topics are welcome and should be sent to: Bruce F. Molnia, Forum Editor, U.S. Geological Survey, 917 National Center, Reston, VA 22092; (703) 648-4120; fax 703-648-4227.

ISSUE: The Future of U.S. Civilian Satellite Remote Sensing

Commercialization of the Landsat program, curtailment of Government subsidies, multiple product-price increases, and increased competition from technologically advanced foreign satellites has put the future of U.S. civilian remote sensing in doubt.

PERSPECTIVE 1: Satellite Remote Sensing—A New Beginning

Murray Felsher, Washington Remote Sensing Letter, Washington, D.C.

In discussing satellite remote sensing (SRS) of Earth—the photography, reconnaissance, surveillance, and monitoring of Earth from space—I will ignore references to the technical aspects of these activities, and concentrate instead on the more pressing problems of institutional relationships. I begin with my conclusion, in order to have you understand, from the beginning, that what I am proposing is not a threat to the existing Federal infrastructure, but rather a means of enhancing both: SRS R&D, which is the very goal of these agencies, and actual applications of satellite remote sensing. My point is that a meaningful applications program provides the only rationale for undertaking an expensive R&D program. In brief, what I am proposing is the creation, by Executive Order, of a new, independent Federal agency, to be called the Space Remote Sensing Applications Agency (SRSAA). By precedence, both the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) were similarly established in 1970 by President Nixon's executive order, bringing together existing Federal assets in related activities hitherto splashed across the Federal landscape.

That is my conclusion and my recommendation. "Indeed," you will say, "Just what we need, another Federal agency." But let me develop the rationale behind this recommendation.

U.S. civilian SRS is tied to the history of the Landsat satellite series. Landsat-1 was launched in 1972, and since then there has been continuous coverage of Earth by this series of sun-synchronous, low-Earth-orbiting, polar satellites. Landsats-2 and -3 were launched in 1976 and 1978, respectively, and Landsats-4 and -5 are currently operating nominally. This sense of technological continuity, however, belies the institutional turmoil that has accompanied the Landsat series and civilian SRS since the beginning. Originally conceived by the National Aeronautics and Space Administration (NASA) as an experimental R&D activity, the Landsat satellites proved their applications capabilities very early in the program. No sooner were the first images returned from the Landsat-1 Multispectral Scanner (MSS), than it was obvious that an important new and sophisticated tool was available to a whole range of users. In fact the immediate applications to such diverse and multidisciplinary areas as mineral and petroleum exploration, environmental monitoring, forestry, land use planning, agricultural crop yield and production forecasting, and coastal zone management, to name but a few, was clearly understood by NASA management. But these very programmatic attributes, as positive as they were, at the same time provided NASA with something of a problem. After all, by its 1958 enabling legislation, NASA was—and is—an R&D agency, chartered to carry on frontier research in aeronautics and space. Fruits of NASA's labors could indeed be undertaken by other operational agencies. But applications of NASA research, such as remote sensing applications, no matter how positive they were, should not, it was felt, drain the budget of NASA itself. So with some not-too-gentle prodding by NASA management during the latter years of the Carter administration, Landsat, by fiat, was declared operational, and as such moved into NOAA, part of the Department of Commerce (DoC). The move to NOAA had less to do with the fact that it was a part of DoC than the fact that NOAA was the home of the long-operational Metsats, the U.S. civilian meteorological satellite program.

Several problems merged at this point. First, the Landsat system was hardly out of the incubation stage, much less operational. Landsat-4, carrying the new Thematic Mapper (TM) was yet to be launched. TM, with its seven spectral bands and 30 m spatial resolution was to augment the MSS sensor flown aboard the earlier Landsats-1, -2, and -3. The four-band, 79 m spatial resolution MSS, though flown three times, was still considered an experimental sensor, and the software to mosaic, merge, enhance, and otherwise analyze and interpret these Earth images from space was still in the earliest stages of development. The second problem was that NOAA, though thoroughly capable and competent in its operation of the Metsat system, a system it had lived with since 1962, had neither the desire nor the personnel to operate Landsat. Further, the Landsat user community was entirely different, in both its constituency and its requirements, from the Metsat user community. Finally, NOAA (rightly) viewed Landsat as a budgetary threat to its own Metsats.

Enter the Reagan administration, and its clearly stated policy decisions and Presidential Directives aimed at moving operational entities out of government and into the private sector. The previous administration's labeling of Landsat as "operational" allowed DoC to lump both the Metsats and Landsats as prime examples of a matured, operational technology ready for commercialization. An immediate outcry, by a well-organized, cooperative NOAA bureaucracy, took very little time to reach the ears of Congress, which acted quickly to prevent the Reagan administration from selling off the U.S. civilian meteorological satellite system. Landsat, however, suffered a different fate. Having neither friends at NOAA nor a unified constituency of outside users, Landsat was put on the block.

A lengthy commercial competition was begun in 1984, culminating with the selection of a vendor, the Earth Observation Satellite Company (EOSAT), to operate Landsats-4 and -5 and to build and operate Landsat-6, then expected to be launched in 1987. EOSAT, jointly owned by RCA-Astro-Electronics and Hughes Aircraft Company, (subsequently acquired by, respectively, General Electric Company and General Motors Corporation), began to do business in the full expectation of continued support by NOAA, as specified in the contract it had signed with the government. However, this promised support began to unravel very quickly, and EOSAT found each NOAA budget a battleground where promised resources seemed to appear, disappear, and reappear at irregular intervals. This quicksand-like, ephemeral situation has done little to enhance EOSAT's marketing campaigns, and its relationship with its customer base has suffered accordingly.

The launch of France's SPOT-1, (Satellite Pour l 'Observation de la Terre), in February 1986, created the first true competition for Landsat and its operator EOSAT. SPOT-1 offered the civilian community 10-m-resolution satellite imagery for the first time, opening up whole new market segments. The successful orbital emplacement of SPOT-2 on 21 January 1990, and the confirmed funding for SPOT-3 and -4 has further demonstrated the continuity of the French activity. This is in marked contrast to the stop-and-go efforts that have marked the entire Landsat commercialization process. The appearance in 1987 of the 5-m-resolution satellite imagery offered commercially by the Soviet Union, the 1989 launch of Japan's MIS-1, and the October 1990 offering of Soviet ALMAZ 15-m-resolution synthetic aperture radar (SAR) data, now serve as further proof that the United States, with its 1960s-technology Landsats, is no longer a leader in civilian satellite remote sensing. It has been a bitter pill for the United States, the country that invented the technology and for 14 years (1972–1986) led the rest of the world in the civilian applications of that technology. The country has abdicated that leadership role, and now purchases space-derived images of the United States from other countries. The message being sent to the user community is loud and clear. The United States is moving out of the civilian SRS business, and users will have to buy any new imagery of Earth from France, Japan, India, Canada, Europe, Israel, the Soviet Union, or from whatever other countries or consortia are willing to launch a remote sensing satellite. This message has been received by these countries with a mixture of astonishment and anticipation.

This, then, is the short and sad history of Landsat ... a story of a technological miracle that has turned into a political and institutional nightmare. It is ironic that the first, largest, and most successful atlas of space-derived Earth images, published in 1974, was entitled "Mission to Earth: Landsat Views the World" and now, some 17 years later, NASA is gearing up for a $35+ billion multi-disciplinary research program for global change measurement entitled "EOS, the Earth Observing System," part of the Mission to Planet Earth program. I emphasize the word "measurement," for reasons noted below.

Long-time followers of U.S. civilian SRS are fully aware of this 18-year random walk that has passed for civilian space policy since launch of Landsat-1. I believe that what is needed now is a wholly new approach—a bold approach that steps back from the numbing institutional constructs and vested interests that to this day have prevented both a U.S. governmental and a U.S. commercial breakthrough in the application of SRS of Earth. We need a new way to look at space-derived data—one that merges our current global environmental monitoring requirements with an institutional mechanism designed to apply the scientific measurements to real problems.

The road from ozone depletion measurements by satellite to interna-

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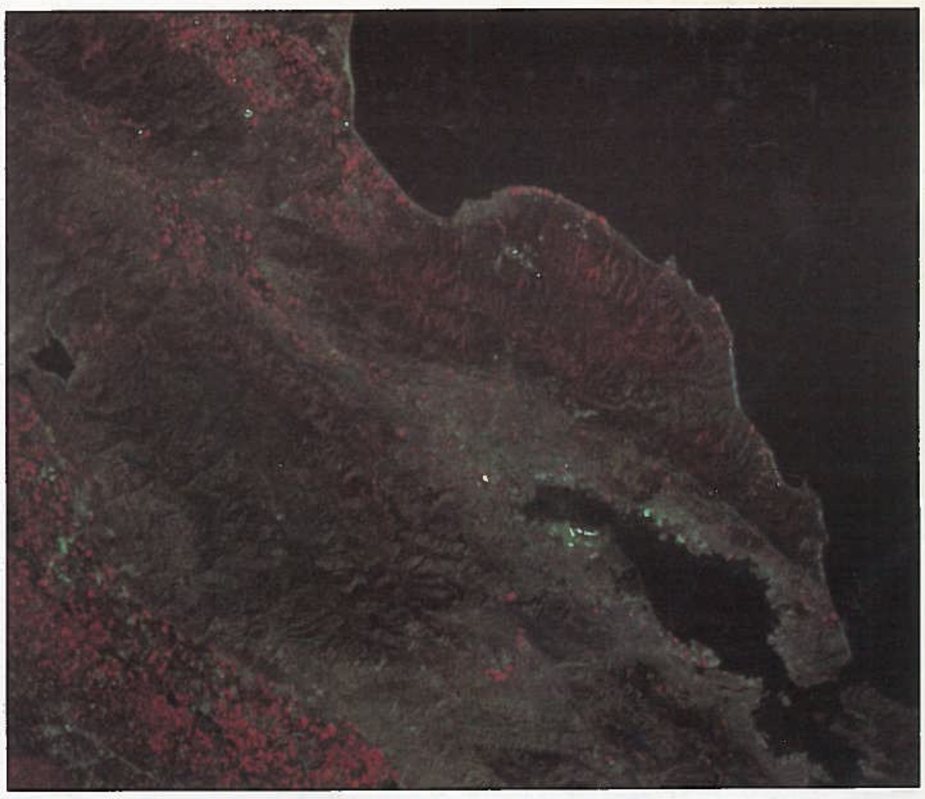

Landsat image of the coast of California from south of Monterey Bay to north of San Francisco. The trace of the San Andreas fault runs diagonally across the image.

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San Diego, October 21–24

GLOBAL PERSPECTIVE

GSA Challenges Geologists to Accept a Leading Role in Finding Solutions to Global Problems

R. Gordon Gastil, 1991 General Chair

Gordon Gastil has a commitment to making this the meeting of global perspective. For the past two years he has encouraged his committee members and GSA staff to concentrate on programs and activities that would contribute to this goal. As you read the Call for Papers that appears in the April issue of *GSA Today*, you will find that within the framework of the technical sessions, field trips, and short courses the primary focus is, in fact, global and environmental.

Look back at the history of American geology: Hall and Dana, King and Gilbert. Their data were important, but it is the people we remember. They and others built a science, societies, and led geological surveys in the movement for national parks. They were not afraid to speak out—geostatesmen, if you will. The acceptance remarks by Fyfe and Newell at the 1990 GSA Annual Meeting in Dallas were in the tradition of geologists who accept a leadership role as citizens. We should meet not just to exchange data, but to interpret our science to everyone. We should let the world know what we have learned, and how it applies to us all. We want you to come to GSA 1991 in San Diego to help us focus on the Earth as a whole, to be part of the solutions to our major environmental problems.

A revolution is occurring in the geologic occupations. Historically, many geologists worked in mineral and energy exploration, and insofar as these industries polluted the environment, geologists were seen by many as handmaidens to some of the worst aspects of civilization. Even the engineering geologist was seen as the lackey of bulldozing development, the diversion of rivers, and the onslaught of freeways. Environmental geology means many things: it means geohydrologists devising ways to clean organic pollutants from aquifers; it means designing building sites that will not slide; it means writing codes that prevent the development of the areas of greatest seismic risk; it means studying paleoseismicity that we can better understand the risks, and warn of earthquakes to come.

With the advent of highly regulated exploration, all geologists become environmental geologists. It is the geologist who must help determine which horizons must not be overpressured if we are to avoid increased oil leakage on the sea floor. It is the geologist who must help devise a plan that will prevent highly toxic mine water from entering the watershed. Not only will we be seen in a different light, but we must see ourselves as protectors, not as apologists. This is the age of ENVIRONMENTAL GEOLOGY, and let this message be sounded loudly.

If we are going to accept the mantle of Protectors of the Earth, let us, as a Society, speak to the broadest possible audience: to at least all of those who have majored in geological sciences, and in a sense, to everyone who has ever completed an introductory course in geology. Recently, I spoke to four of our Masters graduates who are employed as geologists by Union Pacific Resources in Fort Worth. They were unaware that GSA had just had its Annual Meeting in Dallas! They were very disappointed that we had been so close and they had been unaware. Apparently, we are not only failing to interface with the burgeoning new fields of Environmental Geology, we are also failing to interface with traditional geological industry.

Why is this? Is it that we really do not care to "dilute" the scholarly purity of our gathering with those who would be perceived as coming for the "party," to meet old friends, and perhaps promote their consulting business? There is a challenge here. If we broaden our Society, we may well include geologists who have different priorities, but we will also add legitimacy to the claim of being the foremost organization representing the earth sciences. In the past year, in which we have seen advocates of creation science sweeping school board elections across rural San Diego County, believe me, we need representation.

It is the hope of the 1991 San Diego Annual Meeting organizers to appeal to those sectors of the population that have in the past been underrepresented. Let us make the Society, which by its name represents America, reach out to those south of the United States/Mexico border, to students arriving in vans, to young couples with children, to teachers in community colleges and high schools, to the young people working on pollution plumes and grading plans in every city and hamlet across the nation. Ask them to tell us what it is that the Society can do for them.

The nightly news tells of a spreading gap in the ozone layer, of projected climate change due to the greenhouse effect, of projected worldwide rise of sea level, of the recurrent El Niño, of international gatherings to discuss acid rain, of the disruption of vast tropical ecosystems due to clearing followed by erosion. Worst of all, we see the effects of the unbridled burgeoning of human population urbanizing the fertile land, polluting the cities, and destroying the last tracts of unspoiled wilderness. This human juggernaut requires ever-growing natural resources from a planet with a finite supply. It will do us little good in the long run to be self-satisfied, enjoying our relative abundance and security. We all live on the same planet—we must have a global perspective.

Global perspective is not new to earth scientists. Long ago paleontologists determined that the appearances and disappearances of species was a worldwide phenomenon. Plate tectonics was the final demonstration that tectonism produces worldwide chain reaction. And, certainly, we have long been aware of the interaction of oceans, weather, and organisms, which, in turn, are influenced by the dust and gas of volcanic eruption and bolide impact, not to mention the ever-changing locations of shorelines and mountain chains. Now, superimposed on these natural variables are the willful and unconscious activities of the most destructive species of all.

The focus of global perspective is one that we can all appreciate; not only the various segments of our science, but the media and the public. From the layperson's perspective, the brain surgeon, the biologist, and the chemist, wearing white coat and holding test tube, are familiar figures. We propose that the geoscientist, too, be perceived as addressing the problems facing our Earth. Can you imagine a classroom of third graders in which one child puts up a hand and says "I want to be a geologist?"

The opening focus session on Monday morning, October 21, will be: "The Global Challenge: Our Environment, Our Resources, Our Responsibility." The global perspective agenda is much more than an opening session, however. It is our intent to get about 20 specialists together on Sunday afternoon to informally discuss the challenge in private. If there are global problems, and there are, and we are the experts on those problems, what is there that we and our Society should and can do? Then, one evening (yet to be decided) there will be an open session in which the same group will express their thoughts and ask for discussion from the floor.

Following the Monday morning Global Challenge session, three theme sessions will follow on Tuesday, Wednesday, and Thursday mornings, facing, respectively, the topics global climate change, natural hazard abatement, and finite resources for an ever more demanding population. Finally, on Thursday afternoon we will have a rapporteur session in which the highlights of the three theme sessions will be recounted and synthesized. The final wrap-up speaker may also address the accomplishments resulting from the two informal sessions.

A big gamble, no doubt. It is our gamble that sufficient attendees will be concerned and will be interested, and that our speakers will earn their attention. It is our challenge to see that this happens and that everyone concerned—the speakers and the audience participants—will leave San Diego believing that something has been accomplished and that we, as a Society and as individuals, have taken a step forward. When we put to rest the GSA Annual Meeting for 1991, we will enjoy the feeling that WE DID IT—that we started a movement in the right direction. ■

If you would like to respond to Gordon Gastil's thoughts, write to:

Dr. R. Gordon Gastil
c/o GSA Headquarters
Meetings Department
P.O. Box 9140
Boulder, CO 80301

Scientists of the World—Arise

Down my microscope I see,
Or on my computer screen I view,
Or on a sheet of dark gray slate I find
An ammonite, ah to explore—
But wait—
Sit back and comprehend
The earth through windows past,
And present.
Bolides strike and plates collide,
And through it all—four billion years of life ...
And only once
Has history's stride
Been in the reach of creatures
To decide, and that is now.

Hmm, yes, but look at this symplectic crystal growth:
Such magnification,
Such tools
To probe and measure, and
We who seek the history and the cause
Across the landscape of the past, are being asked
To heed the present
And that to come.

Is ours a science of fossils, old?
From data that is frozen, cold?
Or can we see the earth that is,
Crystals that are growing now, and yes
Explore the globe in hope
That we are not too late.
If I, a student of the Earth
Am not concerned—then who?
If now is not the time to act—then when?

Oh beautiful planet—viewed from space
I still hold hope that the human race
Will right your course, steer out the storm.
Reach out and grasp your sister's hand
And form an earth-encircling band—
That together we may stand
As scientists
And as husbands of the soil,
As statesmen, and as those who toil
For the riches yet in store.
That we shall poison less, not more
And live free from the want imposed
On a species overgrown, and
Headed on a course unknown.

R. Gordon Gastil

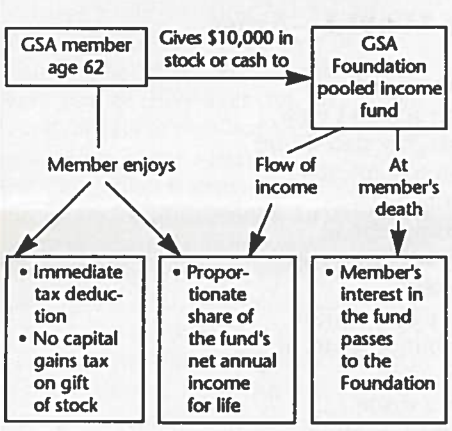
Robert L. Fuchs

The GSA Foundation Pooled Income Fund—Income for Life

A popular estate planning tool, the pooled income fund, is now available to GSA members. The Foundation has established the GSA Foundation Pooled Income Fund, which possesses three main attributes. First, the fund provides an income stream for life to the donor and/or a designated beneficiary such as a spouse. Second, the principal passes to the GSA Foundation upon death, similar to a bequest, enabling GSA to use the money in support of its programs such as research, publications, and education. Finally, the donor receives a tax deduction at the time of contribution to the fund, the actual amount based on actuarial calculations.

The Pooled Income Fund is essentially a GSA Foundation mutual fund in which contributors own individual shares. The Foundation serves as administrator and trustee of the fund, GSA through its Investment Committee oversees the financial policy of the fund, and the Society's money managers and custodians handle day-to-day management and investment of the money.

How the Foundations's Pooled Income Fund Works



An important investment aspect of the Pooled Income Fund is the commingling of gifts from a number of members, in order to minimize investment risk and maximize investment opportunity.

Another benefit of the fund is the annual income stream earned by the investments. Net income after fund expenses is paid to the GSA member contributors in proportion to their respective interests in the fund. This net income will vary each year since it depends on the earnings of the fund's investments. A contributor may designate someone other than himself or herself as income beneficiary.

Upon the death of the participating member, or a remainder beneficiary if any, the remainder interest, that portion of the assets of the fund attributed to that member, passes to the Foundation. Up until then the Foundation does not have title to the member's gift, even though the gift may have been made many years before.

In spite of this delayed transfer of title, a tax benefit accrues to the donor in the year that the gift is made. The actual amount of the tax deduction generated by the gift is based upon the present value of the remainder interest that will pass to the Foundation at the member's death. This present value is calculated from the Fund's historical return. The income beneficiary's age and life expectancy are also entered into the calculation. As one might expect, IRS regulations provide tables to calculate the amount that can be deducted in the gift year. The tax benefit of a gift to the Pooled Income Fund will be less than a direct contribution of cash or securities, but this is compensated for by the lifetime income stream.

The Pooled Income Fund is an excellent way to take present advantage of a tax deduction for a future charitable gift. In the last years prior to retirement, a GSA member may attain peak income levels, with consequent high taxation. The tax benefits are needed in those years, but the asset base is also needed to provide postretirement income. The Pooled Income Fund gives the member a way to arrange personal finances to meet this need, thus resolving the dilemma. An added attraction of the Pooled Income Fund is its appropriateness for gifts in the $5000–$50,000 size range, amounts generally considered too small to create individual remainder trusts.

Contributions to the GSA Foundation Pooled Income Fund will presently be invested in one of the Counsellors Funds, a group of funds managed by the prestigious New York investment firm of Warburg, Pincus Counsellors, Inc. This firm is one of GSA's principal investment advisers, currently managing some $6 million of Society and Foundation assets. Income funds in the Counsellor family of funds include Cash Reserve Fund, Intermediate Maturity Government Fund, Fixed Income Fund, and Global Fixed Income Fund. These funds are invested in fixed income securities, dominantly government bonds and notes, but also including some high-grade corporate obligations. In addition, WP Counsellors manages several equity funds for capital appreciation. WP Counsellors distributes earnings from the income funds directly to the participant at least quarterly.

USGS Employees Cleared To Participate

The USGS has received an opinion from the Department of Interior, Secretary's Office, that the GSA Foundation Pooled Income Fund is considered "an appropriate investment club" for Survey employees. In other words, participation in the Fund does not violate ethics and conflict rules with respect to personal investment holdings.

Should you wish further information about the Foundation's Pooled Income Fund or to discuss its application to your personal financial plans, please call the Foundation office at (303) 447-2020, or mail the accompanying coupon. ■

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*Second Century Club—gifts of $100 or more

Penrose *continued from p. 51*

of petrofacies boundaries. The discussion of these topics was continued on the second day during a field trip around the lake.

"Lake Basin Analysis," the theme for the second day of the conference, generated lively evening discussion about the nature of tectonic and climatic controls on lacustrine stratigraphic sequences and the degree to which deterministic models of basin development can be used to predict lake history patterns. Using the complex history of the Late Cretaceous–early Tertiary foreland lake basins of the western United States as an example, Tom Fouch argued that most ancient lake deposits are, by their very preservation, atypical systems. Lakes with an excellent stratigraphic record, which persist for long periods of Earth history, therefore may be telling us as much about profound disruptions in Earth's crust as they are about the climatic controls on lake development. Bill Bosworth synthesized much of the recent developments in understanding the structural controls on rift basin development. He proposed that most are probably underlain by a basal detachment fault, which in turn regulates the gross asymmetry in rift-basin tectonics and deposition. The precise position of a detachment fault as it intersects the earth surface probably regulates the position of accommodation zones (which segment rift basins), and reversals in half-graben polarity. Bosworth and Joe Lambiase argued that when viewed over the entire basin history, rift lake development and sedimentation may follow a predictable path controlled largely by structure and only secondarily by climate. The interplay of tectonic and climatic history in determining patterns of lacustrine deposition also figured in several of the poster presentations (Thomas Kreuser, Alan Carroll).

Much of our understanding of the relation between structure and stratigraphy in lake basins has come about by way of the vastly improved quality of seismic data (both high resolution and multichannel) recently available for both ancient lake deposits and modern lakes. The 5000 km of multifold reflection data obtained by Project PROBE in the African Rift lakes has demonstrated the utility of a sequence stratigraphic approach to understanding basin architecture, in a fashion analogous to continental margins (Chris Scholz). Important differences between the two environments are evident however, in the rarity of progradational packages and downlapping terminations within the rift lakes in comparison with the oceans. New seismic and core data from Lake Baikal obtained by Steve Colman and Doug Williams were also the subject of much discussion. In the case of the glacial lakes of New York and Canada, Hank Mullins showed how an integration of seismic, piston and drill coring, and down-hole geophysics can be used to infer both glacier development and lake history. Glacial-erosional surfaces and depositional features associated with glaciation are readily imaged below postglacial lake deposits. Dave Rea and Ted Moore presented a poster on seismic profiles and side-scan sonar records from northern Lake Michigan which showed large circular depressions that may result from the last deglaciation. Marcel Oullet displayed high-resolution seismic profiles from lakes in Quebec that indicated considerable disruption of stratigraphy by dewatering of glacial sediment and the effects of earthquakes.

Under the rubric of the third day's theme, "Deciphering the Lake Record," conference participants looked at recent geochemical, geophysical, and sedimentological developments in the analysis of lake deposits. Mike Talbot, in his keynote address, discussed the interpretation of C and O stable isotopic data from lakes. Patterns of covariance between ^{13}C and ^{18}O data may be useful indicators for distinguishing closed-basin from open-basin conditions. Complimentary data about ancient lake conditions may be derived from ^{15}N analyses, which appear to be linked to patterns of nutrient cycling and nitrogen fixation. Thure Cerling reviewed the cycling of major ions in lake basins. He showed, with data from Lake Turkana, Kenya, how mass-balance studies can be used to infer patterns of solute evolution and water-sediment ionic exchange in large closed-basin lakes during the late Quaternary. Advances in understanding the organic geochemistry of lake deposits were reviewed by Lisa Pratt. Unraveling the carbon cycle in lakes and its effect on organic carbon deposition has been difficult because of the myriad of processes affecting this cycle. Better understanding of the meaning of biomarker data as well as new developments in gas chromatography and mass spectrometry techniques hold great promise for resolving this problem. Case studies utilizing both organic and inorganic geochemical techniques in paleoenvironmental and diagenetic analyses were presented as posters by Elaine Kennedy, Gary Isaksen, George Smith, Berry Lyons, Patrick Ng'ang'a, Rick Sanford, Mary Rose Cassa, and Tim McHargue. In Precambrian, nonfossiliferous strata, a combination of sedimentological and geochemical approaches may help differentiate lacustrine from marginal marine strata to a skeptical public (Lisa Pratt, Don Winston).

Lake statigraphers now have a wide variety of chronostratigraphic tools at their disposal (Ken Verosub, Glen Berger). Wherever possible, stratigraphers should use several independent methods and assume, in making age and rate interpolations, that the lacustrine record is likely to be replete with gaps.

"Lakes and Global Change" was the theme for the final day of talks. In his keynote address, Kerry Kelts noted that the lacustrine record offers the best combination of resolution and duration for unraveling a record of climatic change, effectively providing us with high-resolution historical experiments (particularly for the late Quaternary). The climate archives recorded in lake sediments can provide a record of environmental change of human (i.e., in decades) dimensions, as well as providing high-resolution windows onto changes that have occurred over longer time scales. Isolating the former from the latter is particularly important as we seek to understand the ecodynamics of abrupt climatic change. Extremely high resolution stratigraphy, even of annual events, can be established from lake deposits by using varve chronologies. Roger Anderson showed how varying decade- to century-long cycle patterns can be inferred from a wide variety of lake deposits, including many of pre-Quaternary age. An extremely broad global spectrum of lake deposits, now being documented by Beth Gierlowski-Kordesch and IGCP 219 (a cosponsor of this meeting) is available for the analysis of historical experiments.

The theme of historical experiments in lakes was echoed by Paul Olsen in his presentation on the relation among basin evolution, orbitally forced climate dynamics, and patterns of ecological and evolutionary change in lakes. In the Triassic-Jurrassic rift lakes of eastern North America, rates of ecosystem development can be estimated from numerous depositional cycles. Faunal turnover caused by limnological or evolutionary change in lakes was also the subject of posters by Ed Theriot, Collette Burke, and Rick Forester.

The Pleistocene lakes of western North America provide an opportunity to investigate the relation between climate change and lake-level fluctuations in a diversity of complex hydrologic systems. Larry Benson, Fred Phillips, and Platt Bradbury showed how the lake systems of the Great Basin have responded in differing fashions to climate change, as a response to variations in their influent and linkage patterns. A detailed record of paleolimnologic change in the Great Basin, aided in particular by the paleoenvironmental and biostratigraphic analysis of pollen, ostracodes and diatoms, has now been pushed back well into the pliocene (David Adam). As the poster sessions demonstrated, high-resolution records of environmental change from lake deposits using these and other techniques are also available for many other time periods and parts of the world (Margaret Jenks, Russell Dubiel, Lee Coshell, Mark Newton, Kenneth Campbell, Steve Colman, Rick Forester, Qi Huang).

The complexity of controls of the global climate system on lake levels and lake-basin development provided the theme for the final two papers by Marty Perlmutter and Alayne Street-Perrott. Urging the audience to "drop your paradigms," Perlmutter argued for a cyclostratigraphic approach to interpreting climate belts. Changes in the latitudinal development of lakes in the past may be less a function of changing tectonic configurations than of orbitally forced changes in the positions of the polar and Hadley cells. Thus, some lakes may have formed in the past under conditions of precipitation, insolation, and evaporation which have no precise analog in the modern climate regime. Street-Perrott discussed the linkage between North Atlantic Ocean circulation patterns and abrupt lake-level fluctuations in Africa. Variations in the linkages among ocean salinity, deep-water thermohaline circulation, and cross-Atlantic heat transport conspire to radically alter precipitation patterns in the tropics and subtropics, forcing lake levels to change extremely rapidly.

High-frequency lake-level excursions were again the theme of the last day of the conference—this time in the field, at Mono Lake. The field trip, run by Scott Stine, concentrated on the evidence for lake-level fluctuations during the late Pleistocene and Holocene and provided participants with a final opportunity to thrash out the questions of climate vs. tectonic controls on lake-basin development.

Acknowledgments

We thank Chevron, Exxon, and Amoco Oil Companies for their generous donations toward this conference. ■

Penrose Conference Participants

David P. Adam
Roger Y. Anderson
Paul A. Baker
Larry Benson
Glenn Berger
William Bosworth
J. Platt Bradbury
H. Paul Bucheim
Collette Burke
Ken Campbell
Alan Carroll
Mary Rose Cassa
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Randell Moory
Henry T. Mullins
Hans Nelson
Mark Newton
Patrick Ng'ang'a
Paul Olsen
Robert Osborne
Marcel Ouellet
Charles Oviatt
Martin Perlmutter
F. Alayne Street-Perrott
Fred Phillips
Nigel Platt
Lisa M. Pratt
David K. Rea
Richard F. Sanford
Michael R. Rosen
Christopher A. Scholz
John Sexton
George I. Smith
Michael Soreghan
Scott W. Stine
Michael R. Talbot
James T. Teller
Edward Theriot
Christine E. Turner
Kenneth Verosub
Douglas F. Williams
Don Winston

CORRECTION: Rocky Mountain–South-Central Sections Meeting

Three symposia were not listed in the final announcement of the Rocky Mountain–South-Central Sections Meeting in the February issue of *GSA Today*. They are as follows:

Pennsylvanian and Wolfcampian Cyclic Sedimentation in the Ancestral Rocky Mountains and Ouachita-Marathon Foreland. Gary Smith, University of New Mexico; Thomas Yancey, Texas A&M University.

Coalbed Methane in the San Juan Basin. Walter Ayers and Stephen Laubach, Texas Bureau of Economic Geology.

Plate Margin and Foreland Deformation: The Ouachita Orogeny and Ancestral Rocky Mountains. Kent Neilsen and Kristian Soegaard, University of Texas at Dallas.

Forum *continued from p. 52*

tional regulations regarding uses of chlorofluorocarbons must first pass through an agency both willing and able to accept space-derived data, to understand the data, to enhance the data, and to transform the data into cogent information. Optimally, the agency would combine that information with other pertinent non–space-derived information, press the resulting knowledge against existing laws and regulations, and then provide the appropriate regulatory and operational agencies with graphics, numbers, text, options, and recommendations. We need such an agency. No such agency exists today.

NASA, as an R&D agency, is recognized worldwide as the premier space research institution. The glory that is NASA is perhaps best exemplified as it develops and flies instruments to construct a baseline archive of accurate and precise scientific measurements. These measurements can be made looking outward to space, or inward to Earth as envisioned by the EOS sensor suite scheduled to fly by the turn of the century. NASA is not an applications agency. We do not have an agency that translates scientific numbers into operational imperatives. I believe that the information that has been and that will be derived from space imagery is the foundation for global environmental health and for global peace and security. In briefings to technical societies, the National Space Council (NSC) and the Congress, I have urged the establishment of a new, independent SRSAA, and I now call upon you, as professional geologists, to support this concept. SRSAA would accept R&D from the U.S. Geological Survey (USGS), NASA, NOAA, the Department of Defense, the National Institute of Standards and Technology (NIST), the National Institutes for Health, and the National Science Foundation (NSF). SRSAA would serve as the government's institutional focus for all applications and problem-solving using space-derived data. The agency would be chartered to apply satellite remote sensing research to real Earth activities and problems, and to serve in support of a growing SRS industry. Neither of these are goals and objectives of any existing Federal agency.

No longer would space remote sensing applications be in direct competition with space basic research for resources. No longer would the building of instruments and the taking of measurements be ends in themselves in satellite remote sensing. Federally supported basic R&D in remote sensing would still be the seed, but the seed wouldn't fall onto bureaucratic concrete; rather, it would germinate and grow and, together with commercial spinoffs, would thrive.

The new agency would bring together from existing agencies those Federal civilian programs, organizations, personnel, and assets that are currently engaged in the application of satellite remote sensing. Remote sensing applications do span the breadth of the Federal government, so a considerable base of such activities already exists in many agencies. The fact that each of these activities is submerged within its own bureaucracy accounts for the reality that they are relatively unknown and their impact has been substantially attenuated over the years. Like the applications themselves, the appliers are spread widely but thinly. Thus, it is not without some difficulty that I have been able to identify specific remote sensing applications units that are now in existence in the following departments and agencies. I recommend that these programmatic entities be drawn together to form the core of a new national agency for applications of space remote sensing: *From the Department of Agriculture*—units within the Agricultural Research Service, Economic Research Service, Forest Service, Foreign Agricultural Service, and Soil Conservation Service; *from the Department of Commerce*—units within the Bureau of Census, NIST, and NOAA; *from the Department of Energy*—units within the Conservation and Renewable Energy Office; Environment, Safety, and Health Office; Fossil Energy Office; International Affairs and Energy Emergencies Office; and Energy Research Office; *from the Department of Health and Human Services*—units within the Public Health Service; *from the Department of the Interior*—units within the Bureau of Indian Affairs; Bureau of Land Management; Bureau of Mines; Bureau of Reclamation; Office of Surface Mining, Reclamation, and Enforcement; Minerals Management Service; National Park Service; U.S. Fish and Wildlife Service; and USGS; *from the Department of State*—units within the Bureau of Intelligence and Research. There are also specific programs and units of independent agencies: EPA, Federal Emergency Management Agency, NASA, NSF, Tennessee Valley Authority, and U.S. International Development Cooperation Agency.

Attempting to reorganize the government is never a trivial undertaking. Attempting to do so at this scale and across so many departments and agencies is at once intimidating and challenging. But I believe that this action is vitally necessary if the United States is to:

(1) have a viable civilian presence in the area of space remote sensing;
(2) reclaim its international leadership role in space remote sensing;
(3) justify its enormous investment in its Mission to Planet Earth and Global Change programs, turning them from pure technological research to meaningful problem-solving applications.

I believe that the time has come for innovation and boldness. An independent SRSAA will allow us to finally move past the acquisition of space-derived data for its own sake to the application of space-derived information "for the benefit of all Mankind."

PERSPECTIVE 2: Landsat: The Key Space-based Component of the U.S. Global Change Research Program for the 1990s

Richard S. Williams, Jr., U.S. Geological Survey, Reston, Virginia

Introduction

Scientists and decision-makers involved in many aspects of global change research, including those associated with NASA's Mission to Planet Earth program, have a rapidly growing and unmet need for access to affordable past, present, and future satellite image data which has been, is being, and will be acquired on a global-scale, systematic, and repetitive basis. The need for such data is *not* being met by the current or planned space program, although the initial objective of the Landsat program was clearly designed to do so.

There is also a compelling scientific need, in support of two very large national and international research programs (U.S. Global Change Research Program–International Geosphere-Biosphere Programme and NASA's Mission to Planet Earth program to: (1) provide easy access for all scientists and other users to past, present, and future satellite image and photographic data, both civilian and declassified military and reconnaissance, and (2) orbit a 10-m-pixel resolution, stereoscopic imaging satellite to acquire a basic global dataset of the topography of Earth (image and digital) and to provide, on a continuing systematic basis, repetitive coverage of the land and shallow-sea areas of our planet.

Many scientists believe that the U.S. Government should adopt the USGS or similar design for a 10-m-pixel, 180-km-wide swath, 910 km orbit, multispectral (downward-looking), panchromatic (fore and aft), convergent stereoscopic (along orbit), linear array–type mapping satellite (e.g., Landsat-7). Data acquired by Landsat-7 will provide a global dataset of stereoscopic image and digital topographic data for most of the land and shallow-sea areas (except regions poleward of about 81°N and S latitude). The mapping spacecraft would be managed by the U.S. Government with the objective of providing a global dataset of stereoscopic image data and digital topographic data, suitable for the compilation of 1:25,000-scale topographic and image map bases and digital topographic information of commensurate horizontal and vertical accuracy.

The U.S. Government should restore the Landsat program to its initial promise ("For the Benefit of All Mankind") and global mission: the systematic and repetitive acquisition of multispectral image data of the land and shallow-sea areas of our planet at an affordable cost (cost of reproduction and distribution). This requires that the Landsat program be decommercialized as soon as possible and that operation of the spacecraft, especially data-acquisition objectives, and data archiving, processing, and distribution be returned to appropriate Federal control and operation.

The systematic, repetitive acquisition of 10-m-pixel-resolution multispectral images of the land and shallow-sea areas of Earth and the ready accessibility and affordability of such data to the scientific community are vitally needed to support various aspects of the U.S. Global Change Research Program, including NASA's Earth Observing System (EOS) space-based component. The data are especially important to the latter program because it represents an already operating part of an EOS and will be needed even after other instruments designed for the EOS program are placed in orbit later in this decade.

Landsat data provide a nearly complete image record of the land and shallow-sea areas of Earth from mid-1972 to about 1976, but only sporadic, nonsystematic coverage is available since that time. Since "commercialization" was adopted in 1985, image acquisition has been based on commercial rather than scientific reasons, and systematic, repetitive global coverage has been deleted from the Landsat capability. The global repetitive acquisition of images by the Landsat series of spacecraft provides global change data superior in systematic coverage to image data produced by any other satellite, past or planned, or civilian or military reconnaissance.

Key Points

1. In September 1966, USGS Director William T. Pecora and Secretary of the Interior Stuart L. Udall initiated a bold series of steps with NASA and other U.S. government agencies to launch the first Earth Resources Technology Satellite (ERTS-1), in July 1972, to map and monitor changes occurring on Earth's surface "For the Benefit of all Mankind." Their vision and that of their supporters provided the initial impetus for what has evolved into the space-based component of the U.S. Global Change Research Program, because it provided an objective means by which scientists and decision-makers could directly document changes on Earth's surface in response to natural and/or human-induced processes. Because of the critical importance of Landsat data to the U.S. Global Change Research Program, the goals originally enunciated for ERTS-1 are even more valid today, and should be reaffirmed by the United States.

2. Landsat is the *only* existing or planned series of spacecraft, U.S. or foreign, civilian or military, that has the capability to effectively document, at a useful spatial resolution, changes that are occurring at Earth's land surface in response to human activities or to natural processes. None of the many instruments proposed by NASA for their EOS can compete with Landsat. The spatial resolution of MODIS is too coarse; HIRIS covers too limited an area on the ground. Therefore, Landsat will still be needed during the EOS era and should be considered as an essential part of NASA's Mission to Planet Earth program. The French SPOT program acquires higher resolution (10 m) data, including some stereo data, but SPOT was not designed to systematically acquire images of all land areas of Earth on a repetitive basis. A SPOT image covers 1/9 the area of a Landsat image. SPOT's panchromatic spatial resolution is about three times better than that of multispectral Landsat TM data. Soviet Soyuzkarta data (images and photographs) provide limited, nonrepetitive coverage of Earth. Some of the photographs have 5-m-spatial resolution or about six times better than Landsat TM data. The U.S. military and intelligence satellites are designed for very high resolution coverage of limited areas. Aside from the access and use limitations resulting from the security classification, the data have only limited value to scientific studies associated with global change.

3. Imagery from Landsat-4 and -5 provides continuity of data from Landsat-1, -2, and -3 which encompass a period of more than 18 years. Landsat -6 and -7 will be the next in the series. Landsat-7 should be a revolutionary spacecraft, the first satellite, civilian or military, specifically dedicated to systematically acquiring stereoscopic image data of the land and shallow sea areas of our planet.

4. The existing archive of Landsat data (more than 2.7 million scenes on file) at the USGS EROS Data Center (EDC) provides an irreplaceable source of information to support myriad ongoing and planned global change programs. The importance of the Landsat data archive to global change derives from its use as baseline information about land use, coastlines, glaciers, vegetation, etc., against which present and future changes can be measured.

5. Neither the weather satellites nor the military intelligence satellites are commercially viable. Why, then, should Landsat be the only satellite in the U.S. space program that must meet such a patently arbitrary requirement? Are not global change data equal in value to data from these other satellite

Forum: *continued on p. 67*

SAGE REMARKS

Allison R. (Pete) Palmer

Opportunities for Partnering—Check Your ZIP Code

We are beginning to receive some Partners for Excellence application forms in the mail from teachers interested in partners. Until we get our partnering database set up, I will use this column to attempt to find partners for these teachers. Teachers in the following ZIP code areas would like to find partners. If your ZIP code matches the first 3 digits and you want to partner, let me know and I'll put you in touch with the teachers.

Northeastern Section	
Delaware	19810
North-Central Section	
Wisconsin	53220
Illinois	60137
Illinois	60634
Missouri	63010
Southeastern Section	
Virginia	24038
Alabama	35405
Cordilleran Section	
Nevada	89015
California	90056

More on Creationism

The following thoughtful opinion was sent in by E-An Zen as an extension to my remarks in my column last June. (I also received some comments from some of my geological old-Earth creationist colleagues, to whom I've responded individually.)

"If scientists construct a wall that cuts off meaningful communication with the creationists, we can expect a wall constructed against scientists in return. Polarization does not promote understanding. As scientists, we assume that the origin and working of the physical universe can be comprehended only with inferences ultimately based on observations of nature; we do not accept or tolerate the idea of possible intercession in the workings of the universe by supernatural causes. I believe this is a good and valuable working assumption, but I must not forget that it is only an assumption. While we can corroborate its usefulness in individual cases, we have no way to independently verify its general validity and thereby to exclude other views of how the universe works.

"Creationists, both the "young Earth" type who insists on a literal reading of the Bible, and the "old Earth" type who accepts the antiquity of the Earth and the universe but thinks Divine or Intelligent Guidance gave rise to life as we know it, challenge the exclusivity of the scientists' basic assumption. Obviously, we cannot refute their viewpoint logically by our assumption. The "young Earth" creationists damage their own credibility when they selectively reject or accept facts (e.g., accept the Second Law of Thermodynamics but reject the constant rate of decay of radioisotopes), or torture the data to fit preconceptions (e.g., misinterpret the rock records to conform to the Noachian flood story). While we rightly deplore these affronts, we would be committing comparable affronts if we extrapolate scientific inferences to areas of human knowledge where they are invalid (e.g., to claim that our observations prove that there is no God). Realization that our work is founded on an unprovable assumption, that is, on faith, should make us humble, and make us listen as well as propound.

"As scientists, we might prefer everybody to see the world the way we do, but the goal of education should not be philosophical conformity. Rather, it should initiate interactive discourse, however bizarre we think the other viewpoints are. Aside from practical, functional literacy, a main goal of science education should be to understand what the scientific method is all about. The splendor of science lies in our method. Scientists are generous to a fault: we deliberately invite the world to examine our hypotheses and find fault with them (i.e., falsify them). Creationists are exercising that prerogative at a very basic level; if we keep our minds open, we stand to benefit from this debate because the creationists can provide us with a different, challenging if jarring, mirror with which to view ourselves."

E-an Zen

Mind Boggles

Many topics related to the Earth and some of the issues that we talk about can be developed from a base of mind boggles. Deep time is one of the most important and was dealt with in our video "The Earth *Has* a History." Here are a few more that have come to mind. If you have any good ones, let me know.

- Do you realize that a global population growth rate of only 0.2%/year (not quite ZPG) will result in an octupling of the world population in about 1050 years? A similar span of time the other way gets us not quite back to the time of Mohammed. Who wants eight times the present garbage or traffic?
- How many students realize that the K/T bolide, when scaled to the size of your 16" office globe, would approximate a grain of silt? It's amazing what that little silt grain may have accomplished.
- How many students realize that the roughness of the paper on that same 16" globe is comparable to the relief on Earth's surface scaled to this size. In a cosmic sense, getting to the top of Mt. Everest isn't getting very far.
- How many students realize that the 10 km K/T bolide would have gone only half-way under water in most of the world's oceans before striking bottom? Not unlike a pebble in a puddle.
- How many students realize that the "cataclysmic" collisions of plates take place at rates similar to fingernail growth rates, and those are fast geologic rates. Remarkably, though, tectonics is far from boring. ■

Venus *continued from p. 50*

basaltic volcanism. Magellan data have revealed some structures and edifices with characteristics that suggest the presence of magmas with higher effective viscosities and/or more acidic compositions. A group of seven steep-sided volcanic domes located east of Alpha Regio (30°S, 11°–13°) show these characteristics (Fig. 7). Each of the domes is about 25 km in diameter and hundreds of metres high, and relatively flat-topped. The steep slopes are very rough and have radial fractures, and the summit is characterized by a polygonal network of concentric and radial fractures and small grabens and by central craters. The general morphology of these domes is very similar to extrusive domes of viscous magmas (rhyolitic, dacitic, andesitic) seen on Earth in association with continental volcanism and large calderas (e.g., Mono Lake, California; Valles, New Mexico). Terrestrial domes are characterized by both endogenous activity (magma intruded internally, causing expansion and growth of the dome) and exogenous activity (breakthrough of flows or small extrusions, and explosive activity due to gas buildup), and both types of activity are seen on the Venus domes. The relatively large diameters of these domes may be due to the high surface temperatures on Venus, which would retard cooling of extruded magma and enhance radial flow distance. At present, it is not known if these represent more acidic compositions and, if so, whether such compositions represent a major component of the crust of Venus.

Tectonic Features

A wide variety of tectonic activity disrupts the abundant volcanic deposits and edifices on Venus (S. C. Solomon et al., in preparation). Some areas of volcanic plains are completely laced by polygonal faults and fractures (Fig. 6), and in some places they are extremely regular and essentially orthogonal in orientation (Fig. 8), almost resembling a perthitic texture. In this example, the fainter lineations are spaced about 1 km apart and are less than a few hundred metres wide. The orthogonal set is brighter, wider, more irregular, and slightly more widely spaced, and appears more dominant. Several members of this set appear to be flat-floored grabens. The origin of such widespread regular deformation is not known.

In other places, deformation is concentrated in linear belts rather than distributed throughout the plains. One type of linear deformation belt is characterized by ridges and broad arches. In the example shown in Figure 9, the smooth volcanic plains are disrupted by north-northwest–trending narrow ridges and a broad arch about 5 km wide. These features are very similar to ridges and arches formed in the lunar maria during loading and subsidence, and they represent small amounts of crustal shortening and buckling. Other linear deformation belts are characterized by narrow parallel and anastomosing fractures and grooves that appear to be of extensional origin. One example (Fig. 10) shows three such belts of features, each separated by about 25 km. The two scales of deformation may be linked to brittle deformation of the upper part of the crust (small features), and broader scale deformation of deeper crustal materials (the belts themselves).

The presence of large circular features on Venus known as corona was revealed by Venera 15/16 and Arecibo images (Pronin and Stofan, 1990). These features, 200 to 1000 km in diameter, are characterized by an annulus of ridges, an exterior moat sometimes filled with lava flows, and interior deformation and volcanism. They are thought to represent the surface manifestation of mantle upwelling (perhaps hot spots). Such a feature may be more readily distinctive and visible on Venus because of the higher surface temperatures and a relatively thinner outer rigid layer there. Magellan data revealed significant details of Quetzalpetlatl, an 800–1000-km-diameter corona in northern Lada Terra seen first in Arecibo data (Fig. 11A). The central part of the corona is seen to be a distinctive volcanic caldera, 150 km wide, 200 km long, and 400 m deep, with a family of associated domes, small shields, and cones (Fig. 11B).

Perhaps the most spectacular tectonic features known on Venus are the orogenic belts of Western Ishtar Terra. These are known from pre-Magellan data to be as much as 1000 km long, several hundred kilometres wide, and more than several kilometres in elevation, and were interpreted to be characterized by folds, low-angle thrusts, and strike-slip faults (Crumpler et al., 1986). The high-resolution Magellan data reveal complex structure within the mountains, particularly showing evidence for extensional deformation superposed on the structure of the mountain belts. One prominent example is seen along the eastern margin of Freyja Montes, a mountain belt at the northern edge of Western Ishtar Terra (Fig. 12). Here, the higher parts of the mountains (a region about 70 × 125 km) are laced with 1–5-km-wide graben. Some graben are parallel to the crest of the mountain, while others are parallel or subparallel to the surrounding slopes. Along the lower flanks of the high region, large- and small-scale folds and thrusts dominate. This collection of features is consistent with gravitational collapse of the mountains.

One of these belts, Maxwell Montes, rises up to 7 km above the adjacent plains and 11 km above mean planetary radius. In Figure 13, the westernmost edge of the radar-bright Maxwell and the distinctive ridges that make up much of the mountainous terrain are visible. The ridges are thought to be of compressional origin, and adjacent to the western edge of Maxwell, the dark volcanic plains of Lakshmi Planum are seen to be deformed in parallel ridge-like fashion. Maxwell Montes is asymmetric in cross section. This side of the mountain is one of the steepest slopes yet known on the planet, with elevations rising several kilometres over a distance of less than 100 km. The presence of these mountains and the implied crustal thickening suggests significant crustal shortening localized along these zones, although the mechanisms of formation and the amount of shortening are not known. The fact that they maintain such high elevations strongly suggests that the forces that formed them have been active in the recent past and perhaps are still active today.

Impact Features

On the eastern slope of Maxwell Montes near the crest is a 100-km-diameter circular feature, known as Cleopatra, that is 2.5 km deep (Fig. 14). Previous data could not resolve conclusively whether Cleopatra was of impact (Basilevsky and Ivanov, 1990) or volcanic (Schaber et al., 1987) origin.

Venus *continued on p. 60*
Figs. 4–15 on p. 58–59

Views of Venus

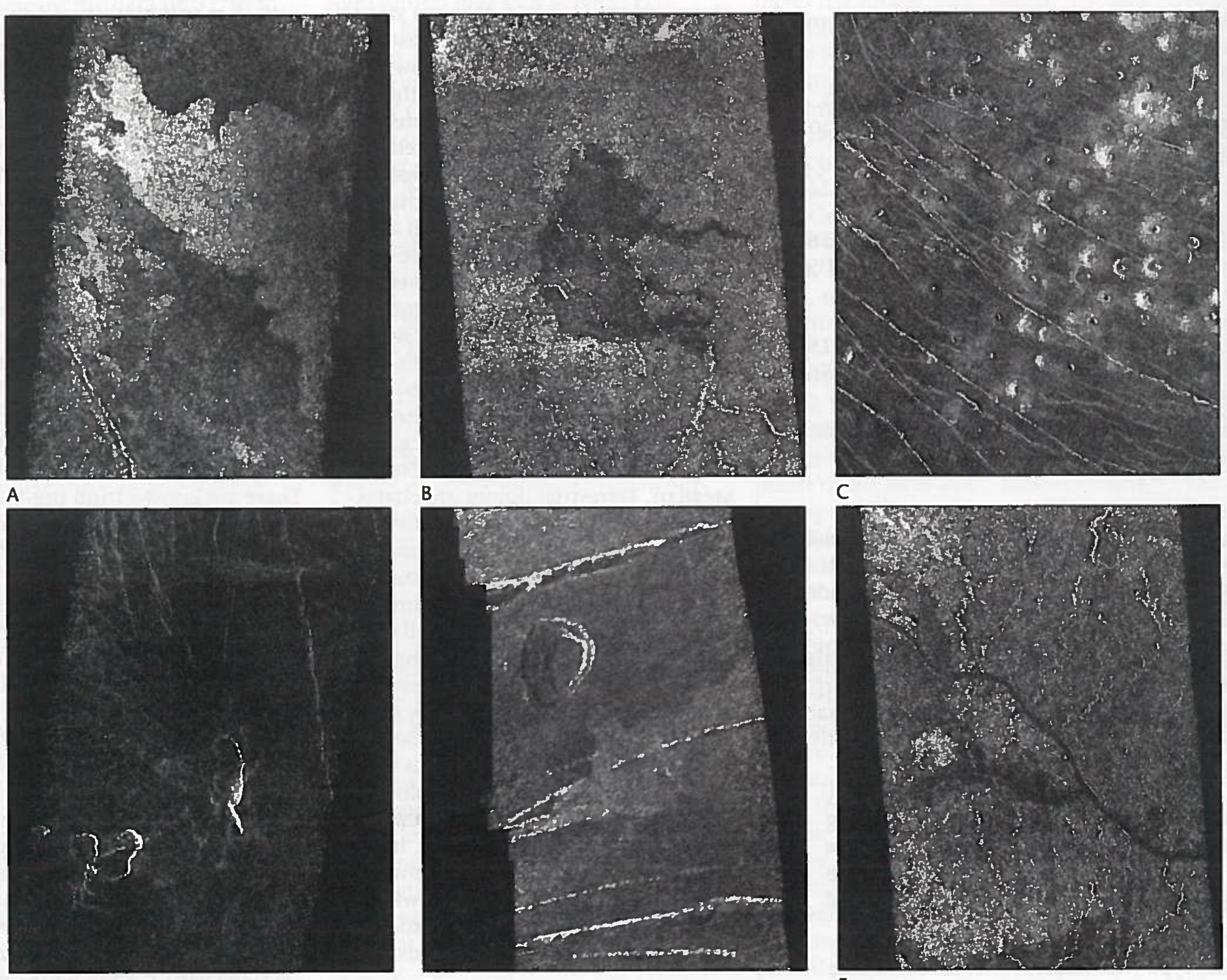
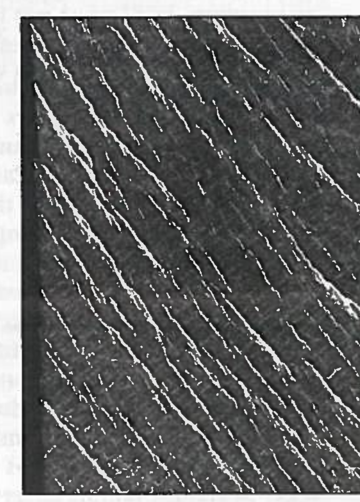


Figure 4. A: Radar-bright (relatively rough) lava flow superposed on radar-dark plains near Phoebe Regio (291°, 20°S). Width of image is 30 km. B: Radar-dark (relatively smooth) lava flows emerging from several sources along a fracture (bright, discontinuous line) and coalescing and ponding in adjacent low part of plains in southern Guinevere Planitia (331.8°, 4.6°N). Width of image is 45 km. C: Field of small shield volcanoes in Guinevere Planitia (330°, 35°N). Most of the shields are 3–8 km in diameter and have distinctive summit pits. D: Irregular-shaped caldera-like feature in Phoebe Regio (292°, 24°S) 8 km long and 3.6 km wide. Kidney-shaped depression is surrounded by volcanic plains. E: Irregular depression located in northern Lada Terra and interpreted to be caldera (356°, 68.7°S). Structure is 8 km by 10 km in dimension and contains an inner steep-sided depression, suggesting several phases of magma filling and withdrawal. F: Radar-dark sinuous channel extending across parts of Navka Planitia (335°, 14.5°S). Channel is 1–2 km wide and has narrow bright margins in some places, suggesting levees. In central part of image, dark material appears to have broken out of channel and flowed to west. Irregular radar-bright lines in plains are parts of patterns of fracturing and deformation.

Figure 7. Seven steep-sided, flat- edge of Alpha Regio (11.8°, 30°S) are very similar to terrestrial rhyoli ture and morphology suggest tha relatively high effective viscosity a



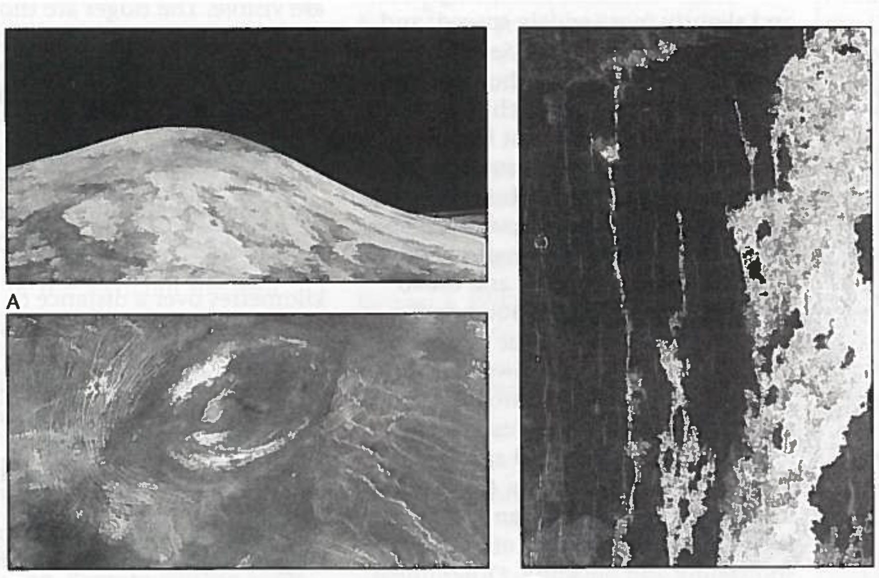


Figure 5. A: Perspective view of summit of the 225-km-wide and 1.7-km-high volcano Sif Mons (352°, 23°N), viewed from northeast. Radar-bright flows stream from summit region and veneer surrounding flanks of Western Eistla rise. B: Details of lava-flow units trending north, down northern slope of Western Eistla Regio. Radar-bright (relatively rough) flows emerge from vicinity of summit region of Sif Mons and extend hundreds of kilometres downslope across variety of volcanic plains units. Locally, flows have been captured by narrow grabens for distances in excess of several hundred kilometres. Width of image is 55 km. C: Sacajawea Patera, large elongate caldera located in Western Ishtar Terra on smooth plateau of Lakshmi Planum (337°, 65.5°N). Sacajawea is 200 by 300 km in dimension and 1–2 km deep and is surrounded by concentric grabens and rift-like zone to southeast. Width of image is about 420 km.

Figure 6. Intensely fractured plains northeast of Ushas Mons (near 330°, 20°S) and superposed dark mantle of fragmental material. Small bright spots are probable source vents, and bright patches near them are believed to represent fragmental material being removed by wind erosion. Width of image is 40 km.

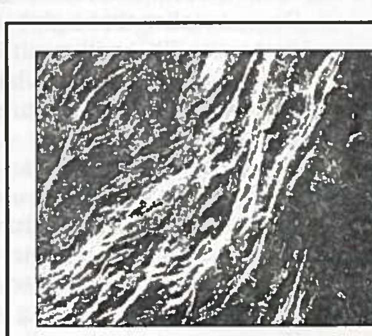


Figure 10. Three parallel belts of Planitia (340.4°, 41.4°S). Belts are troughs from 200 m to 3 km wid

Figures 4–15 from "Geology of Venus: A Perspective From Early Magellan Mission Results"
by James W. Head and R. Stephen Saunders

domes located in plains near eastern
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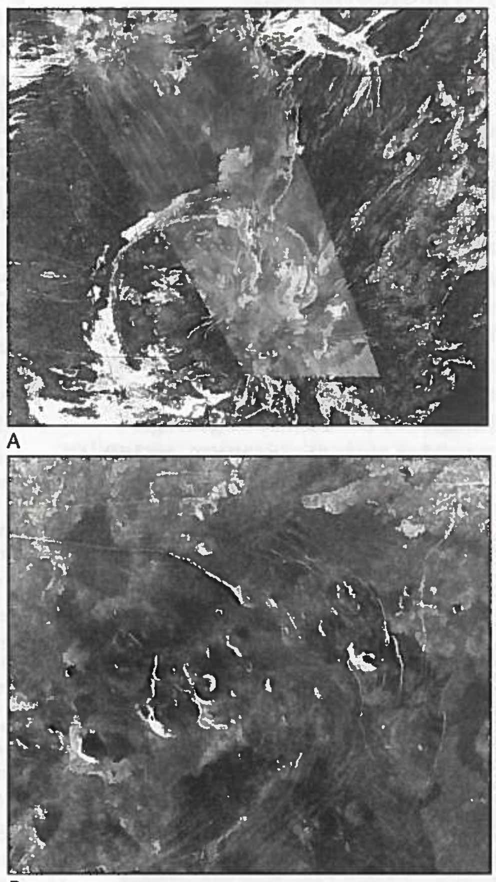

Figure 11. A: Quetzalpetlatl corona (355°, 68°S) in northern Lada Terra. This composite image was created by inserting new Magellan data into an Earth-based image obtained at Arecibo Observatory in Puerto Rico in 1988. Outer deformed annulus is developed in northern part of corona, and lava flows flood adjacent parallel depression in northwest. Width of corona is more than 800 km. B: Caldera-like region in southeast part of Quetzalpetlatl corona (355°, 68°S) in northern Lada Terra. Numerous domes, volcanic shields, and associated flows are visible within and adjacent to caldera fractures. Width of image is about 200 km.

Figure 12. Faulted and folded mountains of Eastern Freyja Montes in Western Ishtar Terra (342°, 72°N). Width of image is about 125 km.

Figure 8. Gridded volcanic plains in Guinevere-Sedna region (333.3°, 30°N). Two sets of fractures have different characteristics and are oriented nearly orthogonally. Width of image is 37 km.

Figure 13. Western edge of Maxwell Montes (bright area in eastern part of image) showing parallel ridges and troughs interpreted to represent compressional deformation in this orogenic belt (358°, 65°N). Adjacent dark volcanic plains of eastern Lakshmi Planum are also deformed. Maxwell Montes rises more than 7 km from base to summit less than 200 km to the east. Series of arcuate troughs 10–40 km wide are seen along southwest part of image. Width of image is 300 km. North is right.

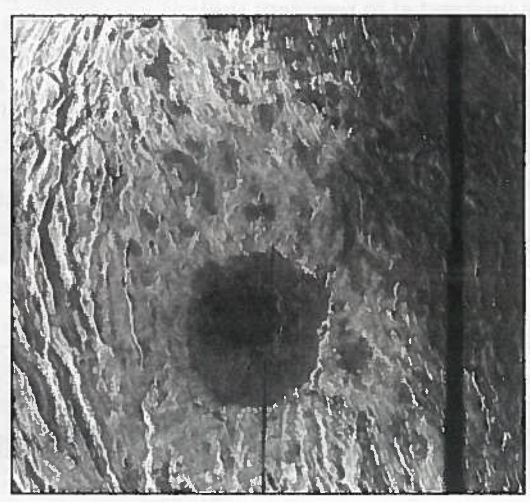

Figure 14. Cleopatra, 100-km-diameter double-ringed crater located near summit of Maxwell Montes, highest mountain belt on Venus (10°, 66°N).

Figure 9. Belt of narrow ridges and broad arches in Lavinia Planitia (337.9°, 36.4°S). These features are similar to mare ridges on Moon and represent modest levels of crustal shortening. Width of image is 37 km.

ractures and troughs located in Lavinia
5 km apart and composed of narrow
sting extensional deformation.

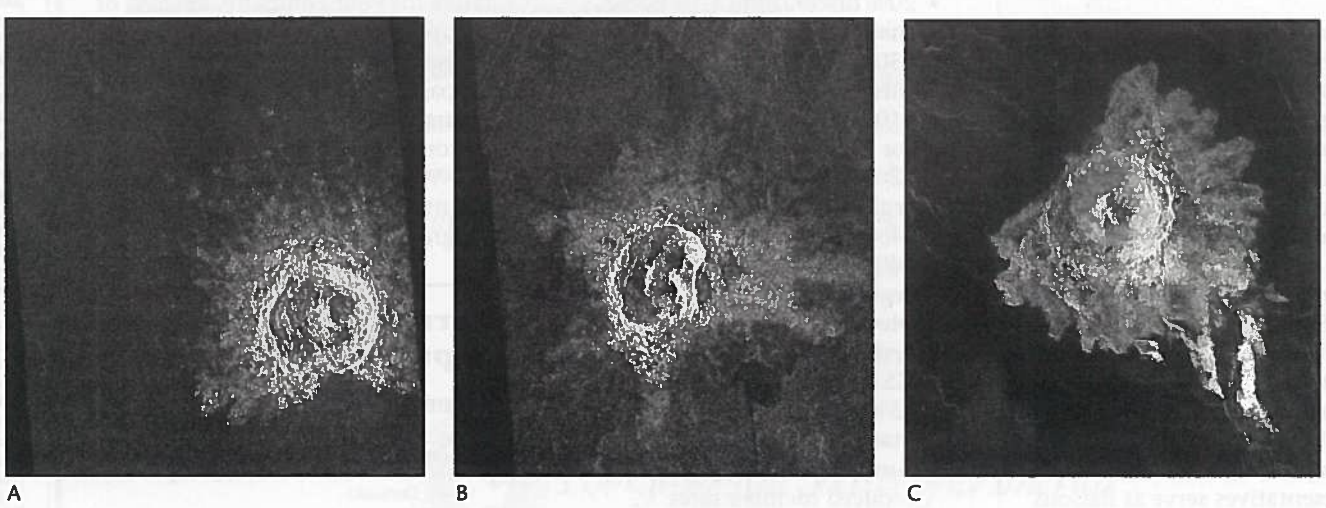

Figure 15. A: Impact crater 12.5 km in diameter located in Guinevere Planitia (335°, 6°N). Asymmetric ejecta pattern suggests oblique impact of crater-forming projectile. B: Irregular impact crater about 9 by 12 km, located in Navka Planitia (334.5°, 21.4°S). Multiple depressions in interior suggest that projectile broke up in dense Venus atmosphere and created simultaneous cluster of small impacts. C: Crater Aurelia (331.8°, 20.3°N), about 31 km in diameter. Note asymmetrical radial lobate ejecta pattern, and bright flows that extend from the southeast part of continuous ejecta deposit.

Venus *continued from p. 57*

Magellan data show details of ejecta deposits on the rim of the double-ringed structure and burying surrounding terrain, supporting the interpretation that the double-ringed crater is of impact origin. However, dark deposits within the inner ring appear to have exited the crater through a breach in the northeastern part of the rim and flowed through a channel, flooding the adjacent ridges along the low parts of the mountain flanks. Such dark material could be impact melt or volcanic material linked to the formation of the impact itself. It is perhaps an odd coincidence that such a large impact is situated near the highest point on the planet on what must be one of the youngest mountains on Venus.

Impact craters are also seen elsewhere on Venus; they have a range of surface morphologies in both their interiors and exteriors (R. J. Phillips et al., in preparation). Craters larger than about 10 km in diameter (Fig. 15A) show features (central peaks, wall terraces, hummocky rims, and radial ejecta) that are similar to those associated with fresh impact craters on the Moon, Mercury, and Mars. In many cases, there are distinctive asymmetries of ejecta (Fig. 15A) which suggest that the projectiles hit the surface at oblique angles. Many of the craters smaller than about 10 km are characterized by a complex interior that appears to represent the impact of several projectiles simultaneously (Fig. 15B). These clusters are interpreted to represent the impact of a family of smaller projectiles derived from a larger bolide that broke up as it encountered the very dense atmosphere of Venus.

Larger craters show evidence for distinctive, bright flow-like features extending tens to hundreds of kilometres from the distal parts of their ejecta deposits. The crater Aurelia, about 31 km in diameter (Fig. 15C), shows an asymmetrical ejecta deposit and distinctly lobate ejecta. Two large flow-like features extend for 45–75 km beyond the continuous deposit and are diverted by local structure. The origin of these flows is controversial, but they may be due to flows of impact melt, nuée ardente–like flows of very fine grained ejecta and incorporated atmosphere, or to other factors.

The number of impact craters can be used to estimate the age of the surface, and the size and frequency distribution of craters revealed so far by Venera 15/16, Arecibo Earth-based, and Magellan data are consistent with the surface ages being variable and less than about 800 Ga.

Erosional Features

Erosional and depositional processes do not seem to be significant on Venus (R. A. Arvidson et al., in preparation). Eolian and mass-wasting transport processes appear not to be significant, particularly because of the lack of sediment supply. In a few regions, distinct wind streaks, resembling those seen in some desert regions of Earth, are seen in the lee of topographic obstacles. Mapping of wind streaks may reveal regional patterns of surface winds on Venus. Evidence for erosion and local transport is seen near local sources of sediment, such as adjacent to fault scarps and impact crater ejecta deposits. On Earth's Moon, the lack of an atmosphere emphasizes the role of micrometeorite bombardment in comminuting rocks and producing a soil layer or regolith. On Earth, the atmosphere screens out micrometeorites, and aqueous physical and chemical processes dominate. On Venus, the dense atmosphere screens out micrometeorites, and the constant high temperatures and lack of water on the surface mean that rocks are not subject to freeze-thaw cycles and aqueous physical and chemical erosion processes as on Earth. Tectonic and volcanic structures and sequences of events are thus remarkably well preserved on Venus, and this will allow study of important processes and relations that are commonly eroded and obscured on Earth.

Discussion

At this point, we have just begun to see the new world of Venus as revealed by Magellan. It is as if we have been studying and classifying hand samples of rocks for several years, and then suddenly we are introduced to the microscope and thin sections. In the coming months, as we build up a global view of the planet at high resolution, we will be working to understand the implications of the details of the images for the nature of geologic processes such as volcanism, tectonism, and impact cratering. At the same time, we will be completing regional geologic maps of the surface (R. S. Saunders et al., in preparation), which will be combined to develop a global view of the distribution of volcanoes, linear deformation zones, orogenic belts, and terrains of different ages. At this point we will be in a position to begin the assessment of global tectonic and volcanic styles and to view the ways in which these link to mantle processes and patterns of mantle flow. In the coming months and years, the global geology of Venus will finally emerge from beneath the clouds, and we will begin the fundamental global comparison of the two largest terrestrial planets.

Acknowledgments

We thank NASA, the Jet Propulsion Laboratory, and the members of the Magellan Project for their untiring efforts to obtain these spectacular Venus images.

References Cited

Barsukov, V.L., and 29 others, 1986, The geology and geomorphology of the Venus surface as revealed by the radar images obtained by Veneras 15 and 16: Journal of Geophysical Research, v. 91, p. D378–D398.

Basilevsky, A.T., 1990, Vital problems of Venus geology: Outlook for their resolution by Magellan and post-Magellan missions: Earth, Moon and Planets, v. 50/51, p. 1.

Basilevsky, A.T., and Ivanov, B.A., 1990, Cleopatra Crater on Venus: Venera 15/16 data and impact/volcanic origin controversy: Geophysical Research Letters, v. 17, p. 175.

Basilevsky, A.T., Head, J.W., Pettengill, G.H., and Saunders, R.S., eds., 1990, Geology and tectonics of Venus: Earth, Moon and Planets, v. 50/51.

Campbell, D.B., Head, J.W., Hine, A.A., Harmon, J.K., Senske, D.A., and Fisher, P.C., 1989, Styles of volcanism on Venus: New Arecibo high resolution data: Science, v. 246, p. 373–377.

Crumpler, L.S., Head, J.W., and Campbell, D.B., 1986, Orogenic belts on Venus: Geology, v. 14, p. 1031.

Grimm, R.E., ed., 1990, Magellan arrives at Venus: Geophysical Research Letters, v. 17, p. 1335.

Head, J.W., and Solomon, S.C., 1981, Tectonic evolution of the terrestrial planets: Science, v. 213, p. 262.

Head, J.W., and Wilson, L., 1986, Volcanic processes and landforms on Venus: Theory, predictions, and observations: Journal of Geophysical Research, v. 91, p. 9407.

Ivanov, B.A., Basilevsky, A.T., Kryuchkov, V.P., and Chernaya, I.M., 1986, Impact craters of Venus: Analysis of Venera 15 and 16 data: Journal of Geophysical Research, v. 91, p. D413.

Pronin, A.A., and Stofan, E.R., 1990, Coronae on Venus: Morphology, classification, and distribution: Icarus, v. 87, p. 452.

Saunders, R.S., et al. 1990, The Magellan Venus radar mapping mission, Journal of Geophysical Research, v. 95, p. 8339.

Schaber, G.G., Kozak, R.C., and Masursky, H., 1987, Cleopatra Patera on Venus: Venera 15/16 evidence for a volcanic origin: Geophysical Research Letters, v. 14, p. 41.

Solomon, S.C., and Head, J.W., 1982, Mechanisms for lithospheric heat transport on Venus: Implications for tectonic style and volcanism: Journal of Geophysical Research, v. 87, p. 9236. ■

More GSA Representatives Needed!

In the mid-1980s, GSA launched a new representative program, targeting companies, agencies, and consultants throughout the country. The purpose was to broaden GSA's representation to include all employment sectors. The program was modeled on the successful campus representative program that began in 1979 and now includes 539 representatives at colleges and universities throughout North America.

We now have 143 company, 93 agency, and 56 consultant GSA representatives. However, we need more volunteers. Our goal is to designate a representative at all major company offices and governmental agencies throughout the country. For example, we hope to have a GSA representative for ARCO in Anchorage, for the Geological Survey of Canada in Vancouver, for the U.S. Geological Survey in Tucson, etc. We want to develop a similar liaison with GSA members who are self-employed and serve as consultants. They would also represent major cities and geographic regions.

Representatives serve as liaisons between GSA headquarters and their constituency in a particular city or region. They provide information on the programs and benefits of the Society to other members in the region and explain to prospective members the advantages of joining GSA. Each representative receives a notebook containing complete information on all GSA programs, activities, publications, meetings, and other benefits that the Society provides its membership.

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We need your help to continue this communications link between GSA headquarters and the membership of the Society. If you are a Member or Fellow (not Student Associate) and are interested in serving GSA as a representative for your company, agency, or group of the employment sector, please complete and return the form on page 63. Play an active role in the affairs of your Society and be the first in your area to represent GSA!

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GSA Reps. *continued on p. 63*

DNAG NEWS

Allison R. (Pete) Palmer

Au Revoir But Not Goodbye

January 11 was my last official workday at GSA. The DNAG Project has wound down to the point where I can take my early retirement one year later than originally planned, and return to my ten-year backlog of Cambrian activities. I will continue to work for GSA on a part-time basis until all DNAG books are finally done. It's been a great ten years and a lot has been accomplished, but the continuing delays in receipt of the final pieces are frustrating to all—probably not the least to the few authors out there whose guilt levels must be pretty high as they hold up their colleagues for yet another month.

Current Status

As predicted last month, the volume on *The Caribbean Region* is now out, *The Heritage of Engineering Geology* has gone off to the printer, and camera-ready pages are being prepared for *The Economic Geology of Mexico.* Three more books, *The Gulf of Mexico Basin, Economic Geology: U.S.,* and *Quaternary Non-glacial geology of the Conterminous U.S.,* were in our hands and in final production by the end of January. The second Canadian DNAG volume, I-1, *Geology of the Continental Margin of Eastern Canada,* was distributed to all prepaying purchasers by mid-January.

There is a glimmer of light ahead for completion of the volume on the U.S. Cordilleran region even though all three editors were overseas for the month of January. Jason Saleeby completed one of his two chapter revisions for this volume, and the other one was to be "in the mail" by late January. A draft of the introductory chapter for the volume is circulating among the editors. Bob Christiansen promised his time-slice chapter revision by January 1, but as of the end of the month he had not returned my call; I hope the further delay is not lengthy. That is the last revision needed to complete the book. I hope this book will have gone into the final production stages in February.

The Precambrian volume has made some important gains. Doug Rankin's multiauthor section on the Appalachian region is in the mill. The multiauthor megachapter by Randy Van Schmus and Pat Bickford was sent to Jack Reed in semifinal form, lacking some key pieces by Van Schmus, who went off to Brazil for several weeks. The other remaining magachapter, coordinated by Paul Link, was awaiting some figures from Don Winston, allowing it to be completed. Both of these megachapters need to be reviewed and revised (if necessary) before that book is in final production, but this could be under way by March.

There are only a few pieces of the Alaska volume left to complete, but nothing is yet predictable.

These volumes will complete the set for The Geology of North America that were the responsibility of GSA.

Two Canadian volumes, on the sedimentary cover of the craton and on the Innuitian region, are done and may be through the bilingual printing process in 1991. The volume on the Canadian Cordillera is done and is next in line. The Economic Geology volume and the volume on the Precambrian still have some unfinished chapters and will be the last ones of The Geology of North America to appear.

Two DNAG special volumes, on Neotectonics and on the Continent-Ocean Transitions, to accompany the 1:5,000,000 stress, heat flow, and seismicity maps, and the transects are still being worked on. Burt Slemmons can't complete his overview chapter for the Neotectonics volume until he has the summary chapter for the section on stress (!) by Mark and Mary Lou Zoback. This was supposed to be here "by Christmas." A fax in mid-January from the Zobacks in Germany said that the manuscript was done except for some reference corrections, giving a projection of late January for completion. We should be wrapping this book up in March. The holdouts on the transects volume were all working against an agreed-upon deadline of the end of February for their chapters.

The last major project, the *Geologic Map of North America,* is still being compiled, and our target is to have the compilation completed by May. It will be at least a year in production after the last of the compilation is done, but it should finally appear in 1992.

My thanks to the many authors of finished DNAG products for their parts in this monster project. The 10,000 pages already published are something you should all be proud of. Best wishes to all as we continue to unravel the geology and geophysics of the North American Plate. ■

In Memoriam

Lucy E. Birdsall
Glendale, California
October 21, 1990

Jonathan O. Davis
Reno, Nevada
December 15, 1990

Arnulf Muan
University Park, Pennsylvania
December 17, 1990

Arthur C. Munyan
Virginia Beach, Virginia

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BOOK REVIEW

Lecture Notes in Earth Science (Series). *Edited by Somdev Bhattacharji, Gerald M. Friedman, Horst J. Neugebauer, and Adolf Seilacher, Springer-Verlag, New York, 1989, 431 p., $49.*

The Landfill: Reactor and Final Storage. *Edited by Peter Paccini.*

Given present world population (over 5 billion) and growth (95 million per year), and garbage production, about 1 kg per person per day worldwide, 1.5 km^3/yr (cf. global volcanism), we have a horrendous world problem. Further, the wastes are very complex, being both organic and inorganic.

The proceedings of this Swiss Workshop on land disposal of solid wastes are timely and important to all of us who live on Earth, and the problem involves many of us in the earth sciences. The workshop included workers from across Europe and a few North Americans. I particularly liked the structure: lecturers, discussion participants, and "troublemakers."

A great deal of the discussion centers around terms like "final storage" and "landfills reactors." Often, what we put in landfills is poorly characterized and the processes that occur in the landfill are a microbiological "black box."

But for me, what was most impressive was the need for the truly holistic approach. What goes in? What comes out? What remains? And what are all the rate processes? The subject is a challenge to all of us in geochemistry, biogeochemistry, and hydrogeology. We must clear up the front end. We should use the methane and hydrogen. The entire issue requires our urgent attention.

This volume will be of great use to all who teach environmental science.

W. S. Fyfe
Dean, Faculty of Science
The University of Western Ontario ■

GSA Reps. *continued from p. 60*

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J. Peter Weidenheim — St. Paul

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Stephen J. Urbanik — New Jersey Department of Environmental Protection, Newton
Timothy S. White — Nittany Geoscience, Inc., State College

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1991

March

■ Hydrocarbon Contaminated Soils and Groundwater Second Annual West Coast Conference, March 4–7, 1991, Newport Beach, California. Information: EPACH Corporation, 150 Fearing St., Suite 17, Amherst, MA 01002; (413) 549-5561; fax 413-549-0579

AAPG/SEPM/SEG/SPWLA Pacific Sections 66th Annual Meeting, March 5–10, 1991, Bakersfield, California. Information: Robert Horton, 1991 Annual Pacific Sections Convention, 4909 Stockdale Highway, Suite 251, Bakersfield, CA 93309.

Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics (including special session on the Loma Prieta [California] Earthquake of October 17, 1989), March 11–15, 1991, St. Louis, Missouri. Information: Shamsher Prakash, Dept. of Civil Engineering, 308 Butler Carlton Hall, University of Missouri, Rolla, MO 65401-0249; (314) 341-4489; fax 314-341-4729.

GSA Northeastern and Southeastern Sections, March 14–16, 1991, Baltimore, Maryland. Information: Emery Cleaves, Maryland Geological Survey, 2300 St. Paul Street, Baltimore, MD 21218; (301) 554-5504; Juergen Reinhardt, U.S. Geological Survey, 926 National Center, Reston, VA 22092; (703) 648-6789.

Appalachian Karst Symposium, March 23–26, 1991, Radford, Virginia. Information: Ernst H. Kastning, Department of Geology, Radford University, Radford, VA 24142; (703) 831-5336 or 5652; fax 703-831-5970.

Sixth Biennial Meeting of the European Union of Geosciences, March 24–28, 1991, Strasbourg, France. Information: Organizing Committee of E.U.G. VI, University of Trieste, Institute of Mineralogy, Piazzale Europa, 1-34100 Trieste, Italy.

GSA Cordilleran Section, March 25–27, 1991, San Francisco, California. Information: Raymond Sullivan, Dept. of Geosciences, San Francisco State University, San Francisco, CA 94132; (415) 338-7730.

Fifth SIAM Conference on Parallel Processing for Scientific Computing, March 25–27, 1991, Houston, Texas. Information: SIAM Conference Coordinator, Dept. CC0990, 3600 University City Science Center, Philadelphia, PA 19104-2688; (215) 382-9800; fax 215-386-7999; E-mail siamconfs@wharton.upenn.edu.

Petroleum-Reservoir Geology in the Southern Midcontinent, March 26–27, 1991, Norman, Oklahoma. Information: Kenneth S. Johnson or Jock A. Campbell, Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd, Rm. N-131, Norman, OK 73019; (405) 325-3031.

April

■ 10th Annual Princeton-Conoco Symposium in Geosciences: Deformation of Earth Materials, April 5–6, 1991, Princeton, New Jersey. Information: Alan Henry, Dept. of Geological and Geophysical Sciences, Guyot Hall, Princeton, NJ 08544; (609) 258-4109; E-mail: alhenry@pucc.

American Association of Petroleum Geologists Annual Meeting, April 7–10, 1991, Dallas, Texas. Information: Charles F. Dodge, General Chairman, 607 Meadows Building, 5646 Milton, Dallas, TX 75206; (214) 363-2937; or AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101; (918) 584-2555.

Engineering Geology and Geotechnical Engineering, 27th Symposium, April 9–13, 1991, Logan, Utah. Information: James McCalpin, Dept. of Geology, Utah State University, Logan, UT 84322-4505; (801) 750-1220.

Permian Basin Section—SEPM Annual Field Seminar: Sequence Stratigraphy, Facies, and Reservoir Geometries of the San Andres/Grayburg/Queen Formations, Guadalupe Mountains, New Mexico and Texas, April 11–13, 1991, Permian Basin, Texas. Information: Sally Meador-Roberts, PBS-SEPM 1991 Annual Field Seminar, P.O. Box 1595, Midland, TX 79702; (915) 684-7122.

Association of American Geographers Annual Meeting, April 13–17, 1991, Miami, Florida. Information: AAG, 1710 16th Street NW, Washington, DC 20009-3198; (202) 234-1450.

International Conference on Environmental Pollution, April 15–19, 1991, Lisbon, Portugal. Information: ICEP Conference Office, ICTR Secretariat, 11–12 Pall Mall, London SW1Y 5LU, England; phone 01-930-6825; telex 925312 REICO G; fax 01-976-1587.

GSA North-Central Section, April 18–19, 1991, Toledo, Ohio. Information: Lon Ruedisili or Mark Camp, Dept. of Geology, University of Toledo, Toledo, OH 43606.

International Symposium on Geophysical Hazards in Developing Countries and Their Environmental Impacts, April 21–27, 1991, Cairo, Egypt. Information: T. S. Murty, Hazards-91, c/o Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C. V8L 4B2, Canada; (604) 356-6311; telex 04-97281; fax 604-356-6390; Mohammed I. El-Sabh, Hazards-91, Dept. Océanographie, Université du Québec, 300, Allée des Ursulines, Rimouski, Québec G5L 3A1, Canada; (418) 724-1707; telex 051-31623; fax 418-723-7234.

GSA Rocky Mountain and South-Central Sections, April 22–24, 1991, Albuquerque, New Mexico. Information: G. Randy Keller, Dept. of Geological Sciences, University of Texas, El Paso, TX 79968-0555; (915) 747-5501; John Geissman or Wolfgang Elston, Dept. of Geology, University of New Mexico, Albuquerque, NM 87131; (505) 277-4204.

European Geophysical Society XVI General Assembly, April 22–26, 1991, Wiesbaden, Federal Republic of Germany. Information: EGS Office, Postfach 49, 3411 Katlenburg-Lindau, Germany; phone 49-5556-1440; fax 49-5556-4709; telex 965564 zil d.

Association of Exploration Geochemists 15th International Geochemical Exploration Symposium, April 29–May 1, 1991, Reno, Nevada. Information: Harold Bonham, 15th IGES, P.O. Box 9126, Reno, NV, 89507; (702) 784-6691; fax 702-784-1709.

Eighth Thematic Conference on Remote Sensing for Exploration Geology, April 29–May 2, 1991, Denver, Colorado. Information: Robert H. Rogers, ERIM Thematic Conferences, P.O. Box 8618, Ann Arbor, MI 48107-8618; (313) 994-1200.

May

■ African Colloquium of Micropaleontology, May 6–8, 1991, Libreville, Gabon. Information: Comité d'Organization de Colloques, D.G.H.B.P. 2199, Libreville, Gabon; tel 241-76-39-23; fax 241-76-39-17.

Society for the Preservation of Natural History Collections, 6th Annual Meeting, May 6–11, 1991, Ottawa, Ontario. Information: G. R. Fitzgerald, Canadian Museum of Nature, Earth Sciences (Paleobiology), P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4, Canada.

14th Annual Spring Systematics Symposium: Origin of Anatomically Modern Humans, May 11, 1991, Chicago, Illinois. Information: Sophia L. Brown, Symposium Coordinator, Department of Geology, Field Museum of Natural History, Roosevelt Road and Lake Shore Drive, Chicago, IL 60605-2496; (312) 922-9410, x298.

Third International Seminar on Coastal Parks and Protected Areas, May 11–June 5, 1991, Florida and Costa Rica. Information: John R. Clark, University of Miami-RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149-1098; (305) 361-4620; telex 317454; fax 305-361-9306; Easylink mailbox 62845425.

International Symposium on Land Subsidence, May 12–18, 1991, Houston, Texas. Information: Ivan Johnson, A. Ivan Johnson, Inc., 7474 Upham Ct., Arvada, CO 80003; (303) 425-5610.

Fifth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring, and Geophysical Methods, May 13–16, 1991, Las Vegas, Nevada. Information: Fifth National Outdoor Action Conf., National Water Well Association, P.O. Box 182039, Dept. #017, Columbus, OH 43218; (614) 761-1711.

Brazil Gold '91, May 13–17, 1991, Belo Horizonte, Brazil. Information: Organizing Committee, Av. Afonso Pena, 3880-3/5 andares, 30130 Belo Horizonte MG, Brazil; or Charles Thorman, U.S. Geological Survey, Box 25046, MS 905, Denver Federal Center, Denver, CO 80225; (303) 236-5601; fax 303-236-5603.

14th International Radiocarbon Conference, May 20–24, 1991, Tucson, Arizona. Information: Austin Long, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721; (602) 621-8888; fax 602-621-2672; telex 650-3839821.

■ XVII Pacific Science Congress—Towards the Pacific Century: The Challenge of Change, May 27–June 2, Honolulu, Hawaii. Information: Congress Secretariat, Nancy Lewis, Secretary General, 2424 Maile Way, Honolulu, HI 96822; (808) 956-7526, fax 808-956-3512.

Geological Association of Canada–Mineralogical Association of Canada Annual Meeting held jointly with the Society of Economic Geologists, May 27–29, 1991, Toronto, Ontario. Information: J. J. Fawcett, Dept. of Geology, Earth Sciences Center, University of Toronto, 22 Russell St., Toronto, Ontario M5S 3B1, Canada; (416) 978-3027; fax 416-978-3938.

June

■ Gordon Conference on Estuarine Processes, June 24–28, 1991, New Hampton, New Hampshire. Information: A. M. Cruickshank, Gordon Research Center, University of Rhode Island, Kingston, RI 02881, (401) 783-4011.

July

Second International Conference on Industrial and Applied Mathematics (ICIAM 91), July 8–12, 1991, Washington, D.C. Information: SIAM Conference Coordinator, Dept. CC0990, 3600 University City Science Center, Philadelphia, PA 19104-2688; (215) 382-9800; fax 215-386-7999; E-mail siamconfs@wharton.upenn.edu.

11th International Symposium on Ostracoda, July 8–13, 1991, Warrnambool, Victoria, Australia. Information: Peter J. Jones, Bureau of Mineral Resources, P.O. Box 378, Canberra A.C.T. 2601, Australia; phone (06) 249 9737; fax 06-257 6465.

Former ENSO Phenomena in Western South America: Records of El Niño Events, July 10–13, 1991, Lima, Peru. Information: ENSO 1991 International Symposium, ORSTOM, Apartado 18-1209, Lima 18, Peru; fax 51-14-40-87-73.

Sixth International Symposium on the Ordovician System, July 15–19, 1991, Sydney, Australia. Information: Earth Resources Foundation, Edgeworth David Building, University of Sydney, Sydney, N.S.W., Australia, 2006; phone (02) 692 2038 (Int. 61+2); fax 02-692 0184 (Int. 61+2).

August

150th Anniversary Conference on the Permian System, August 5–10, 1991, Perm, USSR. Information: A.E.M. Nairn, Perm Conference, Earth Sciences & Resources Institute, University of South Carolina, Columbia, SC 29208; (803) 777-6484; fax 803-777-6437; telex 9102501347 USC ESRI UQ.

Sedimentary and Paleolimnological Records of Saline Lakes, August 13–16, 1991, Saskatoon, Saskatchewan. Information: Robin W. Renaut, Dept. of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0, Canada; fax 306-966-8593; W. M. Last, Dept. of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada; fax 204-261-7581.

SEPM Midyear Meeting—Continental Margins, Tectonics, Eustacy and Climate Change, August 15–18, 1991, Portland, Oregon. Information: Sam Boggs, Jr., Dept. of Geology, University of Oregon, Eugene, OR 97403; (503) 686-4573.

1st International Meeting of Young Geologists, August 22–28, 1991, Budapest, Hungary. Information: Anna Balog, Dept. of Geology, Technical University of Budapest, H-1521 Budapest, Hungary; phone (36-1) 16-67-370; fax 36-1-16-66-808; telex 225931.

Third U.S. Conference on Lifeline Earthquake Engineering, August 22–23, 1991, Los Angeles, California. Information: American Society of Civil Engineers, Specialty Conference Dept., 345 E. 47th St., New York, NY 10017; (212) 705-7139.

September

International Symposium on Computer Applications in Geoscience, September 2–6, 1991, Beijing, China. Information: Zhang Bojun, 31 Xue Yuan Rd., Beijing 100083, China; phone 2012233, ext. 312; fax 2024674; telex 222484 GBCC CN.

Geometry of Naturally Deformed Rocks (John Ramsay Meeting), September 9–11, 1991, Zürich, Switzerland. Information: E. Pour, Geologisches Institut, ETH-Zentrum, CH-8092, Zürich, Switzerland; phone 256 36 80; fax 252-70-08. (*Abstracts deadline: June 1, 1991.*)

International Symposium on Fossil Cnidaria Including Archaeocyatha and Porifera, September 9–14, 1991, Münster, Federal Republic of Germany. Information: Fossil VI. Cnidaria, Pferdegasse 3, D-4400 Münster, Federal Republic of Germany.

Gold and Platinum in Central Africa, September 11–13, 1991, Bujumbura, Burundi. Information: W. Pohl, Institute of Geosciences, Technical University, P.O. Box 3329, D-33 Braunschweig, Germany.

Second International Conference on the Abatement of Acidic Drainage, September 16–18, 1991, Montreal, Québec. Information: Pamela Friedrich, Centre des Recherches Minérales, 1665, boulevard Hamel, Édifice 2, 1er étage, Québec, Québec G1N 3Y7, Canada.

2nd International Symposium on Environmental Geochemistry, September 16–19, 1991, Uppsala, Sweden. Information: Mats Olsson, Dept. of Forest Soils, Swedish University of Agricultural Sciences, Box 7001, S-750 07 Uppsala, Sweden; phone 46-18-672212; fax 46-18-300831. (*Abstracts deadline: March 28, 1991.*)

Second Hutton Symposium on Granites and Related Rocks, September 23–28, 1991, Canberra, Australia. Information: ACTS, GPO Box 2200, Canberra City, ACT 2601, Australia.

■ **15th International Cartographic Conference–9th General Assembly of the International Cartographic Association**, September 23–October 1, 1991, Bournemouth, England. Information: James R. Carter, Academic Computing, Illinois State University, Normal, IL 61761; (309) 438-3758; fax 309-438-5319.

International Mine Water Association Fourth Congress, September 25–30, 1991, Ljubljana, Yugoslavia. Information: Miron Veselic, S.P. Geoloski Zavod Ljubljana, Dimiceva 14, 61000 Ljubljana, Yugoslavia; fax 38 61 371 557.

New England Intercollegiate Geological Field Conference, September 28–30, 1991, Princeton, Maine. Information: Allan Ludman, Department of Geology, Queens College, 65-30 Kissena Blvd., Flushing, NY 11367-0904.

1991 American Association of Petroleum Geologists International Conference and Exhibition, September 29–October 2, 1991, London, England. Information: 1991 AAPG International Conference, P.O. Box 979, Tulsa, OK 74101-0979.

Society of Organic Petrology 8th Annual Meeting, September 30–October 1, 1991, Lexington, Kentucky. Information: Jim Hower, Center for Applied Energy Research, 3572 Iron Works Pike, Lexington, KY 40511; (606) 257-0261; fax 606-257-0220.

October

Fifth International Congress on Pacific Neogene Stratigraphy and IGCP 246, October 6–10, 1991, Shizuoka, Japan. Information: V-CPNS-IGCP246 Organizing Committee, Geoscience Institute, Faculty of Science, Shizuoka University, Shizuoka 422, Japan; fax 81-542-37-9895.

■ **Federation of Analytical Chemistry and Spectroscopy Societies and Pacific Conference on Chemistry and Spectroscopy**, October 6–11, 1991, Anaheim, California. Information: FACSS, P.O. Box 278, Manhattan, KS 66502; (301) 846-4797.

■ **Rocky Mountain Friends of the Pleistocene Annual Field Trip**, October 11–13, 1991, Lake Bonneville, Utah. Information: Richard Van Horn, U.S. Geological Survey, Box 25046, MS 966, Denver, CO 80225.

International Symposium on Debris Flow and Flood Disaster Protection, October 14–20, 1991, Emeishan City, Sichuan Province, China. Information: Tong Yuling, International Research and Training Centre on Erosion and Sedimentation (IRTCES), P.O. Box 366, Beijing, China 100044; phone 8413372; telex 22786 ITCES CN; fax 8412539.

American Institute of Professional Geologists Annual Meeting, October 16–19, 1991, Gatlinburg, Tennessee. Information: Lawrence I. Benson, ERC/EDGE, P.O. Box 22879, Knoxville, TN 37933-0879; (615) 966-9761; fax 615-966-4155.

New York State Geological Association 63rd Annual Field Conference, October 18–20, 1991, Oneonta, New York. Information: James R. Ebert, Department of Earth Sciences, State University of New York, Oneonta, NY 13820-4015; (607) 431-3065; fax 607-431-2107.

International Symposium on Geological Hazards and Prevention, October 20–25, 1991, Beijing, People's Republic of China. Information: Chu Zhanchang, Secretariat, Organizing Committee, International Symposium on Geological Hazards and Prevention, 64, Funei St., Beijing, People's Republic of China; phone 658561-410.

Geological Society of America Annual Meeting, October 21–24, 1991, San Diego, California. Information: GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301; (303) 447-2020; fax 303-447-1133.

■ **Arbuckle Group Core Workshop and Field Trip**, October 27–29, 1991, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm. N-131, Norman, OK 73019; (405) 325-3031.

Brazilian Geophysical Society Second International Congress, October 28–November 1, 1991, Salvador City, Bahia, Brazil. Information: Brazilian Geophysical Society—SBGf, Alberto Brum Novaes, Universidade Federal da Bahia/UFBa-PPPG, Rua Caetano Moura 123, Federacão 40.210, Salvador BA, Brasil; phone 55-071-2370408. (*Abstracts deadline: May 31, 1991.*)

November

■ **Hydrology and Hydrogeology in the '90s, Issues, Strategies and Technologies**, November 3–7, 1991, Orlando, Florida. Information: AIH, 3416 University Ave. S.E., Minneapolis, MN 55414; (612) 379-1030.

5th International Circum-Pacific Terrane Conference, November 11–28, 1991, Santiago, Chile. Information: D. G. Howell, U.S. Geological Survey, MS 902, 345 Middlefield Rd., Menlo Park, CA 94025; (415) 329-5430.

Clean Seas 91, International Conference on Marine Pollution, November 19–22, 1991, Valletta, Malta. Information: Lesley Ann Sandbach, Project Manager, Clean Seas 91, The Spearhead Group, Rowe House, 55-59 Fife Road, Kingston upon Thames, Surrey KT1 1TA, UK; phone 081 549 5831 (intl: +44-81-549-5831); telex 928042 SPEARS G; fax 081-541-5657 (intl: +44-81-541-5657).

December

Mining Indonesia '91, December 4–7, 1991, Jakarta, Indonesia. Information: Eileen M. Lavine, Information Services, Inc., 4733 Bethesda Ave., #735, Bethesda, MD 20814; (301) 656-2942; fax 301-656-3179.

1991 Penrose Conference

October

Development and Evolution of Foreland Basins, October 6–11, 1991, Oliana, Spain. Information: James H. Meyers, Dept. of Geology, Winona State University, Winona, MN 55987; (507) 457-5266 (dir.), (507) 457-5000 (dept.), fax 507-457-5586; Douglas W. Burbank, Dept. of Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740; Lee J. Suttner, Dept. of Geology, Indiana University, Bloomington, IN 47405; Cai Puigdefabregas, Dept. de Politica Territorial, Servei Geologica de Catalunya, Diputacio, 92, 5e, 08015 Barcelona, Spain.

1992

February

First South Asia Geological Congress—GEOSAS-I, February 23–27, 1992, Islamabad, Pakistan. Information: Hilal A. Raza, GEOSAS-I Secretary General, Hydrocarbon Development Institute of Pakistan, 230-Nazimuddin Road, F-7/4, P.O. Box 1308, Islamabad, Pakistan; phone 9251-823690 or 821417; telex 5516 HDIP PK; fax 9251-828773.

March

■ **Second Conference on Earthquake Hazards in the Eastern San Francisco Bay Area**, March 25–28, 1992, Hayward, California. Information: Sue Ellen Hirschfeld, Dept. of Geological Sciences, California State University, Hayward, CA 94542; (415) 881-3486.

April

XVII General Assembly of the European Geophysical Society, April 6–10, 1992, Edinburgh, Scotland. Information: EGS Office, Postfach 49, 3411 Katlenburg-Lindau, FRG; tel (49) 5556-1440; fax 49-5556-4709; telex 965564 zil d; SPAN: LINMPI::EGS; EARN: U0085@DGOGWDG5.

June

American Association of Petroleum Geologists Annual Meeting, June 21–24, 1992, Calgary, Alberta, Canada. Information: George Eynon, General Chairman, Bow Valley Industries, Ltd., P.O. Box 6610, Postal Station D, Calgary, Alberta, T2P 3R7, Canada; (403) 261-6100; or AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101; (918) 584-2555.

Interpraevent 1992—Protection of Habitat against Floods, Debris Flows and Avalanches, June 29–July 3, 1992, Berne, Switzerland. Information: Interpraevent 1992, c/o Bundesamt für Wasserwirtschaft, Federal Office for Water Management, Postfach 2743, CH-3001 Berne, Switzerland.

July

■ **7th International Symposium on Water-Rock Interaction**, July 13–22, 1992, Park City, Utah. Information: Yousif Kharaka, Secretary-General, U.S. Geological Survey, MS 427, 345 Middlefield Road, Menlo Park, CA 94025; (415) 329-4535; fax 415-329-5110.

August

29th International Geological Congress, August 24–September 3, 1992, Kyoto, Japan. Information: Secretary General, IGC-92 Office, P.O. Box 65, Tsukuba, Ibaraki 305, Japan; phone 81-298-54-3627; fax 81-298-54-3629; telex 3652511 GSJ J.

September

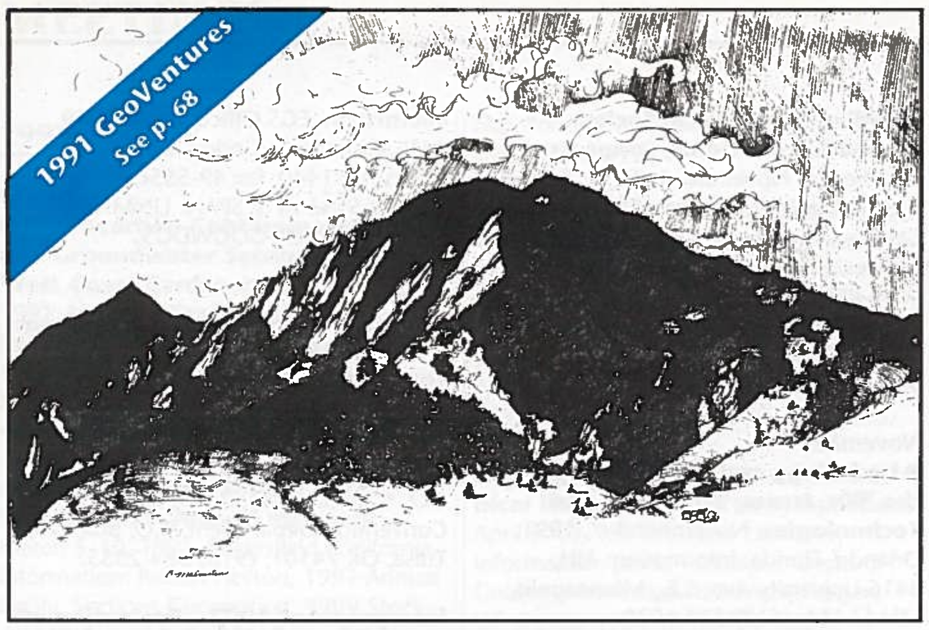
4th International Conference on Paleoceanography, September 21–25, 1992, Kiel, Federal Republic of Germany. Information: ICP IV Organizing Committee c/o GEOMAR, Wischhofstrasse 1-3/Bldg. 4, D-2300 Kiel 14, Federal Republic of Germany.

American Institute of Professional Geologists Annual Meeting, September 27–October 1, 1992, Lake Tahoe, Nevada. Information: Jon Price, AIPG, P.O. Box 665, Carson City, NV 89702; (702) 784-6691.

October

Geological Society of America Annual Meeting, October 26–29, 1992, Cincinnati, Ohio. Information: GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301; (303) 447-2020; fax 303-447-1133.

Send notices of meetings of general interest, in format above, to Editor, *GSA Today*, P.O. Box 9140, Boulder, CO 80301.



The Flatirons, Boulder, Colorado. *Drawing by Barbara Malmsten*

GSA ANNUAL MEETINGS

■ 1991

GSA Annual Meeting, San Diego, California
October 21–24

General Chair:
R. Gordon Gastil, Dept. of Geological Sciences,
San Diego State University, San Diego, CA 92182

■ 1992

GSA Annual Meeting, Cincinnati, Ohio
October 26–29

Call for field trip proposals:
Send proposals to Thomas M. Berg, State Geologist and Chief, Division of Geological Survey, Ohio Dept. of Natural Resources, Fountain Square, Columbus, OH 43224; (614) 265-6605

■ FUTURE

San Diego	October 21–24	1991
Cincinnati	October 26–29	1992
Boston	October 25–28	1993
Seattle	October 24–27	1994
New Orleans	November 6–9	1995

For general information on technical program participation (1991 or beyond) contact: Sue Beggs, Meetings Manager, GSA headquarters.

GSA SECTION MEETINGS

■ 1991

Northeastern-Southeastern
Omni Inner Harbor Hotel, Baltimore, Maryland, March 14–16

Emery Cleaves, Maryland Geological Survey, 2300 St. Paul Street, Baltimore, MD 21218; (301) 554-5504
or Juergen Reinhardt, U.S. Geological Survey, 926 National Center, Reston, VA 22092; (703) 648-6789

Cordilleran
Cathedral Hill Hotel, San Francisco, California, March 25–27

Raymond Sullivan, Dept. of Geosciences, San Francisco State University, San Francisco, CA 94132; (415) 338-7730

North-Central
University of Toledo, Toledo, Ohio, April 18–19

Lon Ruedisili or Mark Camp, Dept. of Geology, University of Toledo, Toledo, OH 43606; (419) 537-2009

Rocky Mountain–South-Central
University of New Mexico, Albuquerque, New Mexico, April 22–24

G. Randy Keller, Dept. of Geological Sciences, University of Texas at El Paso, El Paso, TX 79968-0555; (915) 747-5501
or John Geissman or Wolfgang Elston, Dept. of Geology, University of New Mexico, Albuquerque, NM 87131; (505) 277-4204

FOUNDATION TO FUND MATCHING STUDENT-TRAVEL GRANTS

The GSA Foundation will award matching grants up to a total of $3000 each to the six GSA Sections. The money, when combined with equal funds from the Sections, will be used to assist students traveling to the 1991 Section Meetings and the GSA Annual Meeting in San Diego.

Travel grants will be awarded and administered by the Sections, whose officers should be contacted for further information.

GSA *BULLETIN* and *GEOLOGY* contents

Are you missing out? If you're not a *Bulletin* or *Geology* subscriber, you may miss the articles listed below. But it's not too late, you can still subscribe and receive all 1991 issues, even if you've already paid your 1991 dues. Just call Membership Services today at 1-800-472-1988.

The Geological Society of America
BULLETIN
Volume 103, Number 3, March 1991

CONTENTS

GEOLOGY
VOLUME 19
NO. 3
P. 193–288
MARCH 1991

CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office 1 month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-1133.

Classification	Per Line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
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Services & Supplies	$4.50	$3.80
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Agencies and organizations may submit purchase order or payment with copy. Individuals must send prepayment with copy. To estimate cost, count 54 characters per line, including all punctuation and blank spaces. Actual cost may differ if you use capitals, centered copy, or special characters.

To answer coded ads, use this address: Code # ----, GSA Advertising Dept., P.O. Box 9140, Boulder, CO 80301-9140. All coded mail will be forwarded within 24 hours of arrival at *GSA Today* office.

Positions Open

FLORIDA INTERNATIONAL UNIVERSITY COLLEGE OF ARTS AND SCIENCES DEPARTMENT OF GEOLOGY WATER RESOURCE GEOLOGY ECONOMIC GEOLOGY

The Department of Geology at Florida International University invites applications for a full-time, tenure-track position at the Assistant or Associate Professor level. The primary responsibility of the successful applicant will be to teach and direct thesis research in hydrogeology, water resource geology and environmental geology, or Economic Geology at both the undergraduate and graduate level. In addition to hydrogeologists, candidates in the areas of aqueous geochemistry, geomorphology or engineering geology, but with appropriate background and experience in hydrogeology are encouraged to apply. Economic geologists with a strong background in the geochemical and/or physical modeling of magmatic-hydrothermal systems are especially encouraged to apply.

A Ph.D. is required and the candidate must demonstrate a commitment to high quality teaching and the potential to develop a vigorous research program.

Send a resume, brief description of research and teaching interests, transcripts and 3 letters of recommendation to Dr. Florentin Maurrasse, Department of Geology, Florida International University, Miami, Florida 33199.

Deadline for application is: April 4, 1991.

Florida International University is part of the State University System of Florida and an equal opportunity, affirmative action employer.

PROFESSOR (RESEARCH). THE DEPARTMENT OF APPLIED EARTH SCIENCES, STANFORD UNIVERSITY, invites applications for a research position in the non-tenure track professoriate at the associate or full professor level for the fall of 1991. We seek a person with broad interdisciplinary research activities who will contribute in the following areas: Neotectonics, Engineering Geology, and Geological Hazards; Rock Fracture Mechanics and Fracture Flow; Structural Geology and Geomechanics. Research should be strongly based on field mapping and field data acquisition within a sound geological context. The analysis and interpretation of data should be based on fundamental principles of engineering mechanics.

Applicants must have a Ph.D. degree, at least five years of post-doctoral or professional research experience, and a nationally recognized research record. This position is contingent upon funding and the successful applicant is expected to raise at least 50% of his or her salary and benefits, and 100% of his or her research funds from external sources. The successful applicant is expected to establish a vigorous research program, to direct graduate student research, and to participate in interdisciplinary research throughout the School of Earth Sciences.

Please send curriculum vitae (including publication list), a description of research interests, and no more than five different reprints from refereed journals by March 31, 1991 to: Chairman, Search Committee, Department of Applied Earth Sciences, Stanford University, Stanford, CA 94305-2225. Stanford University is an equal opportunity affirmative action employer. Women and minorities are encouraged to apply.

GEOLOGY
Ball State University, Muncie, Indiana

The Department of Geology invites applications for a tenure-track position at the assistant professor level beginning with the 1991-92 academic year. The candidate should have teaching and research interest in aqueous geochemistry or structural geology. Since it is our intention that the new faculty member will complement existing strengths and interests, candidates with primary specialties in other areas will be considered, including but not limited to: engineering/environmental geology, geology of Quaternary deposits, igneous/metamorphic petrology, oceanography, global tectonics, and sedimentary basin analysis. The successful candidate will also be expected to teach geology courses in the university general education program, develop a program of research, and advise student research at graduate and undergraduate levels.

Ball State University is primarily a teaching institution with the emphasis on undergraduate education. The Department of Geology also has a small but successful M.S. program. The Ph.D. degree is required for this position and applicants should have their degree in hand or near completion. Applications will be considered until the position is filled; salary will be competitive and commensurate with experience. Applicants should send vita, statement of teaching and research interests, and names of at least three references to Chairman of Search Committee, Department of Geology, Ball State University, Muncie, IN 47306.

Ball State University Practices Equal Opportunity in Education and Employment.

Services & Supplies

LEATHER FIELD CASES. Free brochure, SHERER CUSTOM SADDLES, INC., P.O. Box 385, Dept. GN, Franktown, CO 80116.

Opportunities for Students

GRADUATE RESEARCH ASSISTANTSHIP in Mineralogy, Iowa State University. 3/4 time. This position requires an M.S. in geology, chemistry, or soil science and knowledge of x-ray diffraction theory and practice. Major responsibilities are to operate and maintain state-of-the-art XRD equipment, to teach students use of the equipment, and to conduct research in soil mineralogy in collaboration with faculty and students. The incumbent is expected to undertake a Ph.D. program in soil mineralogy. Annual stipend is $17,523. Contact Dr. Michael L. Thompson, Agronomy Department, Iowa State University, Ames, Iowa 50011, (515) 294-2415 for more information.

Forum *continued from p. 56*

systems? The United States should embrace continuation of the Landsat program as a national priority.

Summary

1. The original goals of the Landsat program must be reestablished to meet the needs of the U.S. Global Change Research Program. This includes systematic repetitive acquisition of images of the land areas of the planet (at least once per year) and provision for permanent archiving and for processing and distribution of the data, in either film or computer-compatible tape (CCT) format, at a cost that is affordable for the scientific community and the general public. This would be similar to the situation that existed under Landsat-1 and -2, when NASA and the EROS Data Center were an extraordinarily effective team.

2. To meet the national needs of the U.S. Global Change Research Program and to meet international responsibilities of the United States to international global-change programs, a decision should be made to decommercialize the Landsat program and return its operation to the U.S. Government. Contractor(s) would still provide support to the Landsat program, but data acquisition would be based on scientific, *not* commercial needs, and the cost of data would be based on cost of reproduction, *not* profit-driven requirements.

3. The Landsat program should be an integral part of NASA's Mission to Planet Earth concept and a companion spacecraft to NASA's EOS. This is especially desirable because the suite of sensors considered by NASA for the EOS polar-orbiting platforms has nothing comparable to the Landsat MSS or TM sensor capability: 10,000 nominal scenes, each 185 km on a side, each at several different wavelength intervals, covering the land and shallow sea areas of the planet, with each of the 10,000 nominal scenes capable of being systematically acquired on an 18-day-repeat cycle of these areas.

4. The USGS EROS Data Center, the world's premier satellite image and photographic archive, processing, and distribution facility, should continue to serve as the primary U.S. Landsat data center. In 1988, the USGS signed a Memorandum of Understanding with NASA for EDC to be the U.S. archive, processing, and distribution center for all land-related data for the EOS program. If Landsat is designated as an integral part of EOS, then all the pieces will be in place for the United States to support a key element (Landsat) of a comprehensive monitoring program for Earth System measurements on a global scale.

5. Because of the overwhelming importance of monitoring global change, steps should be taken to declassify much of the image and photographic data acquired by military and intelligence satellites. Although the classified data may have only limited value to global-change studies, scientists should have access to what data are actually useful. For example, the Soviet Union has released thousands of Soyuzkarta satellite images and photographs of Antarctica. Changes in the coastal areas of Antarctica are of particular concern to scientists interested in the impact of global climate warming. If the U.S. classified satellites have acquired images and photographs of Antarctica, they should also be made available to the scientific community. Declassified image and photographic data should be archived at the EROS Data Center, where it can be processed at the cost of reproduction and be distributed to all users. ■

GEOVENTURES 1991 (GeoHostels and GeoTrips for GSA Members and Friends)

Great Britain GeoTrip: Lulworth Cove in the Hampshire Basin of south-central England. *Photo by Dottie Stout*

GSA GeoHostels

GeoHostel is a learning experience for geologists. It is site-specific with a combination of classroom and field experiences which start from the same location each day. A GeoHostel is held for five to seven days at a destination that is rich in geological interest as well as plentiful in opportunities for side excursions.

GeoHostels offer:

- an enjoyable experience with an educational focus on topics appealing to a wide range of geologists and their guests
- ample free time to enjoy the special environmental and cultural aspects of the location
- leadership by enthusiastic, well-organized geologists who can speak well and who can cover the topics at a level appropriate for the professional non-expert.

Colorado GeoHostel Program

Colorado School of Mines, Golden, Colorado
Five Days: Sunday, June 23–Thursday, June 27

Scientifc Leaders:
Kenneth E. Kolm and Gregory S. Holden
Colorado School of Mines

Colorado School of Mines is set in the foothills of the Colorado Rockies and is conveniently located between Denver and Boulder. June will be a wonderful time to visit Colorado and the spectacular high country of the Rockies.

GH91A **Evolution of Geologic Landscapes in the Colorado Rockies,** 8:00–9:30 a.m.

GH91B **Environmental and Engineering Issues in Colorado,** 9:30–11:00 a.m.
These two geology classes will be offered each morning and include local field trips. They are meant for professional geologists who are not experts in this area, but anyone may attend. A person may take one or both classes.

GH2B **Old Mining Towns of the Rockies,** 9:30–11:00 a.m.
Also offered, primarily for the nongeologist, is a fascinating class on Colorado's mining towns. This class will include at least one full-day trip to visit several mining towns. Persons registering in this class will not be able to take either of the geology classes.

Registration

Minimum age: 21 years. No other limits.

Program

Saturday, June 22: Welcoming Get-together
Sunday, June 23 through Wednesday, June 26: Morning Classes
Thursday, June 27: Full Day Field Excursion and Farewell Party

Fees and Deposit

GeoHostel cost: $350 (nonmembers and guests)
Special discount rate for GSA members: $325
Fee includes classroom programs and materials, field excursions, lodging (double occupancy), breakfast, welcoming and farewell events.
Not included are transportation to and from Colorado, transportation during nonclass hours, meals or other expenses not specifically included.

$50 deposit is due with your reservation. It will be applied to the total due and is refundable up to *April 1*.

March 1 .... 50% of balance is due
April 1 .... 100% of balance is due

GSA GeoTrips

GT912

Great Britain's Classic Geologic Sites

6 SPACES STILL OPEN AS WE GO TO PRINT. CALL ASAP.

Co-sponsored by NAGT
21 days: Saturday, June 15–Saturday, July 6

Scientifc Leaders:
Donald McIntyre, Pomona College
Ron Roberts, Geological Museum of London
D. H. Tarling, Plymouth Polytechnic Southwest

This adventure is being coordinated by NAGT President Dorothy (Dottie) Stout, Cypress College, California, who has had abundant experience with geologic trips to our sites in Great Britain, Wales, and Scotland. The itinerary includes visits to the following geologically and historically colorful places: London, Chalk Cliffs, Lyme Regis, Sidmouth, Cornwall, Stonehenge, Bath, Isle of Arran, Parallel Roads of Glenroy, Hadrian's Wall, Great Glen Fault, Torridonians, Moine Thrust, Siccar Point, Edinburgh, and Newcastle-upon-Tyne. Full details available from GSA GeoVentures Coordinator.

Registration

Fee includes double occupancy lodging, ground transportation, all breakfasts plus 15 dinners and a farewell fête, entry fees, and theater tickets.
Airfare not included.

Open to all geologists and their friends.
GSA and NAGT members will enjoy a $100 special discount.
Minimum age: 21 years. Trip limit: 30 persons.

Fees and Deposit

Cost: $3090 (based on 25-person minimum)
Special for GSA and NAGT Members: $2990

A $250 deposit is due with your reservation.

GT913

Grand Canyon Adventure

FILLED. STANDBYS ACCEPTED. CALL TODAY.

An educational adventure: rafting, hiking, and camping
Sunday, July 14–Monday, July 22

Scientific Leaders:
George H. Billingsley, USGS, Flagstaff
William K. (Ken) Hamblin, Brigham Young University

Registration

Fee includes meals, tent and sleeping bag package, geologic materials, bus travel to and from Grand Canyon and Las Vegas.
Minimum age: 16 years. Trip limit: 35 persons.

Fees and Deposit

Cost: $1440
$100 less for GSA Members

$150 refundable deposit will hold a standby place.

GEOVENTURES REGISTRATION

REGISTER TODAY! CALL GSA GEOVENTURES
(Please have your credit card ready)

1-800-472-1988 or (303) 447-2020
Questions welcomed anytime

Non–U.S.-based registrants are encouraged to use GSA's fax number: 303-447-1133

Give name(s), address, phone, GeoVenture title, and credit card number