

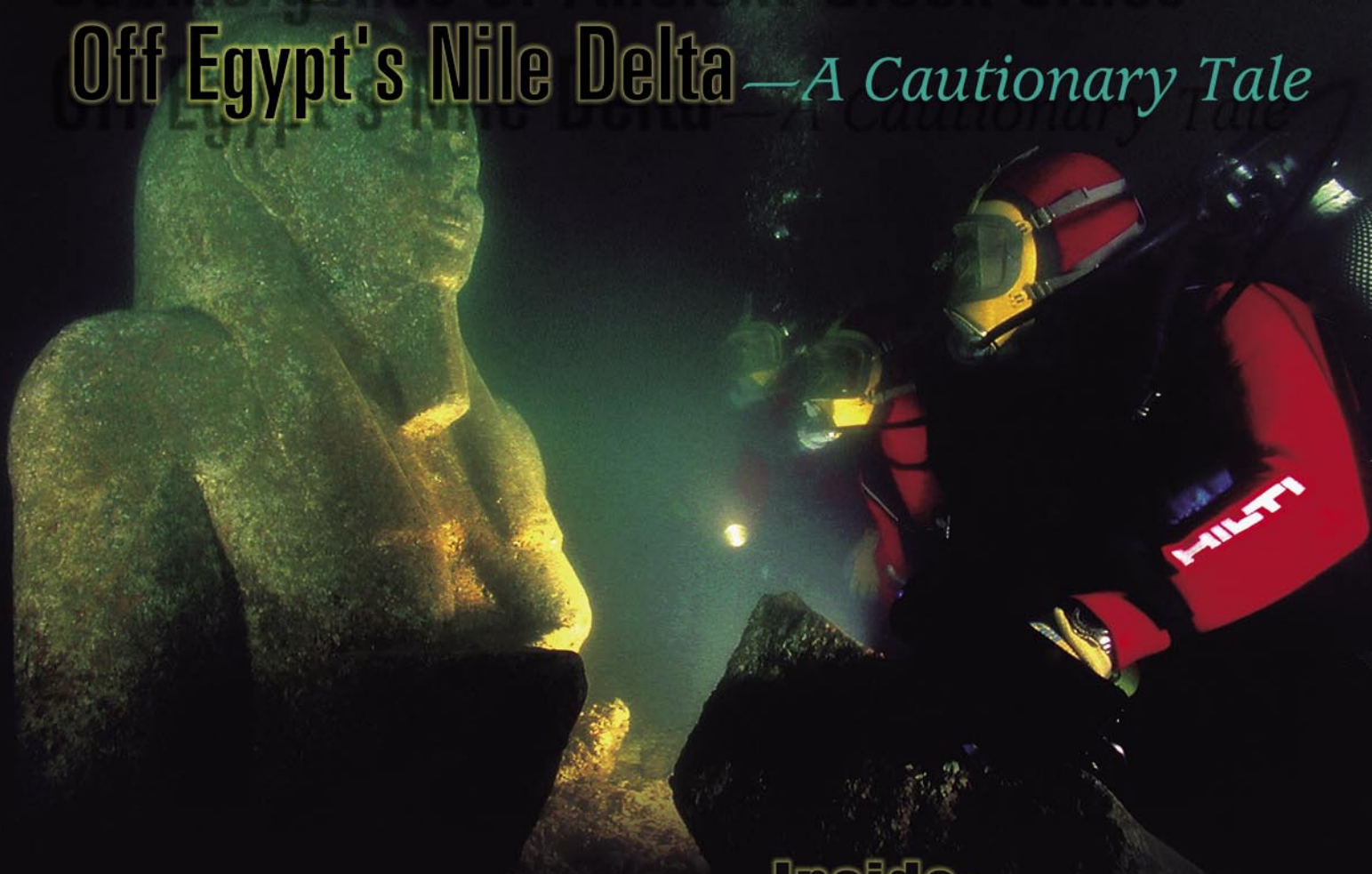
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JANUARY 2004

Submergence of Ancient Greek Cities Off Egypt's Nile Delta—*A Cautionary Tale*



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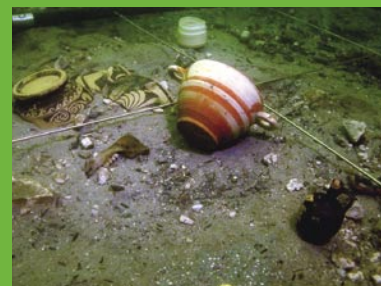
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Cover: Colossal statue of Hâpi, god of Nile flooding, in front of temple dedicated to Herakles at Herakleion. Right: Artifacts, including pottery from eastern Greece and coins, recovered at Herakleion. Photos courtesy of Christoph Gerigk, Franck Goddio and the Hilti Foundation. See "Submergence of ancient Greek cities off Egypt's Nile Delta—A cautionary tale," by Stanley et al., p. 4–10.



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Submergence of Ancient Greek Cities Off Egypt's Nile Delta—A Cautionary Tale

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ABSTRACT

This geoarchaeological analysis illustrates the extreme consequences that occur when protection measures related to coastal sites and associated environmental conditions are overlooked. Two ancient Greek cities, Herakleion and Eastern Canopus, originally occupied low-lying delta coastal areas along the Canopic channel of the Nile. Both were unprotected against flooding, earthquake, tsunami, and consequent subsidence. These sites, recently discovered in Abu Qir Bay on the northwestern margin of Egypt's Nile delta, were lowered a total of 8 m during the past 2500 yr, and now lie at water depths of 5–7 m. The two cities were located along the delta coast at river mouths that flooded annually, and man-made structures were built directly on underconsolidated sediment prone to geohazards. Processes leading to their submergence are interpreted on the basis of integrated archaeological, physiographic, geological (including cores), and geophysical (side-scan sonar, nuclear resonance magnetometer, high-resolution seismic) information. Gradual subsidence due to relative sea-level rise (eustatic rise, land lowering by sediment compaction) accounted for 4–5 m of submergence. Episodic failure during floods and earthquakes by loading and sediment remobilization of the water-saturated substrate upon which the cities were situated likely caused the additional 3–4 m of subsidence. Without foundations, pilings, dikes, or other protection measures, it is not surprising that the sites, over the long term, were

damaged and subsided completely into the bay. Ancient cities discussed here cause us to reflect on present-day site selection and construction practices in modern deltaic and associated wetland settings, and potential challenges related to substrate failure and other coastal hazards.

INTRODUCTION

Venice, Shanghai, New Orleans, and Bangkok are among better-known large population centers in low-lying coastal areas subject to submergence from natural (sea-level rise, land lowering) and anthropogenic (water pumping, load compression) processes (Milliman and Haq, 1996; Waltham, 2002). These

and other urban areas have undergone extensive hydrological and engineering studies to implement protective measures to mitigate geohazards (Barends et al., 1995). An example is recent approval for a complex system of locks to be emplaced in Venice lagoon to minimize flood and high-tide damage.

When left unchecked, the terminal consequences of flooding processes at coastal margins are extensive damage to cities and their eventual submergence. Here, we consider two such recently discovered examples, the Greek cities of Herakleion and Eastern Canopus, now entirely submerged in western Abu Qir Bay, Egypt (Fig. 1). These localities provide useful insights into what can be viewed as an extreme result of unfavorable site selection and absence of foundation protection measures. The cities were originally built on the Mediterranean coast east of the ancient city of Canopus (present Abu Qir), along Egypt's northwestern Nile delta (Constanty, 2002). Once located at outlets of the now-defunct Canopic distributary branch of the Nile River, both are currently at water depths of 5–7 m below sea level (Fig. 2).

Historic and stratigraphic documentation of the late Quaternary of the lower Nile delta is extensive. Much of what is known of the petrology of its sedimentary deposits has been obtained by

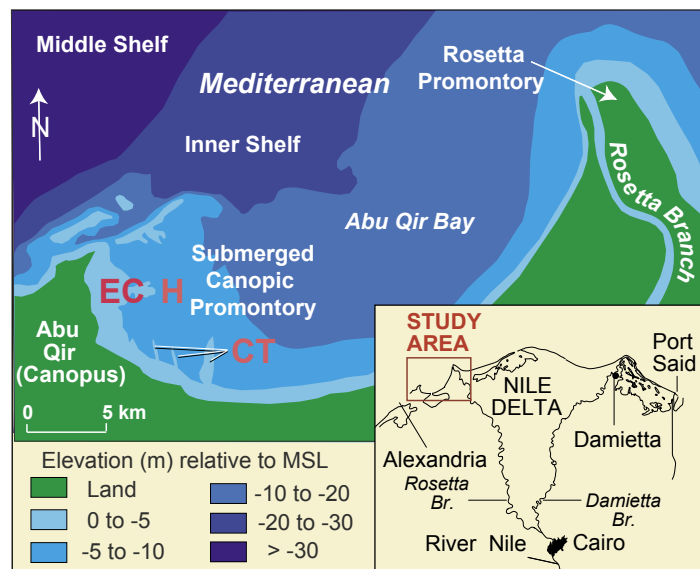


Figure 1. Abu Qir Bay on the northwestern margin of the Nile delta, Egypt. CT—traces of the relict Canopic branch, EC—Eastern Canopus, H—Herakleion.

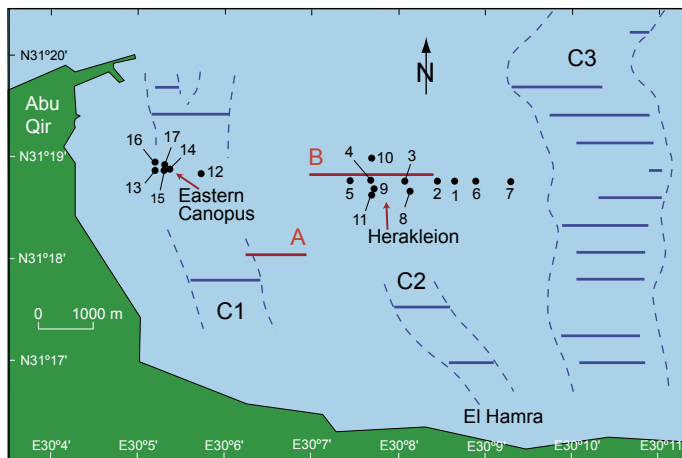


Figure 2. Western Abu Qir Bay, showing locations of Heracleion and Eastern Canopus and two selected high-resolution seismic profiles (red lines, shown in Fig. 4). Numbered dots show 17 vibrocore sites. Three Canopic sublobe channels (C1, C2, C3) are revealed by seismic profiles (blue lines) and cores detailed in Stanley et al. (2004); these channels once extended >5 km north of the present coast. Depth and horizontal scale in meters.

cores showing that the delta is formed largely of dark organic-rich silts of Holocene age, ranging in thickness from ~10 to ~50 m (Fourtau, 1915; Attia, 1954; Butzer, 1976). Radiocarbon dating of nearly 400 delta core samples serves as a prime chronostratigraphic base (Stanley et al., 1996). Extensive coring exploration indicates that a large proportion of unconsolidated deposits in the lower delta, within 30 km of the present coast, were originally laid down in shallow lagoons. Considerable published data is available on sediment deposition and delta margin evolution, as related to climatic, eustatic, fluvial, and coastal marine processes (Sestini, 1992; Said, 1993; Stanley and Warne, 1998). This information, serving to define the three-dimensional (temporal, aerial) anatomy of the late Quaternary delta, is also used as the base for the present and ongoing study in the bay (Stanley et al., 2004).

Heracleion and Eastern Canopus were established as navigational centers along mouths of the Canopic when this was the largest Nile delta branch and

the delta shoreline was located ~5 km north of the present coast (Fig. 2). The cities were primary gateways to northern Egypt, where goods were transported to the major Greek trading center of Naukratis in the delta proper, about 55 km inland from the present coast (Coulson and Leonard, 1979). Historical documentation in conjunction with archaeological information indicates that Heracleion (Fig. 3) was active from about the sixth century B.C. to the first century A.D. Eastern Canopus, the younger city, disappeared after Greek, Roman, and Byzantine rule and shortly

following the Arab conquest (Bernard, 1970). This is substantiated by writings of Sophronius of Jerusalem, who indicated that a temple dedicated to Christian Evangelists in Eastern Canopus was still upright at the beginning of the seventh century A.D. At that time, it was located on a beach with marine waters lapping against its base and coastal sand accumulating along part of its foundation (Toussoun, 1934). Dated gold coins discovered at the site indicate that the temple's final destruction and submergence occurred in the mid-eighth century A.D. (Stanley et al., 2001).

Processes that induced submergence of the two cities in Abu Qir Bay are interpreted on the basis of integrated archaeological information (1996–present), close-grid bathymetric, magnetometer, and side-scan sonar exploration (in 1996 and 1997), high-resolution sub-bottom seismic survey (in 2000), and sediment vibrocore recovery (in 2001).

GRADUAL SUBMERGENCE

Abu Qir Bay occupies an area that is only moderately active tectonically (Kebeasy, 1990) and is subject to recent loading and sediment compaction from large depositional input at Canopic channel mouths (Hassouba, 1980). High-resolution seismic profiles (Triton EdgeTech XStar system) show the configuration of the ~3–15 m thick Holocene sediment section of Nile derivation in the 50-km-long bay. The pro-

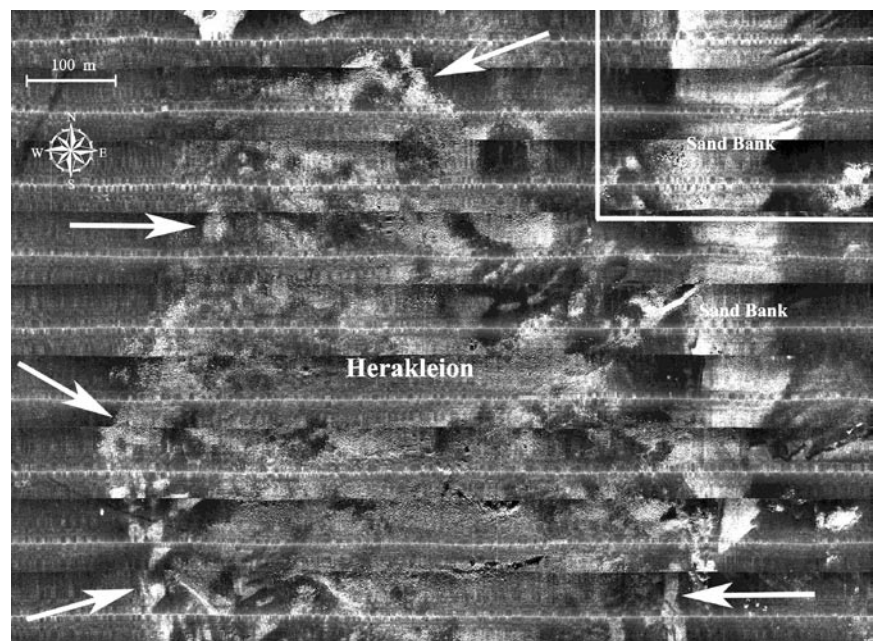


Figure 3. Side-scan sonar image partially shows the oval configuration of Heracleion ruins (arrows delineate general city limits) at water depths of 5–7 m. Diver exploration shows feathery patterns in upper right panel are tilted and uplifted mid-Holocene strata exposed on the bay floor. Each side-scan swath = 80 m.

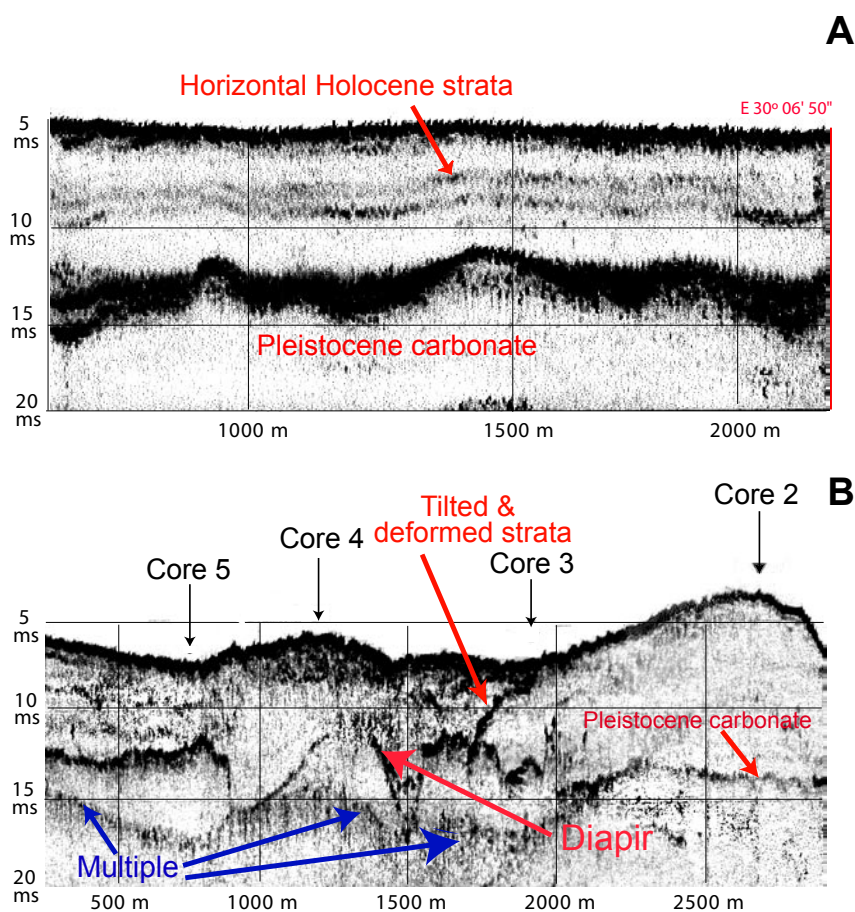


Figure 4. High-resolution profiles in Abu Qir Bay (location in Fig. 2) showing (A) Holocene horizontal strata above Pleistocene limestone base, between Herakleion and Eastern Canopus, and (B) tilted and deformed Holocene substrate directly under Herakleion ruins. Depth in milliseconds (10 ms = 7.5 m); horizontal scale at base of profiles in meters (vertical exaggeration ranges from 40 (in A) to 80 (in B)).

files, collected along 15 N-S and 22 E-W oriented transects, are spaced from 100 to 1000 m apart (Stanley et al., 2004); they account for ~350 km of profile lines covering an area of nearly 100 km² (Fig. 2). The basal consolidated Pleistocene carbonate unit, subaerially exposed until about 10,000–8000 years ago, forms a blocky configuration (Fig. 4; note strong, well-defined basal seismic reflectors). The overlying Holocene sediment, comprised of silty muds and sands, began to accumulate about 7500 years ago, when post-glacial rise of sea level had nearly reached its present stand (Stanley and Warne, 1994). This sediment section in the bay thickens toward the east, covering Pleistocene carbonates.

More than half of the bay is covered by near-horizontal stratified Holocene deposits that parallel and subparallel the seafloor surface (Fig. 4A). Gentle down-

ward-bowing of recent sediment sections is a function of rapid deposition, compaction, and weighting of the late Holocene section at former Canopic mouths. Core analysis indicates these are flat-lying strata of Canopic delta sublobes (mostly wetland deposits). During the past 13 centuries, strata were submerged by two gradual processes: eustatic (world) rise in sea level and concurrent lowering of land. The eustatic sea level component at that time accounts for a rate of rise of ~1 mm/yr in this Mediterranean region (Milliman and Haq, 1996). Moreover, the delta margin in the study area concurrently subsided at a rate of ~1 mm/yr (Chen et al., 1992; Sestini, 1992; Warne and Stanley, 1993), resulting in a relatively rapid cumulative rise of 2 mm/yr. This rate approximates the average ~2.5 mm/yr measured for the lower Nile delta margin as a whole, and accounts for a

gradual but substantial long-term submergence component at both Herakleion and Eastern Canopus.

For more specific measurement of gradual submergence, three factors are assumed. (1) Large human-made structures at the two sites were originally emplaced at the maximum land elevation of 2 m above mean sea level (m.s.l.) (i.e., above the adjacent delta wetlands of lower [<1 m above m.s.l.] elevation). (2) A value of 6 m below m.s.l. is used for the average depth of submerged ruins presently on the bay floor. These two factors account for a total lowering of ~8 m. To measure the subsidence rate at Herakleion, it is also assumed that initial construction began after Pharaoh Psamtik (Psammetichos) I authorized Greek merchants to trade in Egypt in the seventh century B.C. It is probable that settlement was well under way by the sixth century B.C., during the reign of Amasis, when ships traveled to the port of Naukratis (Coulson and Leonard, 1979). Thus, (3) the time between construction and present discovery of ruins in the bay is ~2500 years.

About 12 centuries elapsed between construction at 2 m above m.s.l. in the sixth century B.C. and the time when Sophronius of Jerusalem described the temple of the Evangelists as still standing at the shoreline at the beginning of the seventh century A.D. (Bernard, 1970). This records a relative sea-level rise of ~2 m in 1200 years (i.e., a minimal mean rate of rise of 1.7 mm/yr). A comparable rate of annual relative sea-level rise (2.0 mm/yr) for this region has been calculated independently on the basis of radiocarbon-dated cores for the mid to late Holocene period, including the time span from 700 A.D. to the present (Chen et al., 1992; Warne and Stanley, 1993). By applying the value of 2.0 mm/yr during the past 13 centuries (from Byzantine time to present), an additional amount of relative sea-level rise of 2.6 m is derived. This would account for submergence of 4.6 m in 2500 years, or only somewhat more than half of the total lowered elevation (~8 m) since initial construction at Herakleion. The gradual rise component would have caused submergence of large areas of low-lying delta margin and considerable shoreline retreat in a southward (landward) direction.

Thus, gradual processes alone would not explain the lowering to ~6 m below m.s.l. Submergence to this depth by only relative sea-level rise would have required a mean annual sea-level rise of at least 3.2 mm/yr, or one much higher than calculated (1.7–2.0 mm/yr) on the basis of radiocarbon-dated core sections and archaeological finds. Or, alternatively, an additional 1500 years (not 2500, but at least 4000 years) would have been needed for a total gradual lowering of the structures by 8 m at the calculated average rate of 2.0 mm/yr. In sum, sea-level rise and gradual sediment compaction account for little more than half of total submergence (4–5 m of the 8 m) in 2500 years. Nevertheless, sea-level rise of this magnitude would have induced migration of channels, delta lobes, and the coastal margin in this region. Seismic profiles and shallow-water coring indicate that at least three shifts of major Canopic channels occurred since the mid-Holocene (Stanley et al., 2004): two older channels were mapped in the western bay, one flowing toward Herakleion and the other toward Eastern Canopus prior to 2500 yr B.P. (Fig. 2, C1 and C2). A third, younger channel (Fig. 2, C3) is detected to the east, in the central bay (El-Bouseily and Frihy, 1984; El Fattah and Frihy, 1988; Chen et al., 1992).

RAPID SUBSTRATE FAILURE

In light of the above findings, other mechanisms in addition to gradual submergence must have contributed to lowering of sites to their present depths. A significant clue is provided by the Holocene sediment substrate observed specifically under Herakleion and Eastern Canopus (each area covers ~1 km²) that is highly disturbed by offset, tilted, uplifted, and/or lowered strata recorded on seismic profiles (Fig. 4B). Also noted are diapirs, large domed, post-depositional, squeezed-upward sediment features, growth and normal faults, and scarps. The bedding, originally laid down horizontally at and seaward of the delta mouths, was deformed by syn- and post-depositional events. Of note are exposed strata on the bay floor of mid-Holocene or older age (tilted and diapiric) uplifted to the bay floor, as noted on side-scan sonar images (Fig. 3) and on seismic profiles

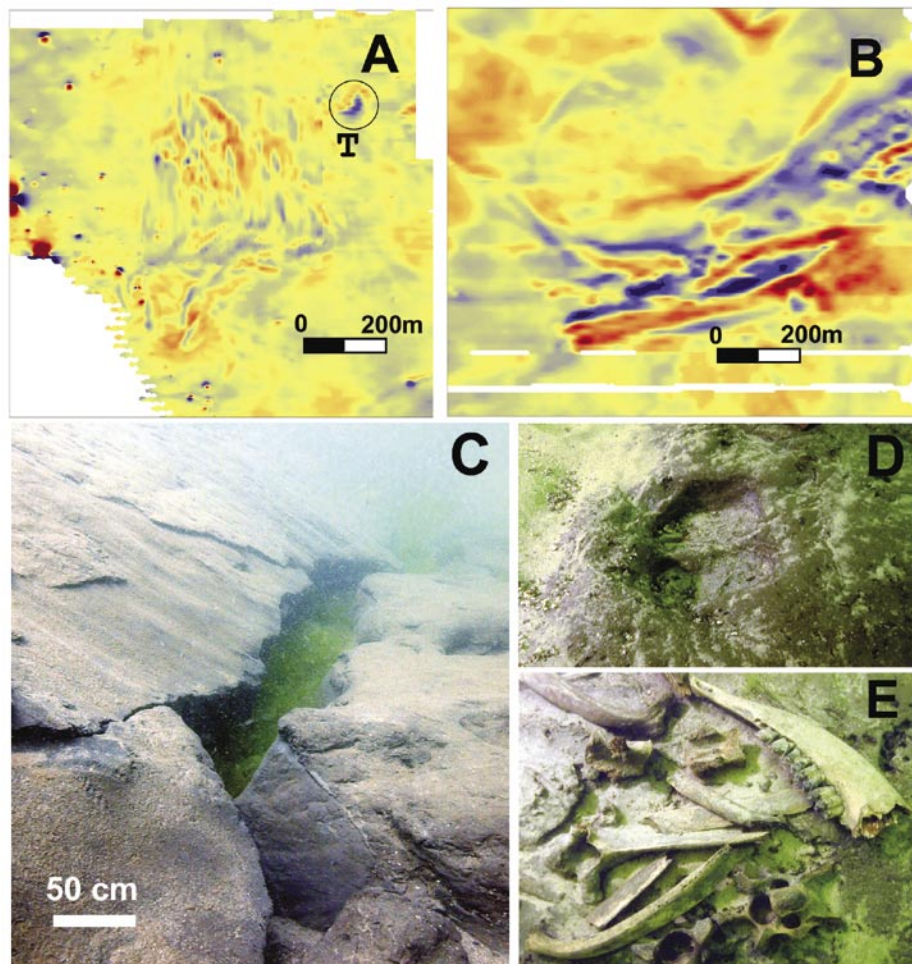


Figure 5. Evidence of important substrate failure restricted to areas underlying the two cities in Abu Qir Bay. **A:** Resonance magnetometer survey showing distinct N-S and E-W anomalies and the diver-excavated trench (T) at Eastern Canopus (details in C–E). **B:** ENE-WSW trending anomalies in the Herakleion area (areas affected in A and B are ~1 km²). **C:** Bay-floor photograph showing base of trench (fault scarp) after removal by divers of artificially-introduced sand fill; note rectilinear fault-like feature in the firm mud base of the trench (~50 cm wide and deep). **D:** Cloven-hooved bovid (probably cow) track in mud at bottom of trench. **E:** Antelope bones in trench base (radiocarbon dated to first century A.D.).

(Fig. 4B). Such offset affected deeper (including early to mid-Holocene) layers that once lay well beneath (at least 5 m) the two cities.

Moreover, a nuclear resonance magnetometer survey (which images differences in density in the shallow subsurface) of the entire western bay (method and coverage detailed in Stanley et al., 2004) was made to detect anomalous signals that record marked natural and anthropogenic features otherwise not visible on and within the Holocene cover in the study area. It is of note that the only two major distinct anomalies were those observed at the seafloor in the immediate vicinity of the two submerged cities (Fig. 5: in A, oriented E-W and N-S; in B, NE-SW). Although the anomaly at locality T at Eastern Canopus (Fig. 5A) is well defined on the

records, exploration of this seafloor area showed only a smooth, sand-covered surface. Diver excavation at anomaly T, located near a large temple, identified a long (~100 m), well-defined trench buried in the underlying Holocene mud substrate (Fig. 5C). Cleared of overlying sand, this curvilinear trench is V-shaped in cross section, about 5 m wide at the top and 2 m deep from the bay floor surface to its base. Moreover, a well-defined, rectilinear fault break (~50 cm wide and deep) is present in the mud that forms its base (Fig. 5C). Diver surveys, along with grain size and compositional analyses of the sand, indicate that the trench (a probable fault scarp; cf. Coleman, 1988) had been artificially filled with sand when the adjacent man-built structures were at the coast and still positioned at an elevation above sea

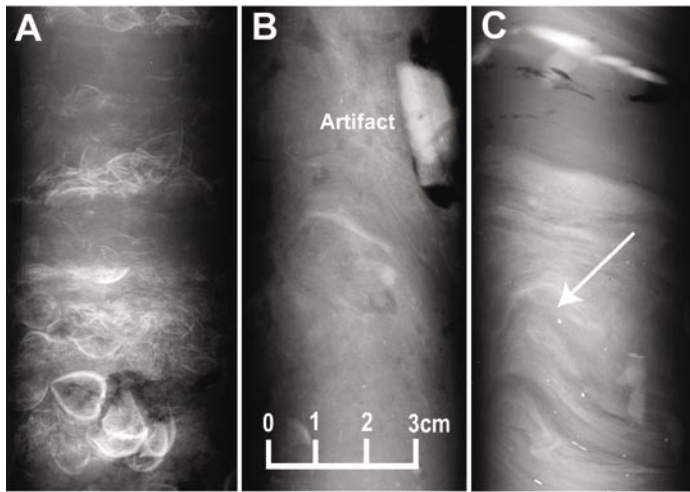


Figure 6. X-radiographs of split-core sections in study area (core sites in Fig. 2). **A:** Core 15 (depth ~110 cm from core top), showing typical delta wetland facies comprising bedded shell horizons in organic-rich silty mud matrix. **B:** Core 5 (depth ~13 cm from core top), with potsherd artifact in sediment-remobilized mud section. **C:** Core 9 (depth ~100 cm from core top), illustrating fluidized section with well-developed flame structure (arrow).

level (Stanley et al., 2001). Additionally, the trench walls were originally lined with mats of fresh and brackish water plants, mainly phragmites, before sand was added in the depression. Well-preserved cloven-hoofed bovid tracks (Fig. 5D) and bones of an antelope (dated to the first century A.D.) were also present on the trench floor (Fig. 5E).

Sediment vibracores (lengths 1.5–5.5 m) were collected at and between the two ancient cities in the study area (Fig. 2). Seven of the 17 core localities were positioned at Herakleion (numbers 3–5 and 8–11), four at and near Eastern Canopus (14–17), and six in bay sectors away from the two submerged sites (1, 2, 6, 7 east of Herakleion, and 12 and 13 between Herakleion and Eastern Canopus). A thin (<1.0 m), surficial marine sand layer at most core tops contains terrigenous components of Nile derivation, carbonate particles, and shell debris of mollusks and other organisms. This sand covers typical delta wetland and margin lithologies: fine to medium grain sand, moderately to well sorted and laminated; dark organic-rich mud (silt and clay components), uniform and non-laminated; mud formed of well-laminated alternating silt and clay; and fine-grained mud with interbedded whole and broken mollusk shells (Fig. 6A).

In six of the 17 borings, there are contorted units (~30–60 cm thick) that show soft-sediment deformation. Contorted strata formed of mud and sand show vertical sediment flow (Fig. 6B) and flame (Fig. 6C) structures, evidence of sediment remobilization (including fluidization) where water-saturated material has flowed upward in liquid-like fashion. They occur in cores 3, 5, 7, and 9 at and near Herakleion and in cores 15 and 16 at Eastern Canopus. Moreover, unusually old radiocarbon dates, ranging from >5000 to ~6880 yr B.P. (uncalibrated dates), were obtained for samples near core tops at both archaeological sites (Stanley et al., 2004). In contrast, much younger dates (to 1980 ± 40 yr B.P.) were obtained in the upper parts of some cores collected in the bay away from

the ruins (e.g., core 13). Samples of peat and organic-rich sediment were also collected by divers in the substrate just beneath archaeological structures at the bay floor. Of 12 such samples, three were dated at ~2000 yr B.P. and five from 2250 to 2360 yr B.P., and these eight appear consistent in that they are within an expected age range for the substrate of a Hellenistic settlement. However, four of the 12 surficial samples were older: one >3130 yr B.P.; and three much older, to 6750 yr B.P. Thus, some unexpectedly old (mid to late Holocene) deposits that lie immediately beneath the two ancient cities probably resulted from tilting to the bay floor (Fig. 4B) and sediment remobilization (Fig. 6, B and C). Moreover, mollusks and microfauna (ostracods, foraminifera) collected in these same core samples are primarily mixes of brackish and fresh-water delta margin species, with only small proportions of open-marine bay forms (M.P. Bernasconi, R. Mellis, and N. Pugliese, 2003, personal commun.).

The disturbed beds, restricted to substrates of the two settlements, were originally deposited close to distributary mouths in Canopic deltaic sublobes. During high and extremely high flood stages, delta mouth settings are characterized by increased outflow velocities, bed shear, and fluid turbulence,

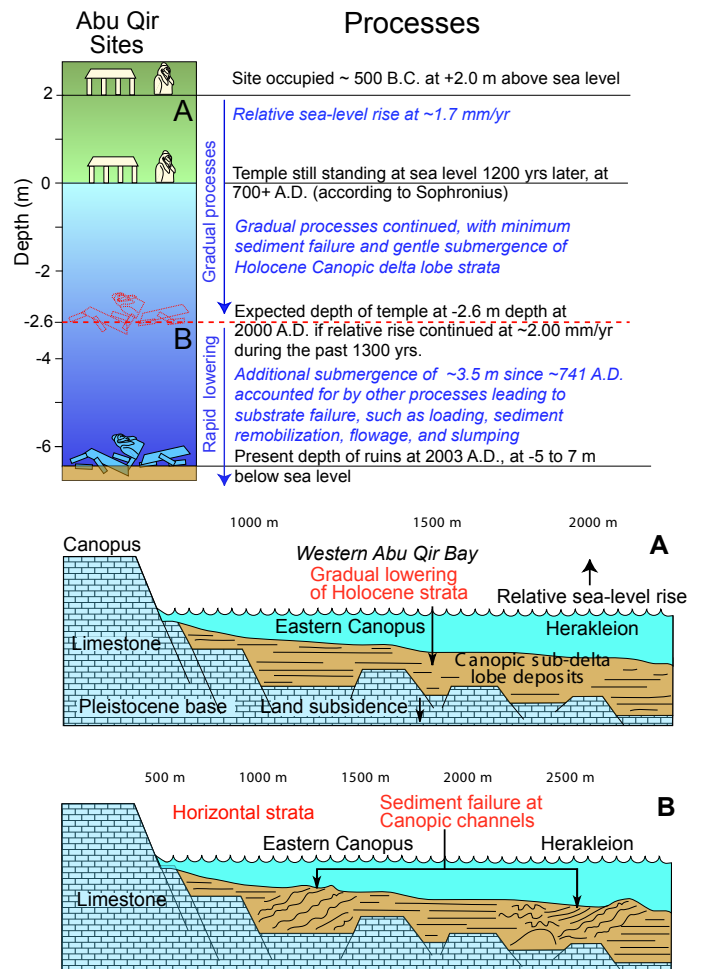


Figure 7. Interpretation of processes that submerged Herakleion and Eastern Canopus to depths of 5–7 m below sea level, from ca. 500 B.C. to the present. Processes involved: **(A)** gradual lowering of strata (as in Fig. 4A) and substrate failure (as in Fig. 4B). Discussion in text.

along with increased and commonly prolonged discharge of denser sediment-laden river waters (Wright and Coleman, 1974). Some water-saturated muds that lose coherence are squeezed upward by differential loading (Fig. 4 B), especially where layers of sandy deposits are added, such as along an advancing river channel and seaward of the mouth (Morgan et al., 1963; Coleman and Wright, 1975). Even in tectonically tranquil regions and on horizontal surfaces, such sediment records rotational slumping, mud flow (Wright and Coleman, 1974; Coleman, 1988), growth, and normal fault offset (Maestro et al., 2002). Sudden sediment displacement commonly occurs from subaerial and submerged natural levees (elevations of +2 to -2 m), displacing strata to the adjacent deeper seafloor.

In addition to natural processes, it is highly probable that subsidence at Herakleion and Eastern Canopus occurred from placement of heavy structures, such as temple columns and large walls, directly on the under-consolidated mud substrate. Even when positioned on special raft foundations, buildings underlain by soft, compressible mud in such settings can subside by 3 m or more in less than a century (Waltham, 2002). Surveys of the two cities made thus far, however, indicate no evidence of solid foundations or pilings emplaced beneath massive structures, including granite columns. Thus, while sites were still occupied, some structures probably tilted or failed under their own weight, thus requiring periodic readjustment or abandonment, even before the overall settlement areas were finally covered by the bay waters.

CONCLUSIONS AND RAMIFICATIONS

Submergence of Herakleion and Eastern Canopus to their present depth involved (1) gradual relative sea-level rise and land subsidence in Abu Qir Bay (Fig. 7A), plus (2) periodic failure events involving lateral displacement of unstable water-saturated sediment at Canopic mouths (Fig. 7B). Geological exploration together with analysis of archaeological data indicate that at least some destruction of settlements and subsidence occurred abruptly. Evidence for sudden and unexpected substrate

shifts includes human skeletal remains and gold, jewelry, statuary and other valuables discovered beneath damaged and toppled walls.

Rapid episodic subsidence would have occurred at Canopic mouth settings, in part, from rapid accumulation of water-saturated sediment, depositional loading, and associated conditions of sediment remobilization that commonly prevail in deltaic settings. Floods, so critical for development of Egyptian civilization, occurred each year in late summer to fall, and their levels were carefully recorded (Popper, 1951). Exceptionally high annual floods are correlated with climatic fluctuations in central and east Africa (Shahin, 1985; Said, 1993). Sudden weighting on unstable channel mouth deposits during, or subsequent to, flood stage was a likely trigger of sediment failure. In the first century A.D., high floods of this type would likely have affected Herakleion by inducing channel migration, substrate failure, and damage to structures. Final destruction of Eastern Canopus is attributed to a particularly high Nile flood (~1 m higher than normal high flood stage) in 741 or 742 A.D. (Stanley et al., 2001), a hypothesis supported by data from the Roda Nilometer in Cairo (Popper, 1951).

Sediment subsidence at these localities may not necessarily have resulted from a single catastrophic event but perhaps a sequence of episodic events. Earthquake tremors possibly also affected the Abu Qir Bay area. Seismo-archaeological surveys in sectors of the Eastern Mediterranean have suggested that the period from the fourth to sixth centuries A.D. was one of unusual clustering of destructive earthquakes (Pirazzoli, 1986; Stiros, 2001). An example of such an event is provided by the August 17, 1999, earthquake that resulted in massive damage of structures and sudden subsidence at Izmit, a Sea of Marmara coastal city in northwestern Turkey (Holzer et al., 2000).

A natural devastating event such as an earthquake or tsunami that could have destroyed these cities likely would have been recorded in historic accounts, but no earthquake activity, for example, is recorded in Egypt during the 741 or 742 A.D. period (Guidoboni, 1994). Moreover, we believe effects of earthquakes and tsunamis would be

observed not only in deposits forming the substrate specifically beneath ruins of the two ancient cities built at river mouths (Fig. 4B), but over a much broader area of the bay and adjacent delta margin. This latter observation, however, is not the case (see Fig. 4A; Stanley et al., 2004).

Combined effects of gradual and sudden events likely resulted in lowering of some settlement areas below the waves, while other parts of the cities remained inhabited on low islands, perhaps as Herodotus described Herakleion around 450 B.C. Recovery of archaeological artifacts such as Byzantine and Arabic coins at Eastern Canopus indicates that habitation of some partially submerged islands in the bay may have continued for decades, or even centuries, following major phases of submergence and abandonment of parts of the original cities.

This geoarchaeological analysis illustrates extreme consequences that occur when carefully implemented protection measures related to coastal sites and associated environmental conditions are overlooked. In the examples presented here, the Greeks and subsequent inhabitants built and maintained their sites on unstable wetland sediment, without foundations and pilings, at distributary mouths that experienced powerful annual Nile floods. Given the remarkable Greek and Roman building and engineering tradition, it is difficult to fully comprehend the decisions that led to emplacement of large, monumental structures directly on underconsolidated and unstable sediment prone to soil instability and associated geohazards. Most likely, this action was taken for specific economic gains and advantages, including collecting tolls and associated trade benefits; ramifications for the long-term were not likely a prime consideration. At this point, it is easy for us to look back two millennia and find fault. However, we know that Greek and Roman engineers were accustomed to other geohazards, such as earthquakes, in many of their population centers landward of the coast where they usually built on a solid base. They were less accustomed to repairing damage caused by coastal geologic factors, and had not fully acquired the experience to foresee hazards associated with floods, storm surges, tsunamis, and sea-level rise.

Moreover, they had not acquired building techniques, such as deep pilings, for construction of heavy structures on soft-sediment based deltaic sites and the building of protective dikes and polders. It is remarkable that, in spite of these deficiencies, the sites at the Canopic mouths remained active for several centuries.

Some old but still active cities in deltaic and wetland settings, such as Venice, are facing comparable hazards. Although remaining extremely vulnerable to coastal geohazards, most have not yet reached the ultimate phase involving toppling of structures followed by complete submergence, as experienced by Herakleion and Eastern Canopus. What is perhaps even more surprising is that, in so many cases, engineers and municipalities still do not fully implement appropriate protection and construction measures, after centuries of building and engineering experience since Hellenistic time. Perhaps the cautionary tale is the extent to which short-term economic exigency remains a recurring element in our cultural and historic traditions.

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JOINT MEETING

Rocky Mountain (56th Annual) and Cordilleran (100th Annual) Sections, GSA

Boise Centre on the Grove, Boise, Idaho

May 3–5, 2004

www.geosociety.org/sectdiv/rockymtn/04rmcdmtg.htm

The 2004 annual meetings of the Rocky Mountain and Cordilleran Sections will be held jointly at the Boise Centre on the Grove, hosted by the Department of Geosciences, Boise State University. Up-to-date information about the meeting can be found at www.geosociety.org/sectdiv/rockymtn/04rmcdmtg.htm or <http://earth.boisestate.edu/GSA2004/>.

ENVIRONMENT

Boise, Idaho's capital and largest city, consistently ranks high on lists of the most livable cities in America. The City of Trees is named in part for the lush riparian environment of the Boise River flowing through town. The city's greenbelt provides more than 20 miles of trails along the river, allowing for hiking, biking, and access for fly fishing. The Boise Foothills to the north provide an alternative arena for outdoor activities and are one reason for Boise's high ranking in mountain biking magazines.

In early May, Boise has daytime highs averaging in the upper 60s to low 70s, with nighttime lows averaging in the high 30s to low 40s. Sunshine reigns here.

Boise is easily accessible by air and is serviced by six major carriers and their regional affiliates. The meetings are being held in the Boise Centre on the Grove, located in the heart of downtown within easy walking distance to hotels, restaurants, the greenbelt, and the foothills.

CALL FOR PAPERS

Papers are invited for a variety of topical sessions (oral and poster), including symposia, theme sessions, and various general technical sessions. Authors interested in volunteering papers for symposia should contact the appropriate convener prior to submitting an abstract. Oral presentations in most technical sessions will be 12 minutes in length, with three minutes for questions. Some sessions may be organized with a longer format (contact session chairs for details). All oral sessions will utilize a single digital projector and PowerPoint software. An overhead projector will also be available in each room. Use of 35 mm slides is discouraged and will only be accommodated by special arrangement with the session chair. Poster space will be 4 × 8 feet, and authors will be required to be present at their poster for at least two hours.

REGISTRATION

Preregistration Deadline: March 29, 2004

Preregistration Fees

	FULL MEETING	ONE-DAY
Professional Member	\$100	\$70
Professional Member (70 and older)	\$70	\$55
Professional Nonmember	\$110	\$75
Student or Associate Member	\$60	\$40
Student Nonmember	\$70	\$45
K–12 Professional	\$35	N/A
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GSA headquarters will handle registration. Preregister to qualify for lower fees. Please register online at www.geosociety.org. If you need assistance, please contact GSA Member Services, 1-888-443-4472, gsaservice@geosociety.org.

On-site Registration Schedule

Sun., May 2.....	4–8 p.m.
Mon., May 3.....	7:30 a.m.–4:30 p.m.
Tues., May 4.....	7:30 a.m.–4:30 p.m.
Wed., May 5.....	7:30 a.m.–noon

ACCESSIBILITY

GSA is committed to making its meetings accessible to all people interested in attending. Please indicate special requirements (wheelchair accessibility, etc.) on the registration form. The Boise Centre on the Grove is ADA compliant.

FIELD TRIPS

For further details on field trips contact either the field trip leader or the field trip chair, Spencer Wood, (208) 426-3629, swood@boisestate.edu.

PREMEETING

- The Rattlesnake Tuff and Other Miocene Silicic Volcanism in Eastern Oregon.** May 1–2. Martin Streck, Portland State University, Portland, Oregon, 97207-0751, (503) 725-3379, streckm@pdx.edu; Mark Ferns, Oregon Department of Geology and Mineral Industries, Burns, Oregon, (541) 523-3133, mark.fern@state.or.us.

Relicts of extensive middle to late Miocene rhyolitic eruptions are exposed in a part of eastern Oregon situated between the Owyhee Plateau to the south, the High Lava Plains to the west, the Blue Mountains Province to the north, and the western Snake River Plain to the east. We'll examine some of the large (really, really large) rhyolitic ash-flow tuffs, lava flows, and domes that began erupting after the main stages of Columbia River Basalt volcanism to the north and Steens Basalt volcanism to the south as we traverse this largely ignored (geologically) part of Oregon. One main focus during the trip will be the youngest

voluminous ash-flow tuff, the ca. 7 Ma Rattlesnake Tuff, whose exceptional lithological and petrological characteristics will be examined from near vent proximal outcrops at Burns to distal outcrops near John Day. Come prepared to ponder the significance of these large silicic eruptions and their relationship to middle Miocene flood basalt magmatism.

Leave Boise Convention Center at 8 a.m., May 1, return at 6 p.m., May 2. Overnight in Burns, Oregon. Limit 26. Cost: \$120 (includes lunches, lodging, transportation, and guidebook).

2. **Upper Paleozoic Continental Margin Tectonics of the Western U.S.: Tectonostratigraphic Framework of Nevada: Elko Area.**

Cosponsored by the Paleontological Society. April 30–May 2. James H. Trexler, trexler@mines.unr.edu, (775) 784-1504, and Patricia H. Cashman, pcashman@mines.unr.edu, (775) 784-6924, Dept. of Geological Sciences, University of Nevada, Reno, NV 89557; Walter S. Snyder, National Science Foundation, Washington, D.C., wsnyder@nsf.gov, (703) 292-4742.

We'll look at the evidence for several late Paleozoic deformation events that occurred between the Antler and Sonoma orogenies. This evidence includes the sedimentology and structure of Mississippian, Pennsylvanian, and Permian strata in the vicinity of Elko and Carlin, Nevada. Localities we will visit preserve data that constrain the kinematics of folding and thrusting, and the precise timing of angular unconformities that mark the deformation events.

Leave Boise Convention Center, April 30, 1:30 p.m., return May 2 at 4:30 p.m. to Boise. Overnight two nights in Elko, Nevada. Limit 26. Cost \$260 (includes lunches, lodging, transportation, and guidebook).

3. **Fire and Ice in Central Idaho: Modern and Holocene Fires, Debris Flows, and Climate in the Payette River Basin, and Quaternary and Glacial Geology in the Sawtooth Mountains.**

May 1–2. Jennifer Pierce, jpierce@unm.edu, (505) 277-2430, and Grant Meyer, gmeyer@unm.edu, (505) 277-5384; Dept. of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131-1116; Glenn Thackray, thacglen@isu.edu, (208) 282-3560, Dept. of Geosciences, Idaho State University, Pocatello, ID 83209-8072.

This two-day trip will highlight impressive recent and Holocene fire- and storm-related debris flows in the Payette River region and geomorphology and geology of alpine glaciations in the spectacular Sawtooth Mountains and Stanley Basin in central Idaho. Storm events following recent fires in the South Fork Payette basin have produced new deposits and have exposed Holocene fire-related debris flow and flood sediments and other alluvial fan-building deposits that yield insights into Holocene environmental change. After an overnight stay in Stanley, Idaho, we'll examine moraine characteristics and sediment cores from the southeastern Sawtooth Mountains and Stanley Basin which provide evidence of Late Pleistocene alpine glaciation. A combination of these glacial records with reconstructions of regional equilibrium line elevations produces late-glacial paleoclimatic inferences for the area.

Leave Boise Convention Center at 8 a.m., May 1, return May 2 at 6 p.m. Overnight in Stanley, Idaho. Limit 26. Cost: \$135 (includes lunches, one night's lodging, transportation, and guidebook).

4. **Owyhee Mountains to the Boise Foothills: Geology Across and Under the Western Snake River Plain.**

May 1. Spencer Wood, swood@boisestate.edu, (208) 426-3629, Dept. of Geosciences, Boise State University, Boise, ID, 83725; Ed Squires, hydrologic@qwest.net, Hydrologic, Inc., 1002 Franklin St., Boise, ID 83702.

One-day trip exploring the sedimentary record of Neogene Lake Idaho along the edges of the western Snake River Plain. Trip starts in the Miocene rhyolite of the Owyhee Mountains and then examines sediments, volcanic ash beds and a giant pumice-block layer in the overlying Chalk Hills Formation. The angular unconformity marking the transgression of the last filling of Lake Idaho, deposition of the Glens Ferry Formation and stratigraphic problems will be examined and discussed. Lunch break at the winery near Marsing and then travel across the plain to the Boise foothills. New seismic profiles, borehole geophysics, and studies of the fluvial and lacustrine aquifers that supply Meridian and Boise will be presented. We then examine the sedimentary record of Lake Idaho in the Boise foothills at localities of prodelta muds, Gilbert-deltas, and oolite beds. Trip will end at the Table Rock quarries for the Boise sandstone and a panoramic view of the Boise River valley terraces, Pleistocene lavas, and the western plain.

Leave Boise Convention Center at 8:30 a.m., return to Boise at 5:30 p.m. Limit 28. Cost \$50 (includes transportation, lunch, and guidebook).

5. **Exploring the Sedimentary Features of Hydrovolcanic Tuffs and Reconstructing the Evolution of the Emergent Tuff Cone at Sinkers Butte, Western Snake River Plain, Idaho.**

May 2. Brittany Brand, BrittanyBrand@mail.boisestate.edu, Dept. of Geosciences, Boise State University, Boise, ID 83725.

This one-day trip focuses on the sequence of basaltic hydrovolcanic deposits that erupted from a large emergent Snake River Plain volcano and now spectacularly well exposed in the walls of the Snake River Canyon. The trip offers the opportunity to view the complete sequence of deposits produced at this center, starting with the subaqueous tuffs and debris flow deposits that comprise the sublacustrine volcanic platform, continuing through a thick section of subaerial fall and surge deposits, and ending with strombolian scoria, spatter, and lava flows. We'll spend one day exploring these deposits, focusing specifically on the great variety of bedding types within the hydrovolcanic tuffs.

Leave Boise Convention Center at 8 a.m., return to Boise at 6 p.m. Limit 27. Cost: \$50 (includes transportation and lunch, and guidebook).

DURING MEETING

6. **Boise Geothermal Area, Idaho Territorial Penitentiary, and the Idaho Museum of Mining**

and Geology. David Leppert, geoleppert@aol.com, (208) 331-0259, Idaho Museum of Mining and Geology, Boise, ID 83702.

Three-hour trips during meeting to northeast Boise area to view foothills geology, the Boise Warm Springs Geothermal District, the Museum of Mining and Geology, and the 1860 Idaho Territorial Penitentiary constructed of the Miocene Boise sandstone. Cost includes transportation. May 3: leave Boise Convention Center at 2:30 p.m. and return at 5:30 p.m. Limit 28, Cost: \$10. May 4: leave Boise Convention Center at 9:30 a.m. and return at 12:30 p.m. Limit 28, Cost: \$10. May 5: leave Boise Convention Center at 9:30 a.m. and return at 12:30 p.m. A second trip leaves at 2:30 p.m. and returns at 5:30 p.m. Limit 28 people each. Cost: \$10.

POSTMEETING

- 7. Craters of the Moon and 20 years after the Borah Peak Earthquake: New Perspectives on Basaltic Volcanism of the Eastern Snake River Plain and a Field Guide to Surface-Rupturing Earthquakes along the Lost River Fault, Idaho.** Two and a half days. May 5–7. Leaders, Craters of the Moon area: Mel A. Kuntz, mkuntz@usgs.gov, (303) 236-1293, U.S. Geological Survey, Earth Surface Processes Team, P.O. Box 25046, MS 980, Denver, CO 80225; Doug Owen, National Park Service; Duane Champion, U.S. Geological Survey; Philip Gans, University of California, Santa Barbara; and Sarah Smith and Cooper Brossy, Bureau of Land Management. Leaders, Borah Peak earthquake: Kathy M. Haller, haller@usgs.gov, (303) 273-8600; Tony J. Crone, U.S. Geological Survey, Geologic Hazards Team, P.O. Box 25046, MS 966, Denver, CO 80225.

First day of this field trip will focus on the Holocene volcanism in and near Craters of the Moon National Monument. Trip will focus on integration of new ⁴⁰Ar/³⁹Ar ages, paleomagnetic data, and geologic mapping of the area around the margins of the Craters of the Moon lava field (1:100,000 geologic map) and on new insights about the processes of basaltic volcanism in Craters of the Moon National Monument. The second day of this trip will be dedicated to examining surface faulting from the 1983 event (*M*_s = 7.3) and the paleoseismic evidence for prehistoric events along this famous normal-fault system.

Leave Boise Convention Center at 4:30 p.m. on May 5, return to Boise at 7 p.m., May 7. Two overnights in Arco or Mackay. Limit 25. Cost: \$180 (includes lunches, two nights' lodging, transportation, and guidebook).

- 8. Miocene Snake River Plain Rhyolites of the Owyhee Front, Owyhee County, Idaho.** May 6–7. Bill Bonnicksen, Idaho Geological Survey, Moscow, ID 83843, billb@uidaho.edu; Mike McCurry, mccumich@isu.edu, (208) 282-3960, Dept. of Geosciences, Idaho State University, Pocatello, ID 83209-8072; Martha M. Godchaux, 927 East 7th St., Moscow, ID; mgodchau@mtholyoke.edu.

This two-day trip examines the many forms of rhyolite beautifully exposed along the north side of the Owyhee Mountains south of Boise. This group of rhyolite units seems to have been erupted over a short time after the

western Snake River Plain graben started to form and range between 11.7 and 10.6 Ma. We'll examine features of rhyolite lava flows, rhyolite spatter, clastogenic units, ignimbrites, domes, feeder dikes, and other features of the western Snake River Plain.

Leave Boise Convention Center at 8 a.m. on May 6 and return to stay in Boise by 6:30 p.m. Leave again from Boise Convention Center at 8 a.m. on May 7, returning to Boise at 6 p.m. Participants make their own arrangements for lodging the night of May 6 in Boise. Limit: 26. Cost: \$80 (includes lunch, transportation, and guidebook).

- 9. Owyhee Mountains to the Boise Foothills: Geology Across and Under the Western Snake River Plain.** (Repeat of premeeting trip; see description above.) May 6. Leave Boise Convention Center at 8:30 a.m., return to Boise at 5:30 p.m. Limit 26. Cost: \$50 (includes transportation, lunch, and guidebook).

ABSTRACTS

Abstract Deadline: January 27, 2004

Abstracts for all sessions should be submitted online at www.geosociety.org. If you cannot submit your abstract electronically, contact Nancy Carlson, (303) 357-1061, ncarlson@geosociety.org.

TECHNICAL SESSIONS

In addition to general technical sessions, the program will include a variety of symposia and theme sessions. Detailed description of symposia and theme sessions can be found at: www.geosociety.org/sectdiv/rockymtn/04rmcdmtg.htm or <http://earth.boisestate.edu/GSA2004/>.

SYMPOSIA

- 1. Geochemical and Geochronological Databases and the Science That Can Be Done with Them.** Allen Glazner, University of North Carolina, afg@unc.edu, (919) 962-0689; Doug Walker, jdwalker@ku.edu, (785) 864-2735.
- 2. Large-Volume Rhyolites of the Western USA: A Tribute to Bill Bonnicksen.** Michael McCurry, Idaho State University, mccumich@isu.edu; Eric Christiansen, Brigham Young University, eric_christiansen@byu.edu.
- 3. Building the Global Geologic Time Scale.** Cinzia Cervato; Iowa State University, (515) 294-7583, cinzia@iastate.edu; Bruce Wardlaw, U.S. Geological Survey; (703) 648-5288; bwardlaw@usgs.gov.
- 4. The Role of Science in Making Natural Resources Decisions.** David Applegate, American Geological Institute, applegate@agiweb.org, (703) 379-2480; Tammy Dickinson, National Research Council, tdickins@nas.edu, (202) 334-2744.
- 5. Paleontology and Geology of the Missouri River: Following the Footsteps of Lewis and Clark.** James E. Martin, Museum of Geology, South Dakota School of Mines and Technology, James.Martin@sdsmt.edu, (605) 394-2427; David C. Parris, Science Division, New Jersey State Museum, david.parris@sos.state.nj.us, (609) 292-6330.
- 6. Sardinia, Italy, and the Development of the Western Mediterranean Basin.** Paola Pittau, Università di Cagliari; pittau@unica.it; Asonio Ronchi, Università

di Pavia; geoars@unipv.it; Claude Spinosa, Boise State University, cspinosa@boisestate.edu, (208) 426-5905.


THEME SESSIONS

1. **Cordilleran Magmatism from the Forearc to the Hinterland.** Calvin Barnes, cal.barnes@ttu.edu, (806) 742-3106; Aaron Yoshinobu, aaron.yoshinobu@ttu.edu, (806) 742-4025; Keegan Schmidt, klschmidt@lscs.edu, (208) 792-2283.
2. **Products and Processes of Hydrovolcanism.** Craig White, Boise State University, cwhite@boisestate.edu, (208) 426-3633; Martha Godchaux, mgodchau@MtHolyoke.edu, (208) 882-9062.
3. **Biogeomorphology of River Systems.** Jim McKean, jmckean@fs.fed.us, (208) 373-4383; John M. Buffington, jbuff@uidaho.edu, (208) 364-4082; Charlie Luce, cluce@fs.fed.us, (208) 373-4382.
4. **Recent Advances and Discoveries in Quaternary Geology and Geomorphology from the West Coast to the Front Range.** Joel L. Pederson, Utah State University, bolo@cc.usu.edu, (435) 797-7097; Glenn D. Thackray, Idaho State University, thacglen@isu.edu, (208) 282-3560.
5. **Applications of Geophysics to Hydrogeology.** Warren Barrash, Boise State University, wb@cgiss.boisestate.edu, (208) 426-1229; William Clement, billc@cgiss.boisestate.edu, (208) 426-1419; John Bradford, jbradford@cgiss.boisestate.edu, (208) 426-2898.
6. **Headwater Hydrologic Processes.** Jim McNamara, Boise State University, jmcnamar@boisestate.edu, (208) 426-1354.
7. **A New Look at Old Mountains: Late Paleozoic Intra-plate Tectonics of the Greater Ancestral Rocky Mountains.** Charles F. Kluth, Colorado School of Mines, ckluth@mines.edu, (303) 904-2939; James H. Trexler Jr., University of Nevada, Reno, trexler@mines.unr.edu, (775) 784-1504.
8. **Rates, Magnitudes, and Tectonic Controls of Late Cenozoic Intra-plate Deformation within the Eastern California Shear Zone, Walker Lane, and Central Nevada Seismic Belt, Western U.S. Cordillera.** John S. Oldow, University of Idaho, oldow@uidaho.edu, (208) 885-7327 or (208) 882-6192; Patricia Cashman, University of Nevada, Reno, pcashman@mines.unr.edu, (775) 784-6924.
9. **Eocene Extension of the Northern Rocky Mountains Region.** David A. Foster, University of Florida, dfoster@geology.ufl.edu; Thomas J. Kalakay, Vanderbilt University.
10. **Proterozoic Geology of the Northwest U.S.: Basement and Tectonic Setting of the Belt Basin and Succeeding Windermere Supergroup.** Paul Karl Link, Idaho State University, linkpaul@isu.edu, (208) 282-3846; Reed S. Lewis, Idaho Geological Survey, University of Idaho, reedl@uidaho.edu, (208) 885-7472.
11. **Upper Paleozoic Biostratigraphy of the Western North America.** *Cosponsored by the Paleontological Society.* Tamra A. Schiappa, Slippery Rock University, tamra.schiappa@sru.edu, (724) 738-2829; Peter E. Isaacson, University of Idaho, isaacson@uidaho.edu, (208) 885-7969.
12. **Using the Local Geological Environment for Communicating and Teaching Earth Sciences.** Karen Viskupic, Boise State University, karenviskupic@boisestate.edu, (617) 216-4965; Charlla Adams, Boise State University, cadams2@boisestate.edu, (208) 426-1720.
13. **Undergraduate Research Poster Session.** *Sponsored by the Council on Undergraduate Research—Geoscience Division.* Kim Hannula, Fort Lewis College, hannula_k@fortlewis.edu, (970) 247-7463; Michelle Stoklosa, Boise State University, mstoklos@boisestate.edu, (208) 426-3645; Charlla Adams, Boise State University, cadams2@boisestate.edu, (208) 426-1720.
14. **State Geological Survey Cooperative Geologic Mapping Projects under STATEMAP and EDMAP.** Kurt L. Othberg, Idaho Geological Survey, University of Idaho, othberg@uidaho.edu, (208) 885-7560; John W. Shervais, Department of Geology, Utah State University, shervais@cc.usu.edu, (435) 797-1274.
15. **New Horizons in Mineral Deposits: Ore Genesis to Mine Closure.** Virginia S. Gillerman, Idaho Geological Survey, Boise, ID; vgillerm@boisestate.edu, (208) 426-4002; Greg Arehart, University of Nevada, Reno, arehart@unr.edu, (775) 784-6470.
16. **Remote Sensing, GIS, GPS, and Geodesy in Geology and Planetary Geology.** Nancy Glenn, Idaho State University, glennanc@isu.edu, (208) 685-6755; John Chadwick, Idaho State University, chadjohn@isu.edu, (208) 282-2949.
17. **The Yellowstone Hotspot Track: What Does It Signify?** Ken Pierce, kpierce@usgs.gov, (406) 994-5085; Lisa Morgan, lmorgan@usgs.gov.
18. **Links Between Thick- and Thin-Skinned Deformation in the North American Cordillera: Laramide-Sevier Revisited.** W.C. McClelland, Department of Geological Sciences, University of Idaho, wmcclell@uidaho.edu; J.W. Sears, Department of Geology, University of Montana, jwsears@selway.umt.edu.
19. **Stratigraphy, Sedimentology, Geochemistry, and Paleoclimatology of the Miocene Sedimentary Interbeds in the Columbia River Basalt Group of Idaho, Oregon, and Washington.** Shane V. Smith, Washington State University, svsmith@mail.wsu.edu, (509) 335-5986.
20. **Current Trends in Program and Curriculum Assessment in the Geosciences.** *Sponsored by the NAGT.* Mary Dowse, dowsem@silver.wnmu.edu, Western New Mexico University; Robert Eves, Southern Utah University, eves@suu.edu, (435) 586-1934; C. Frederick Lohrengel II, Southern Utah University, lohrengel@suu.edu, (435) 586-7941.

WORKSHOPS

1. **Digital Field Mapping.** Sun., May 2, 9 a.m.–5 p.m. Joan E. Fryxell, jfryxell@csusb.edu, and Mark P. Kumler, California State University, San Bernardino. An introduction to emerging technologies in real-time digital field

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mapping, including hands-on experience with some of the hardware and software available in this rapidly emerging aspect of geologic field work. Cost: \$30.

2. **New Satellite Data and Processing Techniques for the Field Geologist.** Sun., May 2, 8 a.m.–5 p.m. Tom Farr (JPL), and John Dohrenwend, johnd@mstcruiser.net. This workshop is an introduction to new satellite data sets and interactive computer processing techniques useful to the field geologist for mapping and analyses. Cost: \$125.
3. **Roy J. Shlemon Mentor Program in Applied Geoscience.** Sponsored by GSA Foundation. Mon., May 3, and Tues., May 4, 11:30 a.m.–1 p.m. Luncheon location information available at GSA's registration desk. Karlon Blythe, kblythe@geosociety.org. This interactive and informative program for undergraduate and graduate students, led by professional geoscientists, will cover real-life issues including professional opportunities and challenges that await students after graduation. Plan to attend both free luncheons to hear different presenters each day. Students will receive FREE LUNCH tickets in their registration packets to attend both Shlemon Programs. However, space is limited. First come, first served.

Other workshops: latest information can be found at www.geosociety.org/sectdiv/rockymtn/04rmcdmtg.htm or <http://earth.boisestate.edu/GSA2004/>.

SPECIAL EVENTS

Ice Breaker. Sunday evening, May 2, Boise Centre on the Grove.

Paleontological Society Luncheon. Tues., May 4, noon.

Cost: \$20/professionals, \$15/students, location TBA.

Rocky Mountain Section Board Meeting. Tues., May 4, 7 a.m. Location TBA.

Rocky Mountain Section Annual Banquet and Business Meeting. Mon., May 3, 7 p.m. Cost: \$25.

Cordilleran Section Board Meeting. Mon., May 3, noon–1:30 p.m. Location TBA.

Cordilleran Business Meeting and Luncheon. Wed., May 5, noon–1:30 p.m. Cost: \$20.

Farewell Party. Wed. May 5, 5 p.m., Boise Centre on the Grove.

SPOUSE AND GUEST ACTIVITIES

The Boise area offers a variety of activities including shopping, hiking, mountain biking, and whitewater boating. For information on these and other activities, contact the Boise Metro Chamber of Commerce (www.boisechamber.org) or Boise Convention and Visitor's Bureau (www.boise.org).

STUDENT TRAVEL

The Rocky Mountain and Cordilleran Sections and the GSA Foundation have made travel grants available for students who are presenting oral or poster papers. Students must be currently enrolled and must be members of the relevant section to apply for support. For more information, contact the appropriate section secretary: Rocky Mountain—Kenneth Kolm, (303) 231-9115, ext. 110, kkolm@bbl-inc.com; Cordilleran—Joan Fryxell, (909) 880-5311, jfryxell@csus.edu.

STUDENT AWARDS

Awards will be given for best student oral (undergraduate or graduate) and poster (undergraduate only) presentations. To be eligible, students must be lead authors and presenters, and they should clearly identify their abstracts as student work.

EXHIBITS

Exhibit space will be available at \$250 per booth for commercial organizations and \$100 per booth for nonprofit organizations. For more information or to reserve a booth, contact Dave Wilkins, (208) 426-2390, dwilkins@boisestate.edu.

ACCOMMODATIONS

A wide variety of hotels is available near the meeting site. For more information and to make reservations via the housing bureau (strongly encouraged), access the meeting Web page, www.geosociety.org/sectdiv/rockymtn/04rmcdmtg.htm or <http://earth.boisestate.edu/GSA2004/>.

ADDITIONAL INFORMATION

If you have additional questions or need further clarification, contact a member of the organizing committee:

C.J. Northrup, chair, (208) 426-1581, cjnorth@boisestate.edu

Craig White, co-chair, (208) 426-3633, cwhite@boisestate.edu

Dave Wilkins, co-chair (208) 426-2390, dwilkins@boisestate.edu

Walt Snyder, technical program co-chair, wsnyder@nsf.gov

John Oldow, technical program co-chair, oldow@uidaho.edu

Spencer Wood, field trips chair, swood@boisestate.edu

Call for Geological Papers: 2004 GSA Section Meetings

South-Central Section

March 15–16, 2004

Texas A&M University, College Station, Texas

Information: Christopher Mathewson, Texas A&M University, Department of Geology & Geophysics, 3115 TAMU, College Station, TX 77843-3115, (979) 845-2488, mathewson@geo.tamu.edu

Northeastern–Southeastern Sections Joint Meeting

March 25–27, 2004

Hilton McLean Tyson's Corner, Washington, D.C.

Information: George Stephens, George Washington University, Department of Earth & Environmental Sciences, 2029 G St., NW, Washington, D.C. 20052-0001, (202) 994-6189, geoice@gwu.edu; Rick Diecchio, George Mason University, Department of Environmental Science & Policy, MS 572, 4400 University Dr., Fairfax, VA 22030-4444, (703) 993-1208, rdiecchi@gmu.edu

North-Central Section

April 1–2, 2004

Millennium Hotel, St. Louis, Missouri

Abstract deadline: January 6, 2004

Information: Joachim O. Dorsch, Saint Louis University, Department of Earth & Atmospheric Science, 3507 Laclede Ave., St. Louis, MO 63103-2010, (314) 977-3124, dorsch@eas.slu.edu

Rocky Mountain–Cordilleran Sections Joint Meeting

May 3–5, 2004

Boise Centre on the Grove, Boise, Idaho

Abstract deadline: January 27, 2004

Information: C.J. Northrup, Boise State University, Department of Geosciences, 1910 University Dr., Boise, ID 83725, (208) 426-1009, cjnorth@boisestate.edu

www.geosociety.org/sectdiv/sections.htm

Students: Mark your Calendars!

Shlemon Mentor Programs
for 2004

Students: If you have career-related questions, plan to attend a Shlemon Mentor Program at a 2004 GSA Section Meeting to chat one-on-one with practicing geoscientists. These volunteers will answer your questions and share insights about how to get a job after graduation. When programs are scheduled for multiple days, each day's program will offer a different set of mentors. These programs are made possible by the Roy J. Shlemon Fund, administered by the GSA Foundation.

FREE LUNCHESES will be served (to students only) at the following Shlemon Mentor Programs at the spring GSA Section Meetings. Stop by the GSA registration desk to get the location of the luncheon.

South-Central Section Meeting

Mon. and Tues., March 15–16
11:30 a.m.–1 p.m.
College Station, Texas

Northeastern–Southeastern Sections Joint Meeting

Thurs. and Fri., March 25–26
11:30 a.m.–1 p.m.
Tyson's Corner, Virginia

North-Central Section Meeting

Mon. and Tues., April 1–2
11:30 a.m.–1 p.m.
St. Louis, Missouri

Cordilleran–Rocky Mountain Sections Joint Meeting

Mon. and Tues., May 3–4
11:30 a.m.–1 p.m.
Boise, Idaho

Students will receive a **FREE LUNCH** ticket along with their registration badge to attend each Shlemon Program. However, space is limited. First come, first served.

LAST CHANCE TO ACT! UPCOMING DEADLINES

Committee Service

Nominations Due February 1, 2004

Candidates are needed for service on the following GSA committees: Arthur L. Day Medal Award; Education; Geology and Public Policy; Honorary Fellows; Joint Technical Program; Membership; Minorities and Women in the Geosciences; Nominations; Penrose Conferences and Field Forums; Penrose Medal Award; Publications; Research Grants; *Treatise on Invertebrate Paleontology* Advisory Committee; and Young Scientist Award. Candidates are also needed for a GSA representative to the North American Commission on Stratigraphic Nomenclature (NACSN). Service begins July 2004 for all positions except NACSN, which begins November 1, 2004, and Joint Technical Program Committee, which begins January 1, 2005.

For complete information on committee service, current vacancies, and required qualifications, see the October 2003 issue of *GSA Today*. Nomination form and instructions are available at www.geosociety.org/aboutus/commtees/.

Officers and Councilors

Nominations Due February 1, 2004

The GSA Committee on Nominations requests nominations for officers (vice president and treasurer) and councilors to serve on the GSA Council beginning in 2005. Each nomination should be accompanied by basic data and a description of the qualifications of the individual for the position recommended. Send materials for committee, officer, and councilor nominations to Ruth Harrison, GSA, P.O. Box 9140, Boulder, CO 80301-9140, (303) 357-1000, ext. 0, 1-800-472-1988, ext. 0, rharrison@geosociety.org.

Medals and Awards

Nominations Due February 1, 2004

Nominations of candidates are requested for the Penrose Medal, Day Medal, Honorary Fellows, Young Scientist Award (Donath Medal), GSA Public Service Award, and Distinguished Service Award. For details on the awards and nomination procedures, see the October 2003 issue of *GSA Today*, go to www.geosociety.org, or call (303) 357-1028. Materials and supporting information for any of the nominations may be sent to Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301-9140.

Student Research Grants

Applications Must be Postmarked by February 1, 2004

For information on 2004 Research Grant Program for Students, see the October 2003 issue of *GSA Today*, visit www.geosociety.org, or call (303) 357-1028. Application forms are available online or from Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301, awards@geosociety.org.

GSA Fellows

Nominations Due January 15, 2004

The Committee on Membership requests nominations of members to be elevated to GSA Fellow status. Any GSA Fellow may nominate a member for this honor. Two other supporting signatures are needed, along with a letter stating the member's qualifications, to be evaluated on the basis of eight established criteria. For more information, a list of the criteria, and a nomination form, please see www.geosociety.org/members/fellow.htm or contact Nancy Williams, (303) 357-1017, nwilliams@geosociety.org.

2004 Doris M. Curtis Memorial Fund for Women in Science Award

(Sponsored by Subaru of America, Inc.)

Nominations Due February 1, 2004

This award is given to a woman or group of women who have impacted the field of the geosciences in a major way based on their Ph.D. research. For nomination, eligibility, and award details, see the October 2003 issue of *GSA Today*, visit www.geosociety.org, or call (303) 357-1028. Send nominations and supporting material to Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301-9140.

John C. Frye Environmental Geology Award

Nominations Due March 31, 2004

In cooperation with the Association of American State Geologists, GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. For details, see the October 2003 issue of *GSA Today*, visit www.geosociety.org, or call (303) 357-1028. Nominations must be sent to Program Officer, Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301-9140.

Congressional Science Fellowship

Applications Due January 23, 2004

For application information for the 2004–2005 GSA–U.S. Geological Survey Congressional Science Fellowship, visit www.geosociety.org/science/csf/, or contact Ginger Williams, GSA Headquarters, (303) 357-1040, gwilliams@geosociety.org.

Antoinette Lierman Medlin Scholarship in Coal Geology

Materials Due February 15, 2004

This scholarship provides full-time students involved in coal geology research with financial support for their project for one year. See the December 2003 issue of *GSA Today* for details. Send materials to: Romeo Flores, USGS, Box 25046, MS 939, Denver Federal Center, Denver, CO 80225, USA; fax 303-236-0459, rflores@dnrcrds0.cr.usgs.gov.

2003 Alternates Receive Student Research Grant Support

Each year, the Committee on Research Grants selects up to ten alternate grant recipients in the event that grant money is returned. According to GSA policy, grant money must be returned if funding is received from other sources or if there is a change in research plans. In 2003, the following eight alternates were awarded \$1,000 each to help with their research costs.

Philip Borkow, Ohio State University
Melinda Huff, University of Minnesota, Duluth
Adam MacConnell, University of Massachusetts
Casey Mobley, University of New Orleans
Rebecca Murphey, University of New Orleans
Clinton Rissmann, University of Texas, Dallas
Jamil Sader, University of Texas, Dallas
Tania Wallace, University of Texas, Austin

Announcement: Travel Grants to Italy

**32nd International Geological Congress
Florence, Italy • August 20–28, 2004**

The Geological Society of America is accepting applications for the 32nd International Geological Congress (IGC) Travel Grant Program. The 2004 IGC will be held in Florence, Italy, August 20–28.

This program was established as a final act of the Organizing Committee for the U.S.-hosted 28th IGC held in Washington, D.C., in July 1989. Surplus funds available at the conclusion of the 28th IGC were transferred to the GSA Foundation with the stipulation that income from the fund be used to support the attendance of young geoscientists to future IGCs, until such time as the United States again hosts an IGC. Travel grants will consist of economy airfare to Italy.

To be eligible, an applicant must be a resident or citizen of the United States (including students); must have a birth date after August 31, 1964; and must have an abstract for inclusion in the program of the 32nd IGC.

Application forms are available at www.geosociety.org/grants/index.htm. To receive a paper copy, please email awards@geosociety.org or call (303) 357-1028. Along with the form, applicants must include a copy of the abstract submitted to the 32nd IGC and two letters of support from current or recent supervisors. **Qualifying applications and letters of support must be postmarked no later than March 1, 2004.** Applicants will be notified of the results in April 2004.

GSA Offers Awards in Geomorphology and Micropaleontology

Two of GSA's most prestigious awards supporting research are made possible by the generosity of the late W. Storrs Cole. Qualified GSA Members and Fellows are urged to apply.

The Gladys W. Cole Memorial Research Award

provides support for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico. GSA Members and Fellows between the ages of 30 and 65 who have published one or more significant papers on geomorphology are eligible for the award. While the funds may not be used for work that is already finished, recipients of previous awards may reapply if they need additional support to complete their work. The 2004 award is for \$8,000.

The W. Storrs Cole Memorial Research Award

supports research in invertebrate micropaleontology. This award carries a stipend of \$7,300 in 2004 and will go to a GSA Member or Fellow between the ages of 30 and 65 who has published one or more significant papers on micropaleontology.

For 2004 application forms visit www.geosociety.org/grants/postdoc.htm. For more information, contact Diane Lorenz, Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301-9140, awards@geosociety.org.

Applications must be mailed and must be postmarked on or before **February 1, 2004**. Applications sent by facsimile or e-mail will not be accepted. The Committee on Research Grants will report its actions to each applicant in April 2004.

The Gladys W. and W. Storrs Cole Award funds are managed by the GSA Foundation.

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(303) 447-2020, option 3, FAX: 303-357-1071,

TOLL-FREE: 1-888-443-4472, E-MAIL: gsaservice@geosociety.org

New GSA Members

The following 635 members were elected by GSA Council action at its October 2003 meeting for the period from March 2003 through September 2003.

Ahmad Nafiz Abdel-Fattah
David T. Adams
Elizabeth A. Albert
Anthony L. Albrecht
Jackie Allen
Frances S. Alvarado
Faith O. Amadi
David W. Amburgey
Alejandro Amilibia
Jennifer E. Anderson
Megan Y. Andrews
Michael S. Annala
Kan Aoike
Beth Apple
Stuart G. Archer
Michael J. Arthur
Niklas Axheimer
Nicholas A. Azzolina
Muhammad Babar
Paul D. Bakke
Kermit M. Bandt
Don S. Basuki
Mark A. Bauer
John F. Beasley
Judi L. Becker
Richard Becker
Joseph J. Beer
Boris Behncke
Daniel N. Behringer
Todd Belanger
Patrick Belmont
Lee E. Benda
Michelle E. Bennett
Donna M. Benson
Martin Beranek
Debora Berti
Rebecca L. Bixby
Alana M. Bixler
Andree P. Blais-Stevens
Carrie N. Blankenship
Andrea M. Blecha
Stein Bondevik
Tanja Bosak
Shamik Bose
James S. Boswell
Obadiah Bowen
Glynnis A. Bowman
Dawn M. Bradley
Jeffrey W. Brame
John L. Bramlet
Henry W. Brenniman
Michael Brickley

David L. Bridges
Robert Brinkmann
Greg A. Briscoe
Rui Brito
David E. Broach
Kristina B. Brody
Bjorn-Gustaf J. Brooks
Rebekah Brooks
Brandon L. Browne
Thomas C. Brownell
Sharon Browning
Derek L. Bryant
S.E. Bryant
Susan Buhr
Minh Bui
Jennifer L. Bukey
John G. Bultman
Armando Burciaga
Kevin E. Burdette
Valentin S. Burtman
Virginia L. Butler
Bruce E. Buttler
Josh Cahill
Kevin E. Cahill
Tracy Cail
Scott Calhoun
Laura Callihan
Bel Campbell
Michelle R. Campbell
Dana D. Carciumaru
Christine R. Carlson
Tyson D. Carlson
Nathan E. Carpenter
Allen Carter
Nathan E. Casebeer
Brianna M. Cassidy
Susan B. Cazull
Angel On Kee Chan
Lia C. Chasar
Yifeng Chen
Cheng Cheng
Chu-Lin Cheng
Ward Chesworth
Karletta Chief
Gaurav Chopra
Anne M. Christian
Christopher Cicerale
Christy D. Clark
Marin K. Clark
Paul R. Clarke
Simon J. Clarke
Scott Close

Luz S. Cobos
Ronald Cohen
Kimberley N. Coke
Robert Cole
Matthew J. Collins
Shannon L. Colton
Xavier Comas
Christopher L. Conger
Thomas J. Connelly
Charles B. Connor
Tim Cook
Frances J. Cooper
Kari M. Cooper
Colleen M. Cope
Daniel Cordalis
Robert Corkery
Laurie A. Cotsonika
Allison Leigh Craig
Lane T. Creech
Eric C. Cross
Leanne L. Crow
Rodolfo Cruz-Orozco
Istvan Csato
Andrew D. Czaja
Eleanor S. Dahlin
Ahmad Y. Dalqamouni
Melinda D. Daniels
James H. Darrell II
Matthew W. Dawson
Luigi De Filippis
Julia L. Deason
Lindsey Degenhart
Pieter A.P. deHart
Andrew A. Delorey
Timothy M. Demko
Laura M. DiCello
Keith E. Dickens
Mark Diederichs
Vanessa M. Diep
David Dietz
Eric R. Dittmer
Larissa Dobrzhinetskaya
Brigid A. Doran
Emma Dowman
Bryan D. Downing
Chanda Drennen
Benjamin Drenth
Natalie A. Drummond
Michelle L. Dry
Dan Duffy
William Eckerle
James Eddleman
Harold H.G. Edwards
Linda T. Elkins-Tanton
Beth Ellis
Tarek Elshayeb
Jaime H. Escobar
Daniel W. Eshete
Thomas Vincent Evans

William C. Evans
Tao Fang
Melissa Farley
Emma C. Farmer
Maurizio Favaron
Adela Fazel
Hans P. Feige
Kenneth C. Fergason
Marie A. Ferland
David C. Fernandez-Remolar
Mustafa M. Fetouri
Justin Filiberto
William H. Finnegan
Robert N. Fisher
Darlene A. Fissler
Roberta I. Fivecoate
Mark G. Foerster
Helen W. Folger
Joshua Q. Ford
Keary L. Fox
Mark R. Frank
Ron Freeman
Brian W. Fribley
Aaron P. Friedrich
Corey Y. Fullmer
Christopher Fuse
Walter Joseph Gage
Christian E. Gandy
Royhan Gani
Samuel S. Garland-Renn
Maureen E. Garrett
Terry Garrett
Nick Garson
Andrew Scott Gendaszek
Ayesha S. Genz
Philip A. Geusebroek
Swati Ghoshal
Habes A. Ghrefat
David P. Gillikin
William H. Godwin
Takashi Gomi
Helge Gonnerman
Richard J. Goode
James E. Goodrich
Ivy A. Graham
Nel N. Graham
Michelle Greene
Darcie Greggs
Eric A. Guarino
Aron M. Habte
Adam R. Hackenberg
Paul D. Hacker
Alan R. Haight
Benjamin Haith
Jochen Halfar
Justin Hall
Patricia B. Hamann-Durrett
Saad S.B. Haq
Shama Haque

Paul S. Hardersen
Elizabeth Hardesty
Meredith D. Hardy
Orvil Harris
Benjamin K. Harrison
Michael Haschke
Christopher Hawkins
Julia Frances Heathcote
Richard Heisler
Kevin J. Henson
Elizabeth Hermsen
David C. Heroy
Richard Herrington
Dale P. Hess
Katie K. Hessen
David E. Hewitt
Michael B. Hillesheim
Christopher S. Hitchcock
Albert G. Holba
Hermann J. Homann
Rudi Hon
Daniel F. Hoop
Susan C. Horvath
Allegra Hosford Scheirer
Carrie E. Hosler
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Abigail Howe
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Jyr-Ching Hu
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Stacey A. Hundley
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Taylor Hunt
Leslie A. Hunt-Bond
Lee S. Hurvitz
D. Jean Hutchinson
Melissa Ingrisano
Allen P. Insabella
Henry U. Iwuh
C. Rhett Jackson
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Richard L. Janak
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Bret D. Jarrett
Leticia Jean Len
Sharon P. Jefferies
Anne Jefferson
Andrea Jennings-Sanders
Brita Jensen
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Stephanie Jones
Brian J. Kappen
Jim M. Karner
Ikuo Katayama
Osamu Kazaoka
Andrew R. Kear
Courtney Kearney
Sean T. Kearney

John F. Kelly
William A. Kiel
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Julia K. Kissel
Elise M. Klarfeld
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Curtis Koger
Jennifer K. Kohl
Gretchen Kohler
Christine Kola
Stephen C. Komor
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Hayrettin Koral
Victor C. Kress II
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William A. LaChapelle
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Mark G. Landis
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Lorraine A. Leon
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Adam R. Lewis
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Tom Lindsay
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Clayton W. Loehn
James P. Loetterle
John Londono
Norma Longo
Cortney B. Lowe
Peter J. Lu
Jane M. Luhn
Stephanie Lukowski
David Luzi
Joseph A. MacGregor
Richard E. MacNeil
Roger W. Macqueen
Richard H. Madden
Christopher Mah
Kate Maher
Christopher M. Mahoney
Wolfgang D. Maier
Candace Olson Major
Ho-Kwang Mao

Maria C. Marcano
Scott T. Marshall
Emily Martin
Kristin T. Martin
Tamara M. Massong
Joseph R. Matthews
Wendy Matthews
Peter J. Mazzeo
Mike Mc Teague
Richard L. McAdoo
Wendy A McCausland
Leslie C. McCombs-Porter
Richard P. McCulloh
William T. McCune
Keith McDermott
John R. McGinley Jr.
Michael W. McGowan
Melissa A. McGuire
Charles L. McIlvaine IV
Brandie R. McIntyre
Jim McKean
James McManus
Walt W. McNab
Craig T. Meyer
Tom Michalek
Meghan S. Miller
Robert D. Miller
Gregory Misterovich
Robert J. Mitchell
Frank S. Mize
Amy P. Moe
Ken W. Moffitt
Redha Mohammad
Marguerite M. Moloney
Loago Molwalefhe
Julie A. Monet
Carolyn T. Moores
Carl A. Morck
Eric Morita
Penny Morrill
Elizabeth J. Morris
Phillip E. Morris
Andrew P. Morrow
Patrick T. Moss
Constantino Mpodozis
Sandeep Mukherjee
Cara K. Mulcahy
Danika Mullen
Jordan R. Muller
Anne Mundel
Keith Musselman
Robert L. Myers
Robert O. Myers
Ian Mynatt
Adam Nagle
Shaji K. Nair
Cheryl Nazareth
Kevin Neary
Mladen R. Nedimovic

Dorothy G. Neely
Karla R. Nelson
Claudia M. Newbury
Juliet A. Newson
Robert R. Nichols
Yaoling Niu
John W. Norby
Flavia Nunes
Geraldine Y. Nzokwe
Kevin D. O'Shea
Adelanke G. Obasorun
Kathryn B. Oheim
Ernest H. Olsen Jr.
Jon Olsen
Wayne Olsen
Anthony J. Olson
Erik L. Olson
Brandon Oman
Ruth E. Ortiz Martinez
Geoff Orton
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Cindy Palinkas
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 Gary M. Schaefer
 Meghan M. Schaub
 Aimee A. Scheffer
 Robert J. Schenck
 John Scherer
 Daniela Schmidt
 Victor Schneider
 Robert B. Schoene
 Kimberly A. Schramm
 Joseph Schuldenrein
 Cynthia Schultz
 Eugenie C. Scott
 James H. Scott
 Tomieka Y. Searcy
 Bethany Sekerak
 Karen S. Sell
 Jacqueline Shea
 Jaleel Shujath
 Heidi L. Sieverding
 Heather M. Silva
 Neal W. Simpson
 Jaap S. Sinninghe Damste
 John M. Sinton
 Sara K. Sjostrom
 John M. Skelton
 Frances N. Skomurski
 Sofia U. Smeds
 Makenzie M. Smith

Nathan W. Smith
 Schaun M. Smith
 Ursula E. Smith
 John D. Sorrell
 Steve Sousa
 Jason M. Spanier
 John Spearman
 David B. Spears
 Siobhan E. Stack
 Mary C. Stacy
 Aaron R. Stallard
 Rebecca E. Stamski
 Jared J. Standish
 Riju Stephen
 Lee Stocks Jr.
 Bruce Stoker
 Morgan D. Sullivan
 Dewan N. Sultana
 Li Sun
 Noritoshi Suzuki
 Mitchell L. Swanson
 Thomas Taglienti
 Tetsuichi Takagi
 Eric T. Tangumonkem
 Dawit T. Teclehaimanot
 Jose E. Tent-Manclus
 Fredrik Terfelt
 Viktor Terlaky
 Samson Tesfaye
 Ronald D. Thomas
 Stephanie Thomas
 Terry-Ann G. Thompson
 Scott Tinker
 Brett J. Tipple
 Robert S. Trahan
 Lynn Tunbridge (Webster)
 James W. Turner
 Roxie Jessica Turner
 Joji Uchikawa
 Daniel R. Ufnar
 Yurika Ujiie
 Charles Umbanhowar
 Emre Unal
 Richard G. Urash II
 Julie Urbanik
 Alexandra Urrego
 Nancy H. Uziemblo
 Richard K. Valenta
 Bas van de Schootbrugge
 Deanna van Dijk
 Pieter-Jan van Helvoort
 Matthijs C. van Soest
 Karen M. Vanaman
 Donna Marie Vaughan
 Jorge Vazquez
 Francisco J. Vega
 Annette M. Veilleux
 Jeremy G. Venditti
 Avner Vengosh

Howard P. Viator III
 Danielle E. Villa
 Melanie L. Vining
 Michael D. Vinson
 Christie L. Vliss
 Matthew von der Ahe
 Philip D. Wade
 Bill Waggoner
 Angela Wagner
 Gregory Waite
 Forest P. Walker
 Daniel P. Walsh
 Carly L. Walton
 Catherine Walton
 Gang Wang
 Qin Wang
 Peter D. Ward
 Clare Warren
 Lisa M. Warren
 Heath D. Watts
 John R. Waugh II
 Frank E. Weagant
 Hamish Weatherly
 Jody M. Webster
 Matthew S. Weikel
 Daniel C. Weinand
 Beth A. Welle
 Jennifer N. Weller
 Craig A. Welsh
 Patricia E. Weston

Evan Whitaker
 John H. Whitaker
 Matthew L. Whitaker
 Brandon Whitehead
 Jessica H. Whiteside
 Christa E. Whitmore
 Bruce Wielinga
 Geoffrey L. Wikel
 R. Jude Wilber
 Steve C. Wilbur
 Matthew C. Wilsbacher
 Jason D. Windingstad
 Janice P. Wittstrom
 Amy Wolfe
 Jeremy M. Wolpert
 Van W. Wolverton
 Teng-Fong Wong
 David R. Woodcock
 Cailai Wu
 Jeremy Wykes
 Aaron Yair
 Jingsui Yang
 Ji-Sun Yi
 Ann Youberg
 Alessandro Zanazzi
 Jianxin Zhang
 Weidong Zhao
 Liming Zhu
 Mindy M. Zimmer
 Gosia Zobel

New GSA Student Associates and Affiliates

The following 275 Student Associates and Affiliates joined GSA during the period from March 2003 through September 2003.

James C. Allen
 Aisha H. Al-Suwaidi
 Peggy W. Altman
 Diane P. Anderson
 Nicolle K. Anderson
 Dixie L. Androes
 Owen A. Anfinson
 Lora Armstrong
 Amy L. Bacastow
 Elizabeth J. Barclay
 Patrice N. Barlow
 Erin Barner
 Mary E. Barrett
 Peter F. Beagle
 Matthew J. Beckwith-Laube
 Whitney M. Behr
 Bryn A. Benford
 Christine M. Benson
 Renee I. Bernstein
 Aaron Bertram

Karine Bibeau
 Robin Dale Billings
 Patrick S. Bingham
 Kristin M. Block
 Rhannon M. Bock
 Nathan Boguslawski
 Charles A. Boland
 Kathleen F. Bolger
 John Bongino
 Thomas A. Boothe
 Graeme C. Bowles
 Brandi L. Boyd
 Brian J. Brock
 Megan C. Brock
 Bonnie N. Broman
 Melissa Kay Brown
 Marc C. Bryson
 Antonio E. Buendia
 Nievita Bueno
 Elizabeth Bufano

W. Paul Burgess
Heather D. Burns
Steven M. Burton
Carla B. Butts
Benjamin L. Byerly
William E. Carlson
Karen R. Carroll
Jason A. Cassara
Elizabeth J. Cassel
Sarah N. Cervera
Patricia T. Chalmers
Rhonda E. Chalmers
Matt L. Chapman
Phillip M. Chapman
Randall Chiu
Geoffrey H. Christensen
Evan Christianson
Gaetano Ciccone
Alexa Clements
Mark H. Cleveland
Matthew J. Cohrt
Kevin Cole
Phillip M. Cole
Sandy M. Conard
Cassandra S. Cook
Jill M. Cooper
John J. Corcoran III
Stacey L. Corrie
Lina Dailide
Lee Daniels
Allicia Davis
Karoline T. Deferrari
Lona Kate Dekeyser
Nicholas DiFrancesco
John P. Diggins IV
Daniel Dorff
Joshua N. Dorin
Courtney L. Drayer
Heidi L. Drexler
Lance A. Dunn
Annaliese A. Eipert
Gena M. Elpers
Karen Emery
Christopher A. Ervin
Rob Fenton
Gregg Ferris
Jane E. Fillmore
Debra Fitch
Erik R. Flesch
Matt D. Forir
Jaclyn Francese
Roark Franklund
Jeremy D. Freeland
Nicholas C. Freiburger
Donald Friedly
Sarah M. Friswold
Andrew C. Frye
Kelsey L. Garner
Nicholas Geboy

Catherine I. Gibler
Danette M. Gilbertson
Benjamin C. Gill
James T. Gleason
James L. Goedert
Michelle E. Goelzenleuchter
Sasha Goldberg
Stacia Gordon
Jeremy C. Gouldey
Frank J. Graf
Lisa M. Graga
Kathryn N. Gray
Walt E. Gray
Lisa Guttery
Emily M. Habinck
Jessica A. Haddon
Debra D. Hallis
Sara Hanson-Hedgecock
Wilfred Haufe
Carol Haynes
Joseph J. Haynes
Andrew Heath
Elizabeth A. Helmke
Kristopher Helton
JoAnn L. Hempel
Bridget G. Herris
Nathan Hess
Jessica L. Hiznay
Jeffrey S. Hoeft
Bradley D. Holland
Elizabeth A. Holley
Jake L. Holloway
Kristin M. Holton
Jenise M. Honesto
Deanna L. Hoppe
Elizabeth Howell
Katie J. Howell
Audrey L. Hucks
David M. Huey
Donna R. Hughston
Daniel Hyslop
Adam Jackson
Bradley J. Jackson
Matt B. Jarrett
Lana F. Jaworski
Breck R. Johnson
Jocelynn J. Johnson
Erika Josson
Daniel S. King
John J. Kirrane
Michael Kloczko
Matthew W. Knuth
James Knutson
Douglas A. Kolb Jr.
Kate D. Krug
Bobby M. Kurtz
Patrick R. Laatsch
Christopher J. Landry
Carrie E. Larson

Daniel R. Lasco
Gregory Lawson
Valerie J. Lenhartzen
Marinna A. Lepp
Daniel D. Lesh
Daniel Linsley
Peter A. Lynch
Jamie Maker
Jacqueline Marshall
Joan L. Mason
Amber E. Massa
Simon L. Masters
Andrea Matthews
Seth T. Mattos
Nicholas A. McClean
Terrence A. McCloskey
Lois M. McDonald
Shauna R. McDonald
Jason Andrew McIlwain
Ryan E. McKeon
Amanda M. Mendonza
Susan Mickiewicz
Jeff W. Miller
Myles L. Miller
Brian W. Miner
Julie E. Mitchell
Napoleon Momtahan
Robert H. Monrreal
Eric Moore
Lindsay Morgan
Laura R. Moyer
David Mrofka
Megan Muretta
Christina L. Myers
Robin Nesbeda
Jennifer New
Jamie Nichols
Andrew Nugent
Aeron O. O'Brien
Danielle R. Odette
Aric A. Olsen
Matthew R. Osborne
Samantha D. Owens
Charles S. Park Jr.
Skyler J. Pauli
Katrina Pekar
Stephanie C. Penn
Gil F. Pepin Jr.
Stephanie Perry
Ryan M. Phelps
Charles J. Phillips
Katherine D. Phillips
Jennifer Polmateer
Shelley R. Poteet
Anthony M. Priestas
Sarah A. Prindiville
Jerod B. Randall
Christine A. Regalla
Aaron B. Regberg

Melissa M. Reisinger
Andrea Repetto
Elizabeth C. Rhenberg
Amber N. Rheubottom
Matthew Richmond
Paul R. Riley
Audrey L. Ritter
Kristine Robson
Amanda Rodrigo
Jonathan Roger
Alex J. Roy
Michael A. Sample
John M. Sandru IV
Jonathan Sanks
Tabinda Y. Satti
Jennifer Ashley Sawyer
Alison J. Schwantes
Debby Seeley
Tanya C. Shavalia
Brian S. Shepherd
Sara M. Smaltz
Ethan N. Smith
Nevada J. Smith
Bev Soran
Vera D. Stinson
Daniel M. Sturmer
Kristin A. Sturtevant
Yuko Takishita
Denise M. Thompson
Dustin M. Tissaw
Paul E. Tobin
Barbara J. Toews
Carl C. Tolliver
Cindy R. Tomai
Alka Tripathy
Richard Trotman
Jon P. Truesdale
Christina Tuggle
Michael L. Tuite
Derick L. Unger
Gwenabeth Urbanik
Paul A. Valdez
James R. Vasquez
Jorge Velez
Laura E. Wagner
Donald Walker
Kevin J. Walsh
Chad Weisenberger
Erika A. Weller
Serena L. Weren
Jan M. Whitaker
Jacqueline M. White
Robin Wiles-Skeels
Melissa M. Wilkens
Kim M. Wilkinson
Francisco Wills
David E. Wolf
Shelley A. Zaragoza

Call for Nominations: GSA Division Awards

Funds for the following GSA Division awards are administered through the GSA Foundation.

Don J. Easterbrook Distinguished Scientist Award—Quaternary Geology and Geomorphology Division

The Quaternary Geology and Geomorphology Division of GSA seeks nominations for the Don J. Easterbrook Distinguished Scientist Award. This award will be given to an individual who has shown unusual excellence in published research, as demonstrated by a single paper of exceptional merit or a series of papers that have substantially increased knowledge in Quaternary geology or geomorphology. No particular time limitations apply to the recognized research. The recognition is normally extended to an individual, but in the event of particularly significant research by more than one person, two people may share the award. Monies for the award are derived from annual interest income from the Don J. Easterbrook Fund, administered by the GSA Foundation.

Although recognition of extraordinary prior research excellence is the principal goal of this award, it carries with it an opportunity for funding additional research. The Easterbrook Distinguished Scientist is eligible to draw funds for research from the GSA Easterbrook Fund in an amount to be determined by availability of funds. This opportunity for funding additional research by the winner is a secondary consideration of this award.

Members of the Quaternary Geology and Geomorphology Division Award Panel will evaluate nominations for the Easterbrook Award. Because the award primarily recognizes research excellence, self-nomination is not allowed.

Nominees need not be members of the division. Nominations are not automatically carried forward to subsequent years, but the same individuals may be renominated.

Nominations must be accompanied by supporting documentation, including a statement of the significance of the nominee's research, curriculum vitae, letters of support, and any other documents deemed appropriate by the nominating committee. Send nominations by April 1, 2004, to Ellen Wohl, ellenw@cnr.colostate.edu, Colorado State University, Dept. of Earth Resources, Fort Collins, CO 80523-1482.

Farouk El-Baz Award for Desert Research—Quaternary Geology and Geomorphology Division

The GSA Quaternary Geology and Geomorphology Division seeks nominations for the Farouk El-Baz Award for Desert Research. This award rewards excellence in research in desert geomorphology worldwide and is intended to stimulate research in desert environments by recognizing an individual whose research has significantly advanced the understanding of the Quaternary geology and geomorphology of deserts. Although the award primarily recognizes achievement in desert research, the funds that accompany it (\$5,000 anticipated for 2004) may be used for further research. The award is normally given to one person but may be shared by two people if the recognized research was the result of a co-equal partnership. Monies for the award are derived from annual interest income from the Farouk El-Baz Fund, administered by the GSA Foundation.

Any scientist from any country may be nominated for the award. Because the award recognizes research excellence, self-nomination is not permitted. Neither nominators nor nominees need be members of GSA. Nominations must be accompanied by a statement of the significance of the nominee's research, a curriculum vitae, letters of support, and documentation of published research results that have significantly advanced the knowledge of Quaternary Geology and Geomorphology of desert environments.

Send nominations by April 1, 2004, to Alan Gillespie, alan@ess.washington.edu, Dept. of Earth & Space Sciences, PO Box 351310, University of Washington, WA 98195-1310.

Laurence L. Sloss Award for Sedimentary Geology

The Sedimentary Geology Division of GSA solicits nominations for the 2004 Laurence L. Sloss Award for Sedimentary Geology. This award is given annually to a sedimentary geologist whose lifetime achievements best exemplify those of Larry Sloss—i.e., achievements that contribute widely to the field of sedimentary geology and through service to GSA. Monies for the award are derived from

annual interest income from the Laurence L. Sloss Award for Sedimentary Geology fund, administered by the GSA Foundation.

Nominations should include a cover letter describing the nominee's accomplishments in sedimentary geology, contributions to GSA, and curriculum vitae. The management board of the Sedimentary Geology Division will choose the recipient from the two nominees forwarded from the nominations committee, and the award will be presented at the GSA Annual Meeting in Denver in October.

Send nominations by March 1, 2004, to Paul Karl Link, Secretary, Sedimentary Geology Division, Dept. of Geology, Box 8072, Idaho State University, 1400 E. Terry, Pocatello, ID 83209-8072.

Gilbert H. Cady Award—Coal Geology Division

The Coal Geology Division of GSA seeks nominations for the 2004 Gilbert H. Cady Award, made for outstanding contributions in the field of coal geology. The first award, established by the division in honor of Gilbert H. Cady, was presented in 1973. Monies for the award are derived from annual interest income from the Gilbert H. Cady Memorial Fund, administered by the GSA Foundation. The award will be made for contributions considered to advance the field of coal geology within and outside North America and will be presented at the Coal Geology Division Business Meeting at the 2004 GSA Annual Meeting in Denver.

Nominations will be evaluated by the Gilbert H. Cady Award Panel and should include: name, office or title, and affiliation of nominee; date and place of birth, education, degree(s), and honors and awards; major events in his or her professional career, a brief bibliography and outstanding achievements and accomplishments that warrant nomination.

Send three copies of the nomination by February 28, 2004, to Cortland F. Eble, Kentucky Geological Survey, University of Kentucky, Lexington, KY 40506-0107, (859) 257-5500, fax 859-257-1147, eble@uky.edu.

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PENROSE CONFERENCE REPORT

Plume IV: Beyond the Plume Hypothesis—Tests of the plume paradigm and alternatives

August 25–29, 2003

Hveragerdi, Iceland

Conveners:

Gillian R. Foulger, U.S. Geological Survey, Menlo Park, and University of Durham, **James H. Natland**, University of Miami, and **Don L. Anderson**, California Institute of Technology

Can “hot spots”—regions of anomalous volcanism—be explained by mechanisms other than deep thermal upwellings? This question was the subject of a week-long debate at the Penrose Conference, “Plume IV: Beyond the Plume Hypothesis,” held August 25–29, 2003, in Hveragerdi, Iceland. Over 60 geologists, geophysicists, and geochemists from 12 nations gathered to brainstorm the fundamental evidence that constrains the origins of volcanism. Seismology, convection modeling, heat flow, geothermometry, petrology, geochemistry, radiometric dating, kinematics, morphology, and basic geology were all considered. This meeting was the most significant gathering ever held of scientists working on alternative mechanisms for anomalous volcanic regions. More such meetings will follow.

Seismology presented included wave propagation, tomography, anisotropy, and a summary of what seismology can and cannot tell us. Contrary to general assumptions, seismic wave speeds beneath Hawaii are relatively high (*Julian*). Whole-mantle tomography favors strong impedance of flow across the 660 km discontinuity and a relatively homogenous middle mantle (*Dziewonski*). Tomographic evidence for slab penetration to the core-mantle boundary is sparse, and detailed scrutiny reveals problems with these interpretations of the most likely images. Anisotropy can reveal the orientation of flow beneath volcanic regions (*Montagner*). Credible images of low-velocity bodies traversing the entire mantle as predicted for hot upwellings from the core-mantle boundary are lacking. Low-velocity bodies extending down to the transition zone have been found beneath a few volcanic areas, but similar bodies also underlie long-extinct volcanic areas such as Brazil and the Ontong-Java plateau (*Foulger*). The interpretation of high- and low-velocity anomalies is ambiguous. Melting,

mineralogy, composition, anisotropy, and temperature variations can all explain seismic wave-speed anomalies, with temperature having a relatively small effect (*Anderson*). A serious problem in many regions is scarcity of ray-path data resulting from the uneven distribution of earthquakes and seismic stations, especially in the Pacific Ocean (*Dziewonski*). This situation could improve if large numbers of ocean-bottom seismometers are deployed (*Montagner*).

Modeling can explore whether convection within Earth is layered or whole-mantle and whether thermal plumes are likely to form (*Ibinger, King*). Early, simple investigations involving tanks of liquids or numerical models have been influential in shaping popular concepts of plumes. However, Earth is radically different from a tank of liquid and is not reliably modeled using mathematical approximations such as ignoring the temperature and pressure dependence of rheology, thermal conductivity, and the coefficient of thermal expansion (*Anderson*). The most sophisticated lower-mantle models to date predict a few vast, sluggish upwellings in the lower mantle and not many localized plumes, and these models still neglect critical factors such as temperature-dependent viscosity (*King*). Earth is probably chemically layered as suggested, for example, by dynamic topography, different grain sizes in the upper and lower mantles and seismic velocities in the transition zone (*Anderson, Hofmeister*).

It is generally assumed that hot spots are hot. They are hot in the sense that volcanic activity occurs at the surface, but the important point is the relative potential temperature of the mantle beneath. Three sessions focused this critical issue. Marine heat flow measurements provide little evidence for enhanced heat flow around hot spots. Two spectacular examples of this are Hawaii and Iceland where heat-flow measurements provide no evidence for elevated sublithospheric temperatures. Such findings are typical of hot spots (*C. Stein*).

Experimental studies consistently indicate low solidus temperatures for mantle materials containing likely amounts of water or carbon and suggest that the seismic low-velocity zone beneath oceans may result from incipient melt since volatiles lower the solidus temperature in adiabatically ascending mantle material (*Green, Presnall*). Thus, either mantle composition or potential temperature is mapped by the low-velocity zone. Subduction reintroduces materials more fusible than peridotite, such as recycled ocean crust into the mantle (*Green*). The existence or otherwise of picritic magmas in both mid-ocean ridge (MOR) and hot spot locations is a critical issue, as the temperatures of primitive magmas are the most direct evidence of mantle potential temperatures (*Green, Presnall*). Parental picritic magmas were proposed in both Hawaiian and MOR settings (normal and enriched mid-oceanic-ridge basalts) leading to the inference of similar mantle potential temperatures (*Green*). Liquidus spinels and harzburgite-residue trends for Hawaiian picrites indicate a more refractory (in major elements) but refertilized (incompatible elements) source, and more refractory residue, than MORB. The role of picrites in MOR settings was challenged and parental MOR magmas comprising olivine tholeiites at ~150 °C below the potential temperature of Hawaiian picrites was advocated (*Fitton, Gudfinnsson, Presnall*). Hot spots on or adjacent to ridges

were considered to be formed at low potential temperatures comparable to those along "normal" ridges (*Presnall*).

Continental breakup and collision—the start and end games of plate tectonics—dehomogenize the shallow Earth. Continental collision traps slabs in and beneath sutured subcontinental lithosphere, where they provide a source of magma both during collision and subsequent continental breakup (*Chalot-Prat, Cigolini, Peccerillo, Finn, Flower, Barry, Fekiacova, Wilson*). Young, thin slabs may be neutrally buoyant in the shallow mantle. The great melt volume of the North Atlantic Volcanic Province and Iceland may result from mantle fertilized with subducted Iapetus crust (*Foulger*). Intense magmatism at the onset of continental breakup may be a result rather than a cause of breakup (*Anderson*). The Central Atlantic Magmatic Province (CAMP) reflects stress patterns related to Pangaeon rifting, and requires a widespread mantle source and extraction of melt from different depths (*Mangas, McHone*). It is best explained by distributed, shallow, small-scale convection. The intense volcanism associated with the breakup of the South Atlantic persisted at some locations, e.g., the Walvis and Rio Grande ridges, where recent, detailed gravity data suggest control by variable lithospheric stress. This may arise from large-scale internal deformation and stress redistribution within the African plate, resulting from changes in its plate-tectonic boundary conditions (*Wilson*). Transform zones (*Beutel*) and also normal ridges (*Bonatti, Chalot-Prat*) are important both in controlling stress and facilitating mantle melting and the ascent of this melt to the surface.

Extraterrestrial volcanism can potentially increase our understanding of volcanism on Earth. Venus has no plate tectonics and its heat budget and thermal history are poorly constrained (*Smrekar, Stofan*). Volcanism may have been localized in part by distributed rifting (*Jurdy*). The large (>2,000 km) rimmed circular structures may also be impact craters dating from the main accretion of the planet, before 3.9 Ga (*Hamilton*).

Geochemistry, including Sr-, Nd-, Pb-, and He-isotopes, cannot be used to estimate a depth of origin or volume of mantle sources. Connections have been

made between He isotopes and FOZO or C in oceanic island isotopic systematics but there is no requirement that FOZO and other enriched components (EM1, EM2, HIMU) must come from the deep mantle (*Natland, Peccerillo, Smith*). Enriched basalts are widely distributed over thousands of seamounts, and are not confined to tops of islands in linear chains. Plume sources cannot explain them all. Os isotopes have been interpreted to indicate a core component, but they could reflect instead a metamorphic or pyroxenitic component (*Anderson, Smith, Walker*). W-Hf isotopic systematics may soon offer a means of testing whether a signal from the core-mantle boundary ever reaches Earth's surface (*Anderson*).

Field associations suggest a heterogeneous upper mantle over which ridges migrate (*Bonatti, Dick, Natland*). The upper mantle appears to contain variably fertile to barren lherzolite and harzburgite, on scales varying from hand-specimen-sized domains to subducted slabs of partly altered, eclogitized ocean crust (*Natland*). Also present is abyssal peridotite, pyroxenite produced by reaction between peridotite and migrating melts, and former terrigenous and marine sediment carrying quartz, water, and carbonate. Blocks of continental lithosphere, isolated during continental rifting, lie in the middle of oceans. Subcontinental mantle may be incorporated in basaltic magma generated in new ocean basins (*Natland, Smith*). The scale of heterogeneity produced at spreading ridges is re-introduced into the mantle at subduction zones, with sedimentary components added. Isotopic variability testifies that melting domains beneath islands and ridges cannot be represented by a single mantle lithology, but that source materials that formerly interacted with the atmosphere and hydrosphere are present.

Melting models based on homogeneous peridotite that vary only the extent of partial melting and mantle temperature are too simple. Iceland, for example, is compositionally anomalous in so many respects that an unusually fertile mantle source, perhaps including substantial eclogite that was originally ocean crust, may be required and be able to explain both the geochemistry

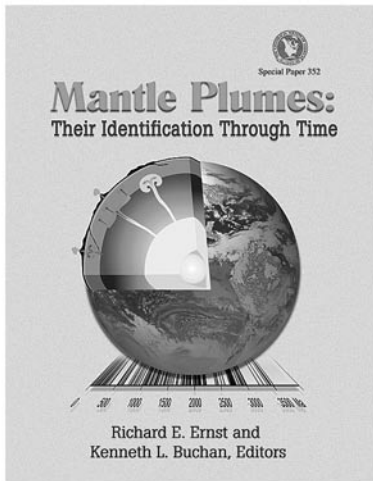
and the crustal thickness there (*Foulger, Natland*). The interpretation of the Icelandic seismic crust in terms of melt thickness is still unclear (*Björnsson, Foulger*). The scarcity of evidence for excessive mantle potential temperatures (*Green, Gudfinnsson, Presnall, C. Stein*) encourages consideration of source variability (*Natland*). Models that involve fertile, fusible patches and lithospheric stress may provide viable alternatives to localized high temperature for many volcanic regions.

The ideal of truly rigid tectonic plates breaks down in reality. Plates move coherently but are not completely rigid, and cracks and volcanic chains can form (*Anderson, Natland, Smith, Winterer*). The Pacific plate may be affected by changes in subduction geometry that change plate-wide stress. Can such stresses produce propagating lithospheric fractures along which basaltic magma erupts? Mesozoic Pacific volcanoes are widely scattered and do not form linear chains. As continental collisions accompanied the close of Tethys in the Eocene (*Flower*), the western Pacific plate became largely bordered with subduction zones and much subsequent seamount and island volcanism on the plate has been linear, age progressive, and parallel. The Emperor-Hawaiian bend does not record a substantial change in direction of the Pacific plate, as may be seen from the continuity of spreading patterns and transform zones of the same age (*Hamilton*), but may represent a change in the orientation of stress imposed on the plate from its edges. Scattered Pacific magmatism could be related to shear heating generated by the so-called westward drift of the lithosphere (*Dogliani*).

Various aspects of volcanism in the Pacific appear to require new models. Linear chains, especially where not time-progressive, suggest tears in the plate or eruption along preexisting structures (*Geist, Harpp, O'Connor*). The most credible nonthermal model for the Emperor-Hawaiian chain is a propagating crack related to stress in the plate. Much plateau formation was associated with triple junctions (*Smith*). Finite-element modeling of ridge-transform junctions reveals an intrinsic pattern of extensional stress that encourages

MANTLE PLUMES: THEIR IDENTIFICATION THROUGH TIME

Richard E. Ernst and Kenneth L. Buchan, editors



The papers in this volume fall most naturally within six themes: an overview of plumes and their geological expression, lessons from Mesozoic and Cenozoic plume-related large igneous provinces, lessons from Mars and Venus, a review of techniques to locate plumes, a survey of early Precambrian plumes and related iron formations, and two global compilations: rifts and large mafic magmatic events through time.

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volcanism (*Beutel*). In the southwest Pacific, the small magma volumes, lack of rifting and uplift, and broad areal distribution could be explained by episodic plate reorganization and recycling of metasomatized lithosphere from subducted slabs (*Finn*).

The Ontong Java plateau, Shatsky Rise, Kerguelen plateau, Deccan Traps, and Bushveld complex are Large Igneous Provinces (LIPs) that represent volumes of magma so huge and eruption rates so rapid that they are difficult to explain by any process. The uniformity and major element geochemistry of Ontong Java plateau basalts was cited as supporting a plume origin and ruling out the involvement of eclogite (*Fitton*). The lack of evidence for precursory uplift and the existence of magnetic stripes across the plateau remain unsolved problems in this model, as is the lack of evidence for fertility in models based on source heterogeneity. Sublithospheric ponding of magmas prior to eruption of LIPs may be required to explain the huge volumes, eruption rates, and compositional homogeneity (*Anderson, Foulger*).

The Shatsky Rise is shown by magnetic stripes to have formed at a migrating triple junction (*Sager*). The Kerguelen plateau contains a continental crustal component and had a long duration of emplacement compared with some other LIPs (*Pringle*). A model presented for the Deccan Traps proposed a source in recycled eclogite trapped in ancient sutures. Evidence for high temperatures is lacking in the petrology, and there was no precursory uplift (*Sheth*), features that are

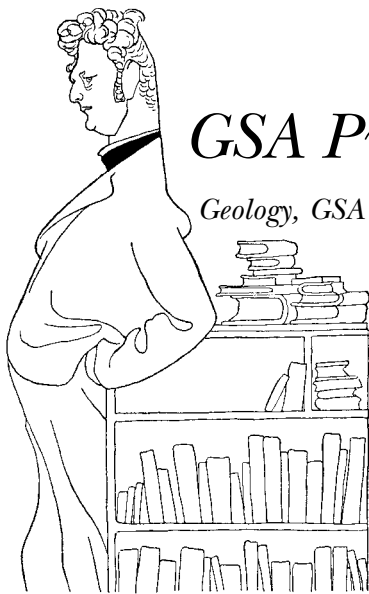
shared by the continental Columbia River Basalts, which formed in a back-arc environment (*Christiansen*). A multiple bolide impact origin for the Bushveld Complex is supported by evidence for ultra-high temperature debris flows and intense deformation there (*Elston*). The absence of LIPs at the ends of many linear volcanic chains (e.g., the Emperor chain) and the lack of linear chains emanating from many LIPs (e.g., the Ontong Java plateau) brings into question the traditional "plume head-plume tail" model. The classic example of a plume head-tail, the Deccan Traps-Chagos-Laccadive Ridge-Reunion Island, was questioned, and the Chagos-Laccadive Ridge ascribed to melting and melt focusing along a southward propagating fracture in the Indian plate (*Sheth*).

An exciting diversity of ideas and concepts was presented at the conference, along with a healthy infusion of skepticism and challenges. In volcanic regions where evidence for a thermal origin is lacking, source fertility, volatiles, recycling of subducted slabs or continental lithosphere, intraplate deformation along faults, rifts, and sutures, stress variations, and bolide impacts are promising avenues to consider. These models require reevaluation of other aspects of our planet, such as the interpretation of seismic anomalies, convection, the longevity of shallow heterogeneities, the importance of lithospheric stress and structure, the origin of geochemical tracers, the fate of subducted slabs, and the melt-retention capabilities of the mantle. Critical data such as seismic measurements from the oceans, heat flow, radiometric dates, and petrological laboratory data are required. Methodologies such as geothermometry and thermodynamic modeling of mantle convection are still too primitive to answer the critical questions. Much work remains to be done.

This Penrose Conference brought together, for the first time, scientists who still seek to understand the fundamental origins of volcanic regions. The full range of ambient ideas in this embryonic field was laid out, brainstormed, criticized, and challenged. The problems, needs, and tasks ahead were brought into focus. We are at the start of a long and exciting journey.

To read more, visit www.mantleplumes.org.

Participants were: Don Anderson, Tiffany Barry, Erin Beutel, Axel Bjornsson, Enrico Bonatti, Françoise Chalot-Prat, Richard Chamberlin, Bob Christiansen, Corrado Cigolini, Marc Davies, Henry Dick, Carlo Doglioni, Adam Dziewonski, Wolfgang Elston, Zuzana Fekiacova, Carol Finn, Godfrey Fitton, Martin Flower, Gillian Foulger, Bjarni Gautason, Dennis Geist, David Green, Gudmundur Gudfinnsson, Giuseppe Guzzetta, Warren Hamilton, Karen Harpp, Anne Hofmeister, Dorthe Holm, Fredrik Holm, Gregory Huffman, Phillip Ihinger, Sveinn Jakobsson, Leonard Johnson, Bruce Julian, Donna Jurdy, Scott King, Vlad Manea, Marina Manea, Jose Mangas, Greg McHone, Jean-Paul Montagner, James Natland, John O'Connor, Angelo Peccerillo, Emma Perez-Chacon, Brian Pope, Malcolm Pringle, Dean Presnall, Will Sager, Hetu Sheth, Olgeir Sigmarsson, Alan Smith, Suzanne Smrekar, Carol Stein, Seth Stein, Ellen Stofan, Richard Walker, Phil Wannamaker, Dayanthie Weeraratne, Marjorie Wilson, Jerry Winterer and Don Wright.



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JOURNALS

Submissions Up, Time-to-Publication Down

With introduction of GSA's online manuscript submission system in 2002, the number of journal articles submitted increased significantly. In the case of *Geology*, 1100 submissions reflected a 35% increase over the previous year.

Process improvements have significantly reduced turnaround times for *Geology* and *GSA Bulletin*. The online submission system has streamlined and improved the review process, reducing acceptance-to-publication time to 9–12 weeks for *Geology*. *GSA Bulletin* also earned a 5-month reduction in review time and acceptance-to-publication time has been reduced by 24%.

Beginning this month, *GSA Bulletin* will be publishing its first "double issue." The Publications Committee approved a schedule of printing issues every other month, with articles posted to the Web as soon as they are ready. This saves in printing and mailing costs while keeping access to articles timely.

High Impact Factor: Citation Index Performance

The high quality of both *GSA Bulletin* and *Geology* is reflected in their citation impact. Both are rated as two of the top earth science journals by *Science Citation Index*.

OF SPECIAL NOTE: ISI's *Journal Performance Indicators* ranks geology journals by the ratio of citations to the number of recent citable items published. *Geology* climbed from #6 to #2 over the past 5 years.

International Scope

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All issues of *Geology* and *GSA Bulletin* dating back to 1988 are available online. Articles in pdf format are reference linked, author indexed, and fully searchable.

GSA BOOKS

Book publications are also on the rise. GSA Books Science Editor Abhijit Basu, Indiana University, has been actively pursuing proposals at U.S. and international meetings, and manuscript submissions are up as a result.

In 2002, a reorganization of the books program reduced time to publication from 12+ months to 6–8 months. As operating efficiencies and a shorter production schedule take hold, book prices are declining, making them more affordable to a wider audience.

GSA's digital map series and field guide series are also now available online. (See page 31 for more on digital maps.)

COMING ATTRACTIONS

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Thanks to the GSA science editors, associate editors, editorial board members, and reviewers, without whom GSA publications could not exist.

Environmental & Engineering Geology

GSA copublishes *E&EG* with the Association of Engineering Geologists. In 2003, a new editorial advisory board was established and new science editors came onboard. The journal will be available online in 2004.



Foundation Silent Auction

This year, the Foundation's Silent Auction at the GSA Annual Meeting in Seattle was a great success. Over \$12,000 was raised. Since the majority of the preparation was handled by volunteers, almost all of the revenue will be applied to the Greatest Needs Fund.

We had a great variety of donated items and appreciate the generosity of the individuals and companies listed below. We plan to continue the event at the 2004 meeting in Denver, and would like to get an early start on collecting items. If you have an item you'd like to donate, please contact George Sharp, geosharp@comcast.net, (253) 581-2603.

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Most memorable early geologic experience:

Phil King drawing a map in the dirt in the Quachita Mountains with the tip of his cane, to show me the locations of wells and scattered outcrops along the Quachita-Marathon belt in Mexico (1973).

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GSA Map and Chart Series Expands with Electronic-Only Publication

J. Douglas Walker, GSA Map and Chart Editor

GSA has been one of the leading scholarly societies for the publication of geoscience maps and charts since its inception over 100 years ago. Maps and charts have been published with papers and more recently as the separate Map and Chart Series. Over the past 30 years, the number of maps and charts has decreased dramatically because of escalating costs of color reproduction and binding into journals. Stand-alone maps and charts have suffered a similar fate. At the same time, geologic and geophysical maps, stratigraphic correlation diagrams, and other necessarily large format diagrams remain basic data for many of the earth sciences. In fact, GSA has recently stated the value of geologic mapping (www.geosociety.org/aboutus/position3.htm); the necessity of mapping is evidenced as well by the large number of programs such as STATEMAP and EDMAP run through the U.S. Geological Survey.

Because of the intrinsic need for maps and charts, and owing to the potential of electronic publishing,



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1. The map or chart must be submitted in a widely usable electronic format. This includes the vector formats PostScript and PDF and raster formats JPEG, GIF, and TIFF. Authors are encouraged to submit any underlying data, such as GIS files, as long as the necessary meta-data are provided.
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ANNOUNCEMENTS

2004

MEETINGS CALENDAR

- March 13–18 Geovisualisation: EuroConference on Methods to Support Interaction in Geovisualisation Environments, Kolymbari, Crete, Greece. **Information:** www.esf.org/euresco.
- May 4–9 50th Annual Institute on Lake Superior Geology, Duluth Minnesota. **Information:** Richard Patelke, rpatelke@nrri.umn.edu, www.ilsg2004.org.
- May 25–30 Karstology—XXI Century: Theoretical and Practical Significance, International Symposium, Perm, Russia. **Information:** Prof. Valery N. Kataev, kataev@psu.ru, Dept. of Geology, Perm State University, 15, Bukirev St., Perm, 614990, Russia, +7-3422-396-506, fax +7-3422-134-967, www.science.psu.ru/karst/.
- June 23–25 Life and Rocks: Bio-Inert Interactions, St. Petersburg, Russia. **Information:** The Saint-Petersburg Society of Naturalists, Universitetskaya nab., 7/9, St-Petersburg, 199034, (812) 328-95-30, fax 812-328-95-30, efokina@ef6885.spb.edu. (*Abstract and registration deadline: April 15, 2004.*)
- November 22–23 GeoSur 2004: International Symposium on the Geology and Geophysics of the Southernmost Andes, the Scotia Arc and the Antarctic Peninsula, Buenos Aires, Argentina. **Information:** GeoSur 2004 Secretary, c/o EAGE-SEG Italian Section, Borgo Grotta Gigante 42c-34010 Sgonico TS, Italy +39-040-2140339, +39-040-327040, eageseg@ogs.trieste.it. (*Abstract deadline: April 15, 2004.*)

2005

- February 10–11 Seismic Geomorphology, Geological Society of London and SEPM, Houston, Texas, USA. **Information:** Jessica Canfor, Conference Coordinator, +44 (0)20 7434 9944, fax +44 (0)20 7494 0579, jessica.canfor@geolsoc.org.uk, www.geolsoc.org.uk/seismicgeomorphology.

Visit www.geosociety.org/calendar/ for a complete list of upcoming geoscience meetings.

About People

GSA Fellow **Lehi F. Hintze** was awarded the first annual Lehi Hintze Outstanding Geologist Award by the Utah Geological Survey and the Utah Geological Association in October 2003. The award, which will be given each fall during Earth Science Week, was named after Hintze because of the unusually large number and variety of ways he has served the Utah geologic community.

The husband and wife team of Marie-Pierre Aubry (professor at Rutgers University, Department of Geology) and GSA Fellow **William A. Berggren** (Distinguished Visiting Professor, Rutgers, Geology Department and retired senior scientist emeritus from Woods Hole Oceanographic institution) received honorary doctorate degrees from the University of Athens October 8. Aubry's award was for her fundamental work on calcareous nannoplankton taxonomy and evolution and her studies on principles and philosophy of chronostratigraphy and studies of hiatuses in the deep sea stratigraphic record. The award to Berggren was for studies in construction of geochronologic scales and principles and philosophy of chronostratigraphy.

History of Geology Field Excursion Announced

Following the 32nd International Geological Congress in Florence (August 20–28, 2004), the International Commission on the History of Geological Sciences (INHIGEO) is

organizing a field excursion (August 29–September 3), visiting field sites, academies, and museums important in the history of geology.

"Italian Institutions and Geological Sites in the History of Geosciences" is open to all persons, regardless of whether they are INHIGEO members or are attending the International Geological Congress. Designed for historians of geology and geologists interested in earth sciences history, the trip will also be of general interest, contributing to knowledge of aspects of scientific and artistic cultural history.

Program: Florence–Siena (Academy of *Fisiocritici*), with stops at Radicofani and Mount Amiata (geological sites). Geological and mining sites in *Colline Metallifere*, Montieri. Etrurian sites in Populonia. Visit to Etrurian mining museum in Campiglia Marittima. Geological sites in Larderello, Saline di Volterra and Le Balze. Volterra to Vinci across Val d'Era and Val d'Arno. Museo Vinciano at Vinci. Bologna (Academy of Sciences; natural history and geological museums). Imola (geological sites and Scarabelli Museum). Verona (Museum of Natural History, with Monte Bolca fossil fish collections; Academy of Agriculture, Sciences, and Letters). Verona–Vicenza: traverse of historical geological sites in Chiampo and Agno valleys. Geological sites in Belluno–Feltre area. Venice (Venetian Institute of Sciences, Letters and Arts; Museum of Natural History). Estimated cost: €900 inclusive. Further information: Professor Nicoletta Morello, Dipartimento di Storia Moderna e Contemporanea, Università di Genova, Via Balbi 6, 16126 Genova, Italy, +039 010 2099838, fax +39 010 2099826, nicoletta.morello@lettere.unige.it.

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June 19–24, 2004, 5 days, 6 nights.

GuestHouse Inn Suites, Dillon, Montana

Scientific Coleaders: Robert C. Thomas and Sheila M. Roberts, The University of Montana—Western. Rob Thomas is a professor of geology in the Department of Environmental Sciences at Western, where he teaches his courses in the natural lab of southwest Montana. Western is the experiential learning campus of the University of Montana and is the first public university in the U.S. to offer semester courses one at a time. Thomas utilizes these field-based courses to incorporate undergraduate students as partners in his research. For example, he and his students have worked on sedimentary basins along the northern margin of the Yellowstone hot spot for the past ten years. Sheila Roberts has been a professor of geology and chemistry in the Department of Environmental Sciences at Western for nine years. By utilizing the department's field-based program, Roberts has incorporated all levels of undergraduate students in her research. Her master's thesis was on Permian rocks in southwest Montana (The University of Montana—Missoula). She teaches regional geology at Western and has edited many publications about western Montana, including the 2000 Rocky Mountain Regional GSA guidebook. Roberts' current research is extremely diverse, and includes aspects of Pleistocene climate change in southwestern Montana, the geology of the Lewis and Clark Trail in Montana, weathering rates of marble tombstones regionally, and the chemistry of natural waters in Beaverhead County.

Description

Extensional tectonism along the northern margin of the Yellowstone hot spot has exposed some of the most diverse and

interesting geology in North America. The pre-hot spot geology includes Precambrian metamorphic rocks, Proterozoic sedimentary rocks of the Belt Supergroup, Paleozoic epeiric sea deposits, Mesozoic foreland basin deposits and associated compressional structures and igneous rocks. The early Tertiary records the beginning of a complex history of regional uplift and basin subsidence as a result of extensional tectonism. By mid-Miocene time, regional extension and sedimentation were influenced by the Yellowstone hot spot. Our trip will focus primarily on the geology influenced by the hot spot, including Tertiary extensional tectonism, sedimentation and volcanism, mountain-front geomorphology, Quaternary glaciation, recent seismicity and hot springs activity. We will base our geological exploration from the small (pop. 5,000) intermountain town of Dillon, Montana. This college town provides the ideal blend of old-west charm and modern conveniences, making it an ideal location for the GeoVenture of a lifetime!

Fees and Payment: \$1,250 for GSA members; \$1,300 for spouse; \$1,350 for nonmembers. A \$200 deposit is due with your reservation and is refundable through May 1, less a \$20 processing fee. Total balance is due May 1. Minimum (*firm*): 25; maximum: 36. **Included:** Classroom programs and materials; field trip transportation; lodging for six nights (single occupancy or double for couples); breakfast and lunch daily; and welcoming and farewell events. **Not included:** Transportation to and from Dillon, Montana, transportation during hours outside field trips; alcoholic beverages; and other expenses not specifically included. Any physical condition requiring special attention, diet, or treatment must be reported in writing when reservations are made. We'll do our best to accommodate special needs, including dietary requirements and physical disabilities.

See the December issue of *GSA Today* or www.geosociety.org/geoVentures for information on other GeoVenture trips.

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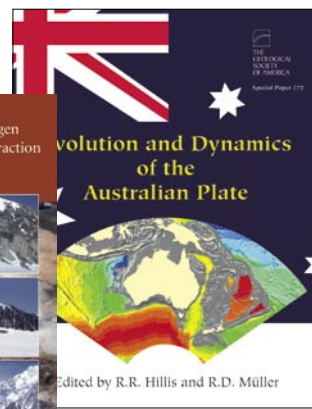
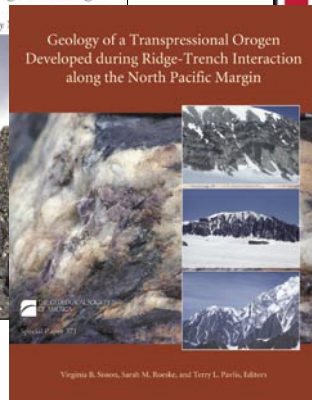
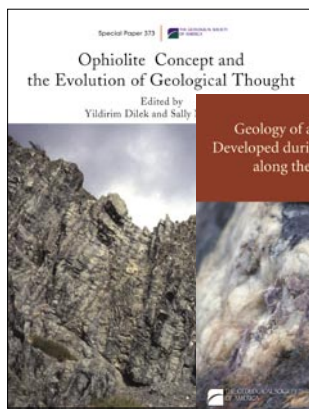
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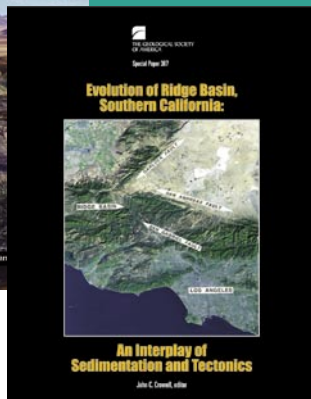
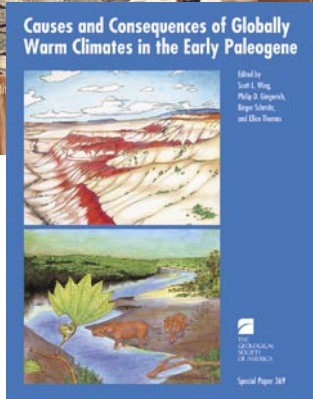
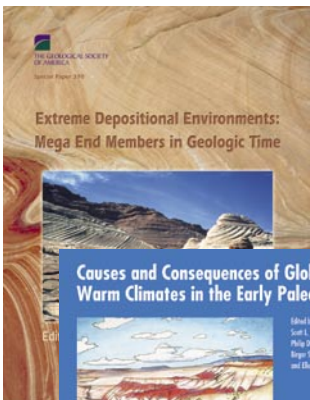
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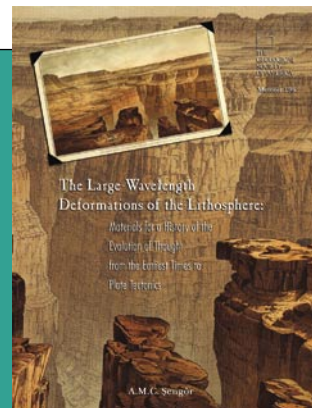
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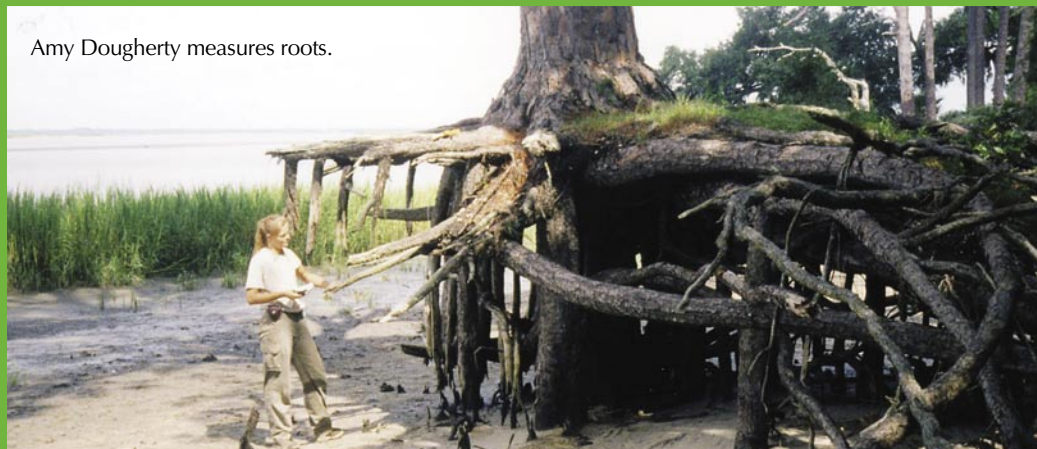


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Call for Applications: 2004

GeoCorps Program

Positions for the 2004 GeoCorps program are posted online at www.geosociety.org/geocorps/.

Applications for the 2004 season will be accepted until February 9, 2004.

2003 GeoCorps America™ Program Highlights

GSA's GeoCorps America™ Program places all levels of geoscientists—college students, professionals, and retirees—in temporary summer positions with the National Park Service, USDA Forest Service, and geoscience companies. GeoCorps is designed to meet the need for geoscience expertise on America's public lands. Participants take part in a variety of geoscience education, research, and resource management projects.

The GeoCorps program dates back to 1997 when, through a partnership with the National Park Service Geologist-In-the-Parks Program, GSA placed two college-level students in summer internships in the national parks. By 2000, the program was redesigned and renamed the GeoCorps America™ Program. Since then, the number of geoscientists placed in temporary positions has steadily increased from two in 1997 to 38 in 2003.

Following are highlights of participant activities in 2003.

Ashley National Forest, Utah & Wyoming

Karen Poole and Joseph Sertich spent their GeoCorps internships conducting a paleontological survey along the perimeter of Flaming Gorge Reservoir. In 10 weeks, they surveyed 200 miles of shoreline and mapped 80 fossil sites. Among their findings were feathers, crocodilian scutes, a perissodactyl footprint, catfish, lily pads, and two large, and as yet unidentified leaves measuring over 50 × 60 cm. These and other collected fossils are now housed at the Utah Field House of the Natural History State Park in Vernal, Utah, under long-term loan from Ashley National Forest.

Hopewell Culture National Historic Park, Ohio

Michael O'Neal was stationed at Hopewell Culture National Historic Park in Chillicothe, Ohio. His research focused on the rate of landscape degradation that has occurred at the Hopewell Culture mound sites in the past 1800 years. The results of his work were presented at a poster session at the 2003 GSA Annual Meeting in Seattle.

Shasta-Trinity National Forest, California

Sarah Pittiglio worked as a soil scientist studying the 100 different soil types that can be found at Shasta-Trinity National Forest. The study's purpose was to correlate the degree of

parent material weathering with the plant species associated with each particular soil.

Inyo National Forest, California

Kyle Anderson developed a geologic trail guide as part of his GeoCorps duties at Inyo National Forest. The informative hiking guide offers 14 geologic interpretive stops with photos and maps describing the geology along a hiking trail in the Sierra Nevada range. Kyle also produced two other lengthy geological reports during his tenure at Inyo.

Forest Service Rocky Mountain Region, Colorado

Annelia Tinklenberg applied her geoscience expertise to the task of producing Web pages for the Rocky Mountain Region's Minerals and Geology Program Web site. Annelia contributed significantly to the regional office and reached her goal of producing an accessible, informative website for the program.

Wupatki National Monument, Arizona

Kirk Peterson worked as a research geologist and interpreter at Wupatki National Monument. He was charged with conducting a paleontological investigation of the trace fossil potential of the park. Kirk's most important accomplishment was the discovery and description of an early Triassic trackway that included large *Chirotherium* trace fossils. The scientific community has shown considerable interest in this find.

Cumberland Island National Seashore, Georgia

Amy Dougherty conducted a research investigation into the back-barrier erosion at Cumberland Island National Seashore that is threatening invaluable archeological sites. Her work provides a foundation for further investigations that can lead to optimal management strategies for the protection of the island's archeological sites. Amy gave a presentation of her findings at GSA's Annual Meeting in Seattle.

Sponsors Make it Possible

GeoCorps is funded through the generous support of our sponsors. We thank the following sponsors for contributing to this valuable program: American Geological Institute; Coconino County, Arizona; GSA Foundation, GeoCorps Fund and John F. Mann Fund; National Park Service, Geologic Resources Division; National Association of Black Geologists and Geophysicists; Shell Exploration and Production Company; S.S. Papadopulos & Associates, Inc.; Subaru, Inc.; and USDA Forest Service.

For more information about GeoCorps America and how to apply for positions, visit www.geosociety.org/geocorps, or contact Elaine Hassinger, ehassinger@geosociety.org. **Applications for the 2004 season are due by February 9, 2004.**

Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department, (303) 357-1053, 1-800-472-1988, ext. 1053, fax 303-357-1070, acrawford@geosociety.org. Please include address, phone number, and e-mail address with all correspondence.

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Positions Open

STRUCTURAL GEOLOGY/TECTONICS THE NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY

Assistant Professor of Geology with specialization in structural geology and/or tectonics. The New Mexico Institute of Mining and Technology (New Mexico Tech) invites applications for a tenure-track position in the Department of Earth and Environmental Science. Appointment at a higher level may be considered for exceptional candidates.

Applicants should have a Ph.D. in Earth Sciences or a related field at the time of appointment. We seek an individual who complements existing strengths and can work collaboratively with other groups and faculty at New Mexico Tech. Possible areas of research include, but are not limited to, faults and fluid flow, crustal structure and evolution, plate boundaries and continental margins, neotectonics, and EarthScope-related research. Potential for excellence in teaching and research are the most important qualifications.

Responsibilities will include developing an active program of extramurally funded research, supervising and supporting M.S. and Ph.D. students, and teaching two classes per semester (typically one graduate and one undergraduate class). The successful applicant must be able to teach structural geology, an additional undergraduate class (e.g., metamorphic petrology, mineralogy) and graduate courses in his/her area of specialization.

New Mexico Tech, located in the scenic central Rio Grande valley, has an enrollment of approximately 1800 undergraduate and graduate students. The Department of Earth and Environmental Science includes 22 faculty members, numerous active adjunct faculty, approximately 60 undergraduate majors, and 80 graduate students. The Department includes programs in geology/geochemistry, hydrology, and geophysics. Additional geoscience professionals on campus include over 30 staff members of the Bureau of Geology and Mineral Resources (New Mexico's geological survey) and seismologists at the Iris/Passcal instrument center. For further information about the Department and this position visit our web site (www.ees.nmt.edu).

Applicants should submit a statement of research and teaching interests, curriculum vitae, and the names of three references to Human Resources, Box 159G, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801. Transcripts will be required if selected to interview. To receive full consideration all materials must be received by March 1, 2004. Email applications are not accepted. New Mexico Tech is an equal opportunity/affirmative action employer.

GRAND VALLEY STATE UNIVERSITY ENVIRONMENTAL GEOLOGIST

Applications are invited for a tenure-track, assistant professor to begin fall 2004. A Ph.D. in Geosciences is required with specialization in Environmental Geology, particularly expertise in coastal geology and/or fluvial geology; an interest in teaching introductory geo-thematic courses; developing our major programs in geology, earth science, integrated science (elementary education); and developing an environmental geology track. Responsibilities include teaching introductory general education courses and courses the applicant develops within their subdiscipline or shares. Faculty do cooperative research with undergraduates and carry out regular duties (advising, committee work, etc). Additional expertise that

increases the breadth of our department is desirable (<http://www.gvsu.edu/geology/>). Send a letter of application, vita, statement of teaching philosophy, and the names, addresses, phone numbers, and e-mail addresses of three references to: Kevin Cole, Chair, Department of Geology, Grand Valley State University, Allendale, Michigan 49401. (616-331-3791) (mailto:colek@gvsu.edu). Review of applicants will begin January 15 with applications accepted until the position is filled. Grand Valley State University is an affirmative action, equal opportunity institution.

POSTDOCTORAL RESEARCH POSITION MULTICOMPONENT REACTIVE TRANSPORT MODELING UNIVERSITY OF BRITISH COLUMBIA

The Department of Earth and Ocean Sciences at the University of British Columbia (UBC), in collaboration with the Department of Civil Engineering at the University of New Brunswick, invites applicants for a postdoctoral research position focusing on the assessment of modeling techniques for water-rock interaction in fractured crystalline rock. The research is being conducted to explore issues of redox stability to depths of several hundreds of metres. The successful candidate will test and identify suitable and efficient modeling techniques for the evaluation of moving redox fronts (oxygen ingress and attenuation) in fractured granitic bedrock. Model formulations to be investigated will include dual-continua and discrete fracture approaches. The modeling will be conducted using an existing multipurpose multicomponent reactive transport code and will be carried out based on available hydrogeochemical and paleohydrogeological data sets.

The ideal candidate will have a solid background in code development, numerical modeling of flow and reactive transport processes, as well as hydrogeochemistry and water-rock interaction. Applications are invited from candidates with any relevant Ph.D. degree (Earth Sciences, Civil Engineering, and others). The position will be available starting January 2004 and the appointment will be for 18 months with a possible extension for an additional 6 months. Salary will range from Cdn\$35,000/yr-Cdn\$45,000/yr, depending on experience of the applicant.

UBC hires on the basis of merit and is committed to employment equity. To apply, send curriculum vitae and a list of 3 referees to: Dr. Ulrich Mayer, Department of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver, BC, V6T 1Z4, Canada (e-mail: umayer@eos.ubc.ca) and Dr. Kerry MacQuarrie, Department of Civil Engineering, University of New Brunswick, P.O. Box 4400, Fredericton, NB, E3B 5A3, Canada (e-mail: ktm@unb.ca). Applications by e-mail are preferred. Applications will be considered until the position is filled.

TURNER POSTDOCTORAL FELLOWS THE UNIVERSITY OF MICHIGAN

The Department of Geological Sciences invites applications for Turner Postdoctoral Fellows, which are positions of two-year duration open to any area of geological and earth system sciences. We offer an annual salary of \$44,000, plus benefits and a research/travel fund. Applicants are encouraged either to collaborate with an existing research group at the University of Michigan that will cost-share salary or to propose an independent project and cost-share salary with moderate teaching responsibilities. Visit our department web pages for more information on faculty and research groups (<http://www.geo.lsa.umich.edu>). Submit a curriculum vitae, a brief (3 pages or less) research proposal, and names of at least three references by January 23, 2004, to: Prof. Philip A. Meyers (pameyers@umich.edu), Turner Postdoctoral Committee, Dept. of Geological Sciences, University of Michigan, Ann Arbor, MI, 48109-1063. The University of Michigan is an affirmative action/equal opportunity employer.

MARSHALL UNIVERSITY/FACULTY POSITION

The Department of Geology at Marshall University invites applications for a full time teaching position beginning August 17, 2004. The vacancy will be filled as a 9 month temporary position at the Assistant or Associate Professor level. The successful applicant will be expected to teach upper level courses in Petrology and Geochemistry as well as service courses in General Geology and Earth Materials Lab. A Ph.D. is required and several years teaching experience is preferred. Preference will be given to candidates whose research focuses on environmental geochemistry. Facilities and instrumentation for teaching and research include an extensive rock and mineral collection, thin and polished section preparation lab, X-ray Diffractometer, ICP and AA Spectrometer, and SEM with EDS.

Candidates should submit a letter of application, curriculum vitae, undergraduate and graduate transcripts, a statement of teaching and research interests, and the names and contact information (including e-mail

addresses) for three references. All application materials should be sent to Dr. Ronald Martino, Chair, Department of Geology, Marshall University, Huntington, WV 25755. Review of applications will begin on January 15 and continue until the position is filled.

Marshall University is an EO/AA employer. Women and minorities are encouraged to apply. For additional information about the Department of Geology and Marshall University, please visit the website www.marshall.edu.

GEOPHYSICS, UNIVERSITY OF FLORIDA

The Department of Geological Sciences invites applications for a tenure-track assistant professor position in geophysics to begin in the 2004-2005 academic year. Preference will be given to quantitative, process-oriented scientists who will develop strong and innovative externally funded research programs, and who exhibit a strong commitment to teaching undergraduate and graduate students. We are particularly interested in scientists whose research addresses fundamental earth processes in a quantitative way through the application of solid earth geophysics including but not limited to passive and active seismology, crustal structure, tomography, magnetics, and gravity. We encourage applications from individuals who will complement existing research strengths of the Department (e.g., crustal evolution and chemical geodynamics, paleomagnetism, tectonics, paleoclimatology, paleoceanography, environmental geology-hydrogeology, isotope geology) and will interface with scientific initiatives such as Earth Scope, Margins etc. For more information about the department, including its remote seismic network, see web.geology.ufl.edu.

Qualified candidates should send a letter of interest including a statement of research and teaching goals, curriculum vitae, and the names and addresses of at least three references to the search committee chair: Dr. David A. Foster (dfoster@geology.ufl.edu), Department of Geological Sciences, PO Box 112120, University of Florida, Gainesville, Florida 32611, Ph. (352) 392-2231/FAX (352)-392-9294.

The review of applications begins on January 5, 2004, and continues until the closing date of February 2, 2004.

The University of Florida is an equal opportunity employer; qualified women and minorities are especially encouraged to apply.

ASSISTANT PROFESSOR GEOLOGICAL SCIENCES-PALEOCLIMATOLOGY AND ENVIRONMENTAL CHANGE UNIVERSITY OF TEXAS AT EL PASO

The Department of Geological Sciences and the Center for Environmental Resource Management at the University of Texas at El Paso invite applications for a tenure-track faculty position at the assistant professor level beginning August 2004. Located on the border with Mexico in a desert-mountain setting, UTEP attracts students from throughout the country and the world to its graduate programs. The Department of Geological Sciences and the Center for Environmental Resource Management (CERM) support undergraduate, M.S., and Ph.D. degrees in Geological Sciences as well as interdisciplinary undergraduate, M.S., and Ph.D. programs in Environmental Science. Additional funding and research opportunities in environmental disciplines come from two university research centers: CERM, and the Pan-American Center for Earth and Environmental Science. The Department is housed in a spacious building that contains extensive analytical and computing facilities. In addition, the collaborative research environment on our campus affords easy access to a superb variety of analytical equipment in other departments. For more information about our activities and facilities, visit our web sites at <http://www.geo.utep.edu> and <http://www.cerm.utep.edu>.

QUALIFICATIONS REQUIRED: The candidate must have a Ph.D. degree at the time of appointment. We seek applicants with research and teaching interests that will augment our programs in environmental science and engineering. Research specialties might include, but are not limited to environmental geology, soil science, stable isotope geochemistry, and surface processes. We are particularly interested in candidates who seek to integrate the record of the past with current questions in environmental research. The successful candidate will be expected to develop a vigorous, well-funded research program, and to teach introductory courses in his/her specialty.

APPLICATION PROCEDURE: Applicants should send a CV, a short description of teaching and research interests and the names of three people willing to provide professional references to: Kate C. Miller, Chair Department of Geological Sciences, University of Texas at El Paso, El Paso, TX 79968-0555, Phone: 915-747-5424, Fax 915-747-5073, Email: miller@geo.utep.edu. We will begin reviewing applications on February 1, 2004, and will accept applications until the position is filled.

The University of Texas at El Paso does not discriminate on the basis of race, color, national origin, sex, reli-

gion, age, disability, veteran's status or sexual orientation in employment or the provision of services.

INDIANA UNIVERSITY COLLEGE OF ARTS AND SCIENCES

The Department of Geological Sciences seeks applications and nominations to fill two to three tenure-track positions. Up to two may fill endowed positions. Our new colleagues will be expected to develop and maintain an internationally recognized research program and to participate in teaching and other academic activities appropriate for faculty members at Indiana University.

We seek a person in any area of sedimentary geology who will complement the Department's recent expansion in hydrogeology, basin analysis, clay mineralogy, sedimentary geochemistry, and mudstone sedimentology. Exceptional individuals with an outstanding record of scholarly achievement may be considered for the Robert R. Shrock Endowed Position in Sedimentary Geology. Questions concerning this position should be addressed to Professor Mark Person, (812-855-4404; email: maperson@indiana.edu).

We invite applications in all areas of Solid Earth Geophysics. We seek an individual who will interact with and effectively complement existing research programs in the Department of Geological Sciences. Preference will be given to candidates whose research contributes to current major national emphasis areas in geophysics. Outstanding candidates with an appropriate background in applied and exploration geophysics may qualify for the Judson Mead Endowed Position. Questions concerning this position should be addressed to Professor Gary Pavlis (812-855-5141; email: pavlis@indiana.edu).

In Biogeochemistry we seek a colleague with research interests in geomicrobiology and/or paleoclimatology engaged in the study of multidisciplinary linkages between the life sciences and the geosciences. Our shared laboratory instrumentation includes state-of-the-art analytical equipment and experienced technical support personnel. The appointee will participate in the design of our custom laboratory space within a new state-funded building. Questions concerning this position should be addressed to Professor Simon Brassell (812-855-3786; email: simon@indiana.edu).

Applicants should send a statement of research and teaching interests, current resume, reprints as appropriate, and names and addresses of three references (including email address) to: Chair, Department of Geological Sciences, Indiana University, 1001 East Tenth Street, Bloomington, IN 47405-1405

The review of applications will begin on January 1, 2004, and will continue until the positions are filled.

Indiana University, as an equal opportunity/affirmative action employer, encourages applications from women and minorities.

POSTDOCTORAL POSITION UNIVERSITY OF CALIFORNIA, BERKELEY

A postdoctoral position is open in the Department of Earth & Planetary Science for collaboration in research concerned with (1) calculation of activity coefficients as a function of temperature, pressure, and composition for aromatic compounds and other hydrocarbon and NSO species that exhibit nonideal behavior in petroleum, (2) investigation using these activity coefficients of the effect of differences in reactant and product kerogen compositions in the system CHNSO on the composition and speciation of different crude oils generated at the same temperature by incongruent melting of the reactant kerogen, (3) determination of the effect of nitrogen and sulfur in the reactant and product kerogen on oil generation and the thermodynamic consequences of reaction among sulfur-bearing species in the oil and sulfide minerals in hydrocarbon source rocks, and (4) chemical and thermodynamic description of the chemical interaction of expelled oil with its aqueous and mineralogical environment. Highly qualified individuals at the time of or shortly after completion of their doctoral studies are invited to apply for this position. A background in thermodynamics and organic geochemistry is desired. Salary commensurate with experience and publication record. The term of appointment is two years with the possibility of a one-year extension. Send a letter of interest, resume, and names and addresses (including email) of three references to Liz Garrity, MSO, Department of Earth & Planetary Science, Mail Code 4767, University of California, Berkeley, CA 94720-4767 by January 31, 2004. The University of California is an equal opportunity employer.

ASSISTANT/ASSOCIATE PROFESSOR OF GEOLOGY EAST TENNESSEE STATE UNIVERSITY

College of Arts and Sciences, Dept. of Physics, Astronomy, & Geology—Assistant/Associate Professor of Geology, tenure track, beginning August 2004. Will teach introductory geology (historical/physical), environmental geology, economic geology, engineering geology, hydro-

geology, and graduate-level courses in his/her specialization; establish a rigorous, externally funded research program; advise students; oversee student projects; serve on committees; contribute to curriculum development; and perform other duties as assigned. Preference will be given to engineering or environmental geologists, and/or those whose research includes the Appalachians. Ph.D. in geology/related field required; completion at time of appointment preferred (must be completed within 6 months). Position open until filled, and contingent upon state funding. Submit a letter of application, statement of teaching philosophy, curriculum vitae, transcripts, and three letters of recommendation to: Dr. Steven Wallace, Geology Search Committee Chair, Dept. of Physics, Astronomy, and Geology, ETSU, Box 70636, Johnson City, TN 37614-1702. AA/EOE.

SUNY POTSDAM, DEPARTMENT OF GEOLOGY

SUNY Potsdam invites applications for a tenure track Assistant Professor position in the Department of Geology to begin in the fall of 2004. Responsibilities include teaching undergraduate stratigraphy and paleontology, an introductory course of the successful candidate's choice and design, and participation in our interdisciplinary science program to train elementary school teachers. Knowledge of GIS is an asset, as is the ability to incorporate hydrogeology into the curriculum. Scholarly research, with student participation, is expected. We emphasize undergraduate research and fieldwork with all majors. Courses taught will complement existing courses in sedimentology, igneous and metamorphic petrology, structural geology, geophysics, mineralogy, and geochemistry. Potsdam is located in the Grenville terrain of the Adirondack Mountains and St. Lawrence River Valley of Northern New York. Field areas abound, and the faculty all actively engage students in their research. The Geology Department, consisting of five full time faculty, currently has about 35 majors. Additional information on the college and the department may be obtained from the college's website: <http://www.potsdam.edu> or by email at: badgerl@potsdam.edu. Facilities to support teaching and research include an SEM, AA, XRD, a seven station seismic network, electrical resistivity, Strataview R24 for seismic reflection and refraction, a Worden Prospector Gravity Meter, a proton precession magnetometer and minimate seismograph. Applicants should have a PhD by August 15, 2004. Applications should provide evidence of teaching ability. Base salary: \$40,500. Applications should be received by February 2, 2004. Please send curriculum vita, cover letter, and phone numbers/email addresses of at least three references to: Search Committee, Department of Geology, SUNY Potsdam, Potsdam, NY 13676. SUNY Potsdam is an equal opportunity employer committed to excellence through diversity.

FULL-TIME TEMPORARY FACULTY POSITION EDINBORO UNIVERSITY OF PENNSYLVANIA

The Department of Geosciences seeks applications for a Full-time Temporary Instructor/Assistant Professor for 2004-2005 academic year. Responsibilities: Teach 12 credits per semester including courses in physical geology, oceanography, and possibly an upper-division seminar in candidate's area of expertise. Qualifications: PhD in Geology expected (ABD considered). Open to any specialty. Deadline: Applications must be postmarked by February 16, 2004.

In addition to teaching responsibilities, faculty members are expected to maintain a record of scholarship, perform additional duties such as student advising, and contribute positively to departmental/university activities, etc., in compliance with a collective bargaining agreement. In order to be a finalist in the search, in addition to the aforementioned requirements, the candidate minimally must be able to communicate well and perform well in an interview and teaching demonstration.

Specify Position #170-1304 and submit a letter of application, CV, copies of transcripts and names/addresses/telephone numbers of three current references to Dr. Eric Randall, Dean of Science, Management and Technology, Department GSA, Edinboro, PA 16444. Contingent upon enrollment. Fluency in the English language for final candidates will be assessed.

Edinboro University of Pennsylvania is building a diverse academic community and encourages people of color, women, veterans and persons with disabilities to apply. AA/EOE. Visit our home page at <http://www.edinboro.edu>, Offices & Services, Employment Opportunities.

DIVISION OF EARTH SCIENCES NATIONAL SCIENCE FOUNDATION ARLINGTON, VIRGINIA

NSF's Division of Earth Sciences (EAR) is seeking a qualified candidate for Program Officer for the EarthScope Program. The Program covers a wide range of scientific areas and the EarthScope facility includes the seismic

element USArray, the geodetic element Plate Boundary Observatory (PBO), and the drilling and deep instrumentation element San Andreas Fault Observatory at Depth (SAFOD). This position involves responsibility and oversight of the facility management, construction, operation and oversight of the EarthScope science component.

Appointment to this position will be on a permanent basis with a salary range of \$81,602 to \$127,168. Applicants must have a Ph.D. or equivalent experience in the earth sciences, seismology, space-based geodesy, drilling technology, geophysics, hydrogeology, stratigraphy, geochemistry, tectonics, or related disciplinary fields, plus six or more years of successful research, research administration, and/or managerial experience beyond the Ph.D. Experience managing large facility construction and/or operations are desirable.

Announcement E20040013, with position requirements and application procedures, are located on the NSF Home Page at www.nsf.gov/jobs. Applicants may also obtain the announcements by contacting Yvonne Woodward at 703-292-4386 (Hearing impaired individuals may call TDD 703-292-8044).

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GEOMORPHOLOGY OR STRUCTURAL GEOLOGY INDIANA UNIVERSITY-PURDUE UNIVERSITY FORT WAYNE

The Department of Geosciences at Indiana University-Purdue University Fort Wayne invites applications for a tenure-track position at the Assistant Professor level, beginning August, 2004. The successful candidate will teach undergraduate courses in physical geology, weather and climate, maps/GIS, geomorphology and structural geology. Candidates must develop an active research program in their field of specialty. Ph.D. required.

The Geosciences Dept. has 5 faculty, secretary and technician located in new facilities designed for geology.

Candidates must submit a C/V, interests statement, and have three letters of reference sent to Anne Argast, Chair, Dept. of Geosciences, IPFW, Fort Wayne, IN 46805-1499. Inquiries to Argast@ipfw.edu. Applications will be reviewed starting March 1, 2004. IPFW is an AA/EEEE institution. More at www.geosci.ipfw.edu.

MARSHALL UNIVERSITY/FACULTY POSITION

The Department of Geology at Marshall University invites applications for a tenure track teaching position beginning August 17, 2004. The position will be filled at the Assistant or Associate Professor level. The successful applicant will be expected to teach upper level courses in Geomorphology, Environmental Geology, Engineering Geology, and Soils as well as service courses in General Geology, Earth Materials Lab. A Ph.D. is required and several years teaching experience is preferred. The successful applicant will be expected to integrate a strong field component into upper level courses and develop a vigorous, externally supported research program that involves undergraduates.

Candidates should submit a letter of application, curriculum vitae, undergraduate and graduate transcripts, a statement of teaching and research interests, and the names and contact information (including e-mail addresses) for three references. All application materials should be sent to Dr. Ronald Martino, Chair, Department of Geology, Marshall University, Huntington, WV 25755. Review of applications will begin on January 15 and continue until the position is filled.

Marshall University is an EO/AA employer. Women and minorities are encouraged to apply. For additional information about the Department of Geology and Marshall University, please visit the website www.marshall.edu.

Opportunities for Students

The Doctoral Program in Environmental Management (D.Env.M.) at Montclair State University is pleased to announce the Catherine McMullen Blake Doctoral Fellowship. This four year fellowship will be awarded to an exceptional new, full-time student beginning Fall 2004. The Fellowship provides a \$20,000 annual stipend (12 months), full tuition waiver, and campus housing as needed. Please see www.csam.montclair.edu/denvm/ for admission criteria and program information. The complete application including letters of reference must be received by Feb. 10, 2004. Applicants must note that they are applying for the McMullen Blake Fellowship. Candidates not chosen for the Fellowship will automatically be considered for a Graduate Assistantship (\$15,000 annual stipend and tuition waiver). Contact Dr. Michael Kruger, Associate Dean, College of Science & Mathematics, Montclair State University, Upper Montclair, NJ 07043 (krugem@mail.montclair.edu). Montclair State is the second largest university in New Jersey, located 20 km west of Manhattan, providing ready access to the sites of environmental concern in the New York metropolitan area.

Ph.D. Student Assistantships. Oregon State and Portland State Universities are offering ten Ph.D. research assistantships to explore all aspects of the Earth's subsurface microbial biosphere. Tuition and stipend are provided by the NSF IGERT program and the two universities. Students will work in interdisciplinary teams of engineers, oceanographers, microbiologists, microbial ecologists, geologists, soil scientists, and chemists to solve environmental problems, to understand global chemical cycles, and to determine the impact of subsurface microorganisms on surface ecosystems. More information can be found at: <http://oregonstate.edu/dept/igert>, or Martin R. Fisk, College of Oceanic and Atmospheric Sciences, Oregon State University, mfisk@coas.oregonstate.edu. Students from all scientific backgrounds are encouraged to apply to departments represented by IGERT faculty at either institution. U.S. citizens or permanent residents can be supported by IGERT funds however students of all nations can participate in the program. Review of applications starts 1/15/04. Oregon State and Portland State Universities are committed to equality in education.

NASA Planetary Biology Internships. The Marine Biological Laboratory, Woods Hole, Massachusetts, invites applications from graduate students and seniors accepted to graduate programs for rewards of \$2,800 plus travel to participate in research in NASA centers and collaborating institutions for approximately 8 weeks.

Typical intern programs include: global ecology, remote sensing, microbial ecology, biomineralization, and origin and early evolution of life. Application deadline: March 1, 2004. For information/applications, contact: Michael Dolan, Planetary Biology Internship, Department of Geosciences, Box 3-5820, University of Massachusetts, Amherst, MA 01003-5820. E-mail: pbi@geo.umass.edu. Tel (413) 545-3223. An Equal Opportunity/Affirmative Action Employer.

New Funding Initiative for Graduate Assistantships, Texas Christian University. The Geology Department announces a new funding initiative for M.S. students. Teaching assistantships available for the spring and fall semesters include nine-month stipend of \$12,500, full tuition waiver, and up to \$2,000 to support thesis research. Areas of department expertise include hydrology, earth-surface processes, remote sensing, environmental geology and geochemistry, carbonate and clastic sedimentology, petroleum geology, petrology and volcanology, structure and tectonics, and computer applications in geology. The department also houses the world-class Monnig Meteorite Museum. Student research is carried out in Scotland, the Sierra Nevada in California, and Africa, as well as Texas and Oklahoma. Contact Dr. R. Hanson at 817-257-7996, r.hanson@tcu.edu, or visit our website at <http://www.geo.tcu.edu>.

JOI/USSSP Internship Opportunities! Joint Oceanographic Institutions (JOI) is seeking qualified U.S. applicants for a one-year internship, beginning summer 2004, at the JOI Office in Washington, D.C. The JOI/US Science Support Program (USSSP) Internship Program's goal is to introduce recent science graduates to science program management. This internship is ideally for spring 2004 graduates seeking experience with a scientific non-profit organization before continuing their education. Interns will work full-time, dedicating half of their effort to special projects and the remainder to other tasks in support of USSSP. For the term appointment, the intern will be a salaried JOI employee with full benefits. Specific start and end dates will be negotiated. Interested applicants should submit a cover letter, resume, and the names of three references to the JOI Office by March 15, 2004. Interviews with finalists will be scheduled in late March/early April, and a decision will be made by mid-April.

For more information about JOI and the science programs it manages, please visit www.joiscience.org. Please direct questions and/or applications to: Margo Cortes (mcortes@joiscience.org), Joint Oceanographic Institutions, 1755 Massachusetts Avenue, NW, Suite 700, Washington, DC 20036. After December 15, please send applications to JOI's new address: 1201 New York Avenue, NW, Suite 400, Washington DC 20005.

Note: Award of the internship is subject to JOI being selected as the successful bidder to NSF for USSSP/IODP.



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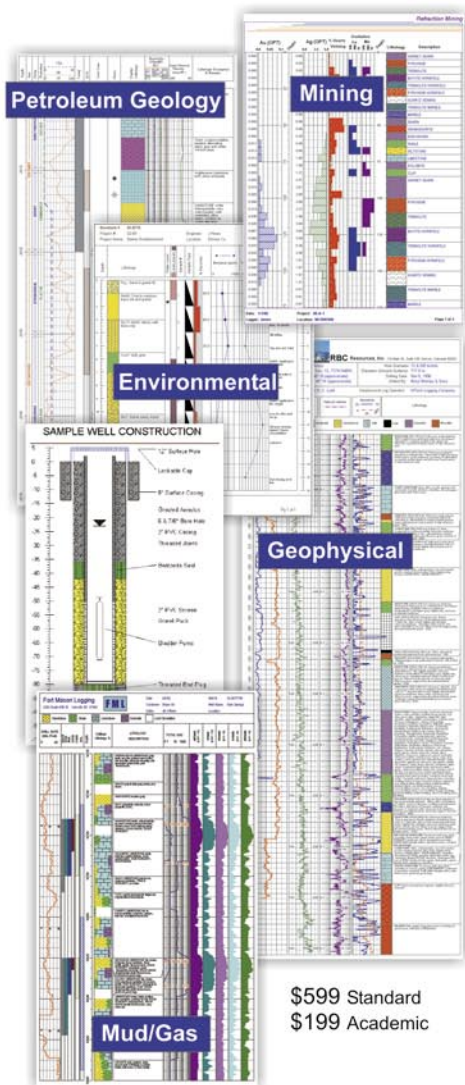
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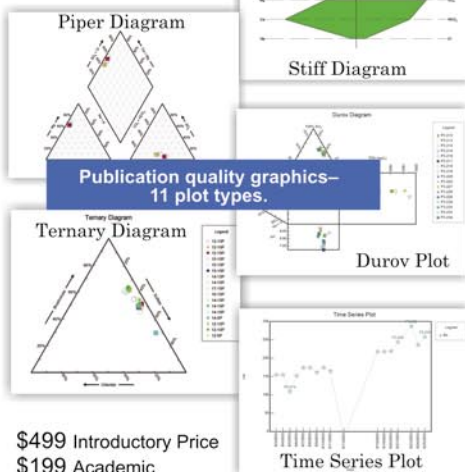
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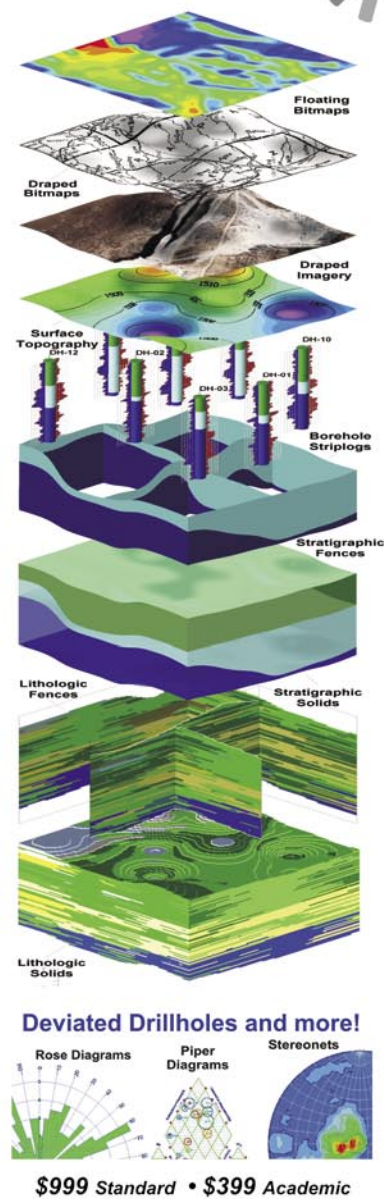
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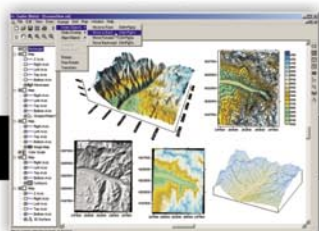
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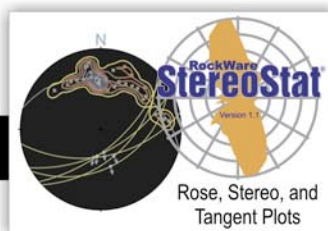
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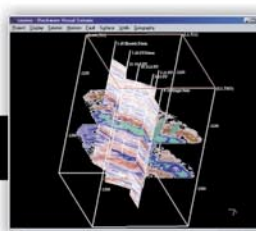
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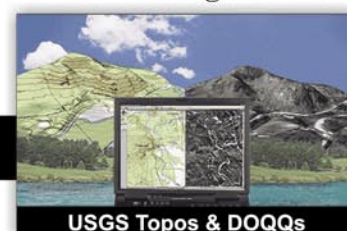
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