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Morphology of the Island of Hawaii

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ABSTRACT

Digital elevation data for the island of Hawaii from the U.S. Geological Survey gridded at 30 m spacing was used to generate a slope map, a shaded relief map, and plots that compare slope and elevation for each of the five volcanoes that compose the island. These computer-generated products are useful in analyzing the morphology of the island. The volcanoes become steeper with increasing age. The five volcanoes, in order of increasing age, are Kilauea, Mauna Loa, Hualalai, Mauna Kea, and Kohala; their average slopes are 3.3°, 5.4°, 6.6°, 7.0°, and 11.3°, respectively. This relation apparently results from growth of the late, steeper alkalic cap on the older volcanoes that includes more viscous, thicker flows, flows that are smaller and hence tend to pile up more near the summit vents, and volatile-rich lavas that commonly produce steep-sided cinder cones at summit vents. The causes of the gentler slopes of younger volcanoes include the high proportion of exposed fluid lava flows from the shield-building stage, the ponding of lava against earlier volcanoes, and the grading of lava to sea level; subsidence of the older volcanoes has caused these gently dipping near-sea-level lava flows to subside below the sea. Finally, steep erosional canyons have developed in large areas of the older volcanoes (notably Kohala).

Virtually all of the major fault systems on the island appear to be related to the upper parts of giant landslides, most of which are hidden below sea level on the submarine flanks of the volcanoes. These are generally normal faults in the tensional regime at the heads and upper parts of the landslides. Subtle changes in slope hint at buried landslide-related fault scarps that have been covered by subsequent lava flows.

Major erosional canyons are present in only two places, each presumed to be in the amphitheaters of major landslides. They probably formed in this setting because stream erosion is favored by the steep slopes generated at the heads of landslides. The slope map clearly displays two bands of steep slope on Mauna Kea that mark the terminal moraines at the edges of the last two advances of the Pleistocene ice cap.

INTRODUCTION

We are on the threshold of a new era of map making and map interpretation as a result of ready access to computer technology to process the body of digital cartographic data that is rapidly increasing in coverage and detail. Recent work has focused on relatively coarse digital data of large areas such as the entire planet (Moore and Mark, 1986) or major parts of continental masses (Pike, 1991; Simpson and Anders, 1992). Here we examine how digital topographic data of a relatively small island (Fig. 1), about 100 km in diameter, can provide new insights into the volcanic and degradational processes that have shaped its surface.

The five volcanoes that compose the island of Hawaii (Fig. 2) are particularly amenable to slope analysis because they are young, they are in a relatively simple oceanic, intraplate geologic environment, and the compositional range of the lavas, as well as the mode of eruption, is limited. Recently available digital elevation data for the island from the U.S. Geological Survey are the most detailed yet available and provide a basis for the computer manipulation of topographic information.

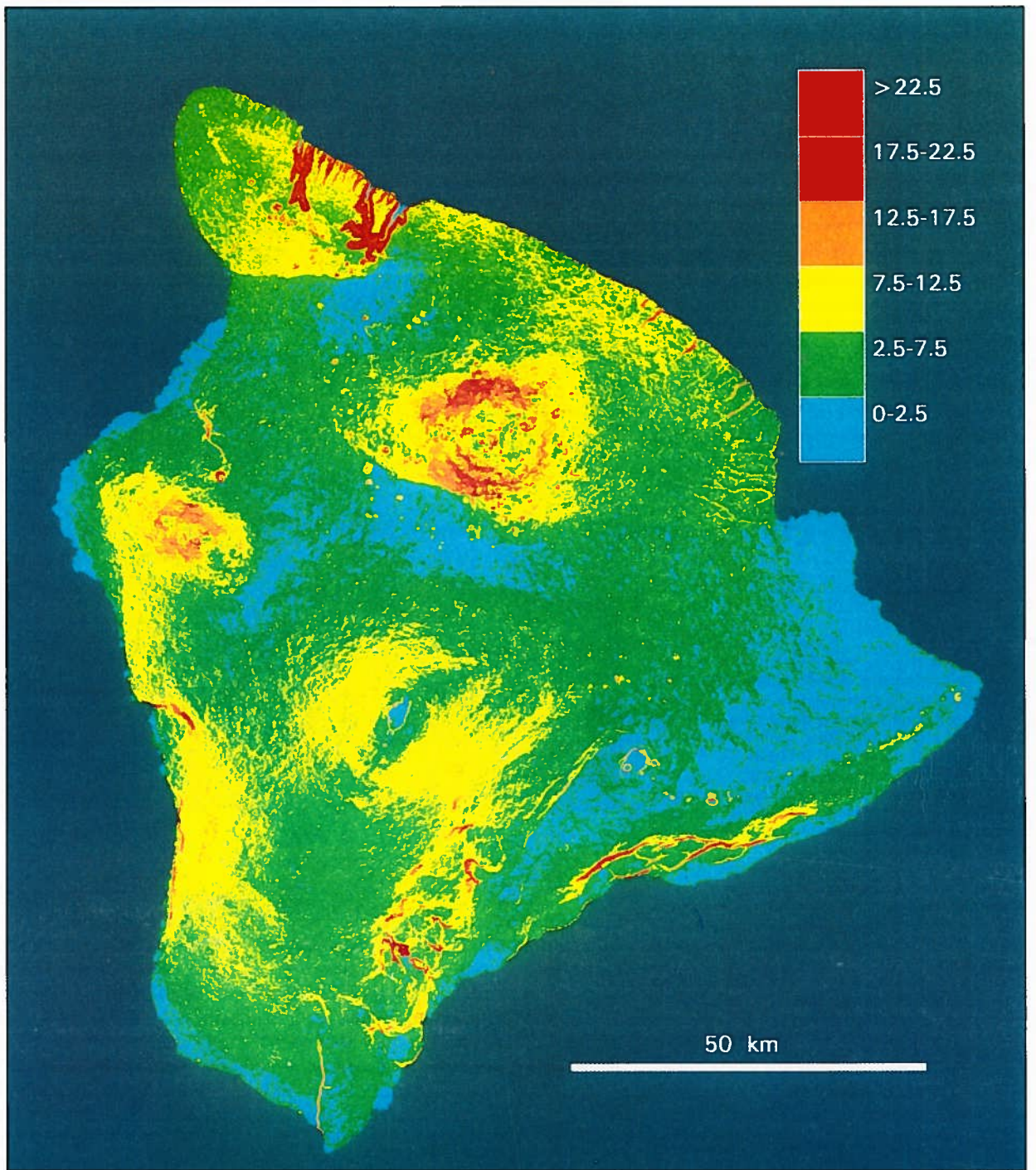


Figure 1. Slope map of the island of Hawaii. Colors indicate six 5° categories of topographic slope; warmer colors indicate steeper slopes.

Terrain slopes are a sensitive indicator both of the processes that built a particular landform and of those that have subsequently degraded it. On Hawaii, the process of construction is largely volcanic. The individual volcanoes were built mostly from lava flows that issued from near the summit and from flanking rift zones. In addition, intrusions of various sizes and depths have played a role in volcanic construction. The shield-building stage of Kohala, the oldest volcano on the island, ended about 465 ka. Shield building on both Mauna Kea and Hualalai ended at about 130 ka, whereas Mauna Loa and Kilauea are still in the active shield-building stage.

Processes that have modified the original volcanic morphology include collapse into magma bodies, producing summit calderas and rift-zone pit craters and grabens, as well as erosion and landsliding. Erosion is minor except on Kohala, which is carved by giant canyons, and Mauna Kea, which was man-

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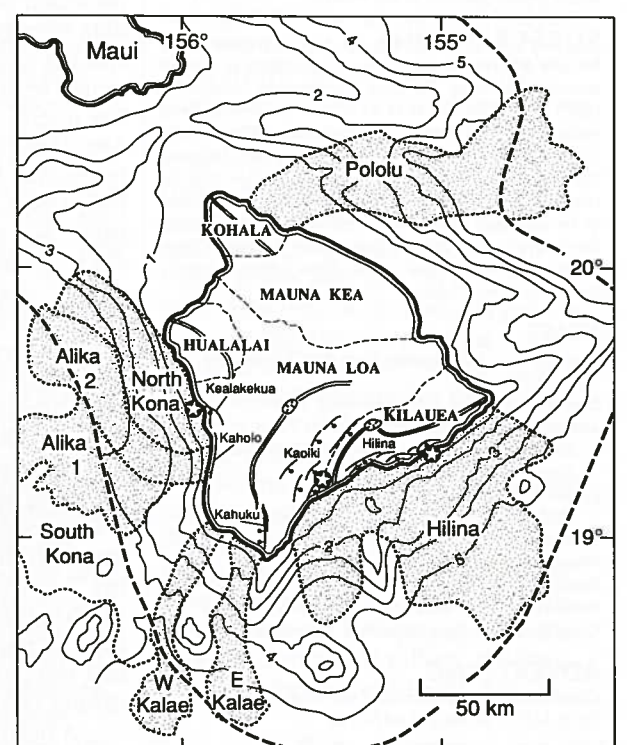


Figure 2. Island of Hawaii and offshore bathymetry; depth contours in kilometers. Dashed lines outline the five volcanoes that compose the island; the dot pattern shows major submarine landslides. Fine lines with ball on downthrown side show major fault systems; double lines show volcanic rift zones. Stars mark largest Hawaiian earthquakes—from west to east, 1951, 1868, 1975.

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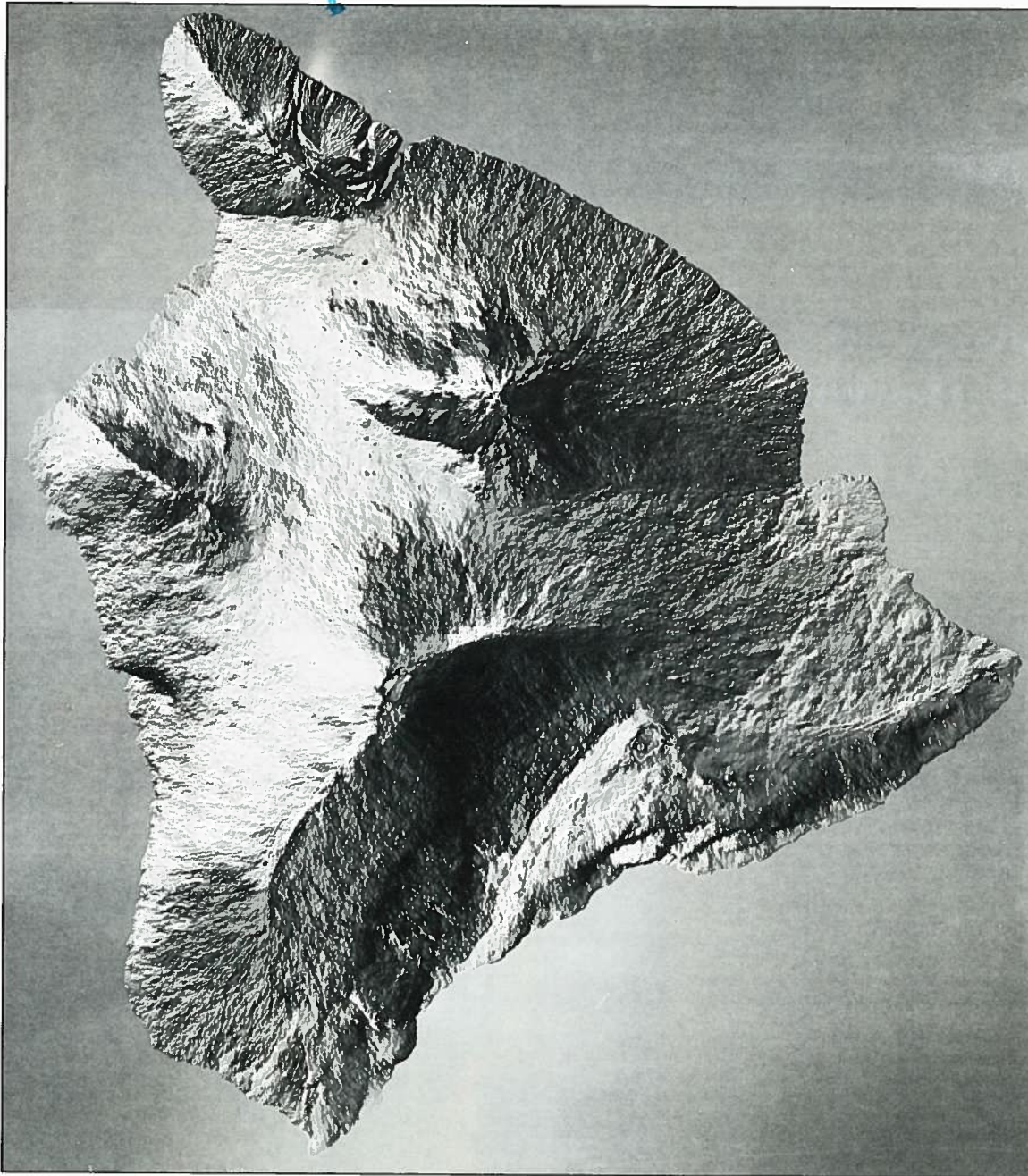


Figure 3. Shaded relief of the island of Hawaii with illumination from north, northwest, west, and southwest combined so as to enhance oblique illumination (see text).

tled by a series of Pleistocene ice caps. Giant slumps and debris avalanches have produced anomalous topography and debris aprons on the submarine slopes of the volcanoes (Moore et al., 1989), but they also are related to most of the fault systems exposed above sea level.

METHODS

Maps and plots were based on recent digital elevation data from the 84 7.5-minute quadrangles that cover the island. These U.S. Geological Survey data were generated by running parallel scan lines at a land spacing of 50–150 m across stereoscopic models projected from aerial photographs. The data were gridded at 30 m horizontal spacing and include 11.6 million grid points with a vertical precision of a few metres. Slopes were computed by ARC/INFO GRID slope function (Environmental Systems Research Institute, Inc., 1991), and the slope map of the island was made by assigning separate colors to each of six ranges of topographic slope (Fig. 1). The general features of this map can be compared with a coarser (750 m grid spacing) slope map of the island, and the surrounding submarine slopes (Mark and Moore, 1987).

Elevation data were acquired by scanning aerial-photograph stereoscopic images along either a north-south or east-west direction. Errors in maintaining the elevation indicator precisely on the ground surface while scanning have introduced a faint north-south or east-west stripe pattern in the map that cannot be readily corrected.

A newly developed technique (Mark, 1992) was used to produce the

multidirectional, oblique-weighted, shaded-relief image (Fig. 3). This image, which emphasizes oblique illumination on all surfaces, was produced by combining four computer-generated shaded-relief images illuminated from 225°, 270°, 315°, and 360° azimuth; each from 30° above the horizon. Weights were calculated for each image, on a cell-by-cell basis, using a generalized aspect map (smoothed 1000 m cells), such that

$$W(225^\circ) = \sin^2(\text{aspect angle} - 225^\circ)$$

$$W(270^\circ) = \sin^2(\text{aspect angle} - 270^\circ)$$

$$W(315^\circ) = \sin^2(\text{aspect angle} - 315^\circ)$$

$$W(360^\circ) = \sin^2(\text{aspect angle} - 360^\circ)$$

$$\text{Weighted image} = [W(225^\circ) \times \text{image}(225^\circ) + W(270^\circ) \times \text{image}(270^\circ) + W(315^\circ) \times \text{image}(315^\circ) + W(360^\circ) \times \text{image}(360^\circ)]/2$$

(315°) x image (315°) + W (360°) x image (360°)]/2. The aspect angle is the azimuth of the downslope direction of a given slope element.

This technique produces more detail in those parts of an image that would otherwise be washed out by direct light or left in darkness by a single-source illumination, and can produce detail in a single image that otherwise would require several images with different directions of illumination (Simpson and Anders, 1992, their Fig. 2).

Plots of elevation vs. average slope (Fig. 4) are useful for evaluating the origin of slope anomalies. They were produced by averaging the slope data points within elevation increments of

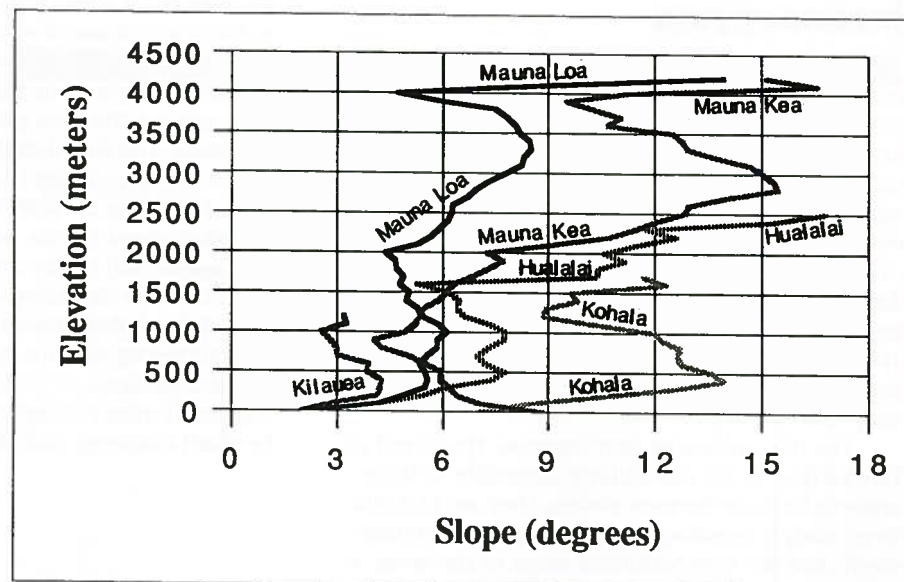


Figure 4. Average slope within 100 m elevation increments for each of the five volcanoes on the island of Hawaii.

100 m and comparing these averages with elevation separately for each of the five volcanoes as delimited by the geologic boundaries described by Stearns and Macdonald (1946). Note that the extreme variations in slope within 300 m of the summit of a volcano result from the steep slopes of summit cinder cones or the steep walls of a summit caldera; these slope averages may be amplified by the small number of points in the uppermost elevation category.

Histograms of slope distribution for each of the five volcanoes (Fig. 5) compare the areal proportion of each edifice that falls within 3° slope categories.

SLOPE FEATURES

Volcanism

The general contrast in morphology of the five volcanoes that make up the island results from many processes, but perhaps the most important is the composition and hence viscosity and eruptive mode of the younger lavas that compose the upper parts of the volcanoes. Mauna Kea, Hualalai, and to a lesser extent Kohala, have steep slopes near their upper parts (Figs. 1 and 4). They have sizable subsummit regions steeper than 17.5°, and Mauna Kea has a considerable area steeper than 22.5° (Fig. 1). The average maximum slope (excluding the slopes within 300 m of the summit) is 15.5° for Mauna Kea at 2800 m elevation, 14° for Kohala at 400 m, and 12.5° for Hualalai at 2200 m (Fig. 4).

The steeper upper-central region of Mauna Kea and to a lesser extent Kohala and Hualalai probably results from their cap of alkalic lava flows, some of which are richer in SiO₂ and more viscous than tholeiitic lavas. These three older volcanoes have undergone the transition from eruption of tholeiitic to alkalic basalt, a transition that occurs near the time when waning of eruptive activity spells the end of shield-building. Consequently, the flows are thicker and pile up closer to the vent. Also, many of the alkalic flows are of small volume, flowed a short distance from their vent, and increased the volume of material deposited near the summit. Finally, the alkalic lavas are richer in gas than the tholeiitic lavas of the shield-building stage and consequently have built numerous cinder cones at vents. These steep pyroclastic cones, concentrated on the upper parts of the volcano, tend to increase subsummit slopes.

In contrast, the slopes of the tholeiitic volcanoes Kilauea and Mauna Loa are gentler. The average maximum slope of Mauna Loa is 8.5° at 3300 m elevation and of Kilauea 4.5° at 400 m. The summit of Mauna Loa is dominated by steep slopes on the caldera walls, whereas the broad, gentle-slope summit region of Kilauea offsets the steep slopes of its caldera walls (Fig. 4).

Several conspicuous regions of gentle slope on the island result from grading of lava flows to sea level or to the flanks of an older adjacent volcano. The still-active volcanoes Kilauea, Mauna Loa, and Hualalai have broad areas of low slope (avg. <2°) near sea level (Fig. 4). The higher average slope at sea level of about 8° for Mauna Kea and Kohala results because they have subsided about 400 m and 1000 m, respectively, since the end of shield building and are graded to previous shorelines now below sea level (Moore, 1987). Mauna Kea has a pronounced average slope minimum at 900 m elevation caused by ponding of lavas in the saddle with Kohala (elev. 880 m); Mauna Loa has a slope minimum at 2000 m caused by ponding of lavas in

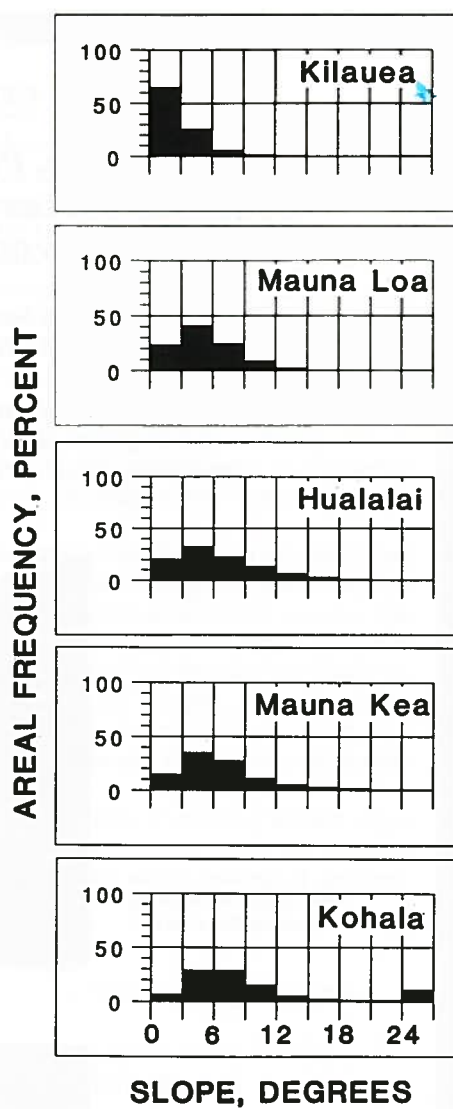


Figure 5. Histograms of slope distribution in 3° categories for each of the five Hawaii volcanoes arranged in order of increasing age.

the saddle with Mauna Kea (2005 m); and Hualalai has a slope minimum at 1600 m caused by ponding of lavas in the saddle with Mauna Loa (elev. 1590 m).

Histograms of slope distribution show a systematic increase in the steepness of overall volcano slope from Kilauea through Mauna Loa, Hualalai, and Mauna Kea, to Kohala (Fig. 5). In this same order, which is the order of increasing age of the volcanoes, the average slope of each volcano is 3.3°, 5.4°, 6.6°, 7.0°, and 11.3°, and the percentage of area where the slope is less than 3° is 64%, 23%, 20%, 14%, and 7%, respectively. This increase of slope with age results not only from the late, steeper alkalic cap on the older volcanoes, but also because lava from younger volcanoes ponds against earlier volcanoes and forms low slopes. Moreover, lava from the younger volcanoes is graded to sea level, whereas the low-slope coastal lavas have subsided below sea level in the older volcanoes. Finally, large areas of steep erosional canyons have developed on the older volcanoes (notably Kohala).

The tholeiitic volcanoes Kilauea and Mauna Loa, still in the shield-building stage, both are indented in their summit regions by young calderas a few kilometres in diameter bounded by well-defined marginal subsidence faults. Calderas do not currently exist on Hualalai, Mauna Kea, or Kohala, and the slope map does not show evidence that they ever existed, though a former caldera could be buried beneath an alkalic cap.

A conspicuous zone of steep slope on the north side of Hualalai volcano (Fig. 1) is caused by the trachyte lava flow that issued from Puu Waawaa, the largest pyroclastic cone on the island. This viscous lava (62–63 wt% SiO₂) flowed 9 km northwest and produced flow units 75–150 m thick whose steep marginal slopes contrast sharply with

those of the surrounding thin and fluid basaltic lavas.

The individual basaltic lava flows on Mauna Loa and Kilauea are virtually invisible on the slope map (Fig. 1), but some are discernible on the shaded relief map (Fig. 3) because of the enhancement achieved by oblique illumination. The more massive aa lava flows are visible on the southwest flank of Mauna Loa, where they are young and virtually untouched by erosion. In contrast, lavas on the older Mauna Kea volcano are emphasized in relief by flanking stream valleys that have produced a prominent downslope-trending pattern on the windward (northeast) slope of the volcano.

The rift zones of Mauna Loa and Kilauea that radiate from the summit calderas are inconspicuous on the slope map (Fig. 1), but they have a variety of small-scale features that are well shown on the shaded relief map (Fig. 3). The east rift of Kilauea is marked on its upper (western) part by pit craters, on the central part by grabens and cracks, and on the lower (eastern) part by cinder cones. In contrast, the southwest rift zone of Mauna Loa shows few such embellishments on the scale of the shaded relief map, but it does display a subtle ridgeline construction along the crest which may be produced by aligned spatter ramparts flanking rift-centered eruptive vents.

High on Mauna Loa are relatively steep (7.5°–12.5°, Fig. 1) regions about 15 km wide on the northwest and southeast sides. This zone appears in Figure 4 as the zone of high average slope (7°–8.5°) between 2800 and 3800 m elevation. This broad swell across the top of the shield possibly results from intrusion of dikes and sills out from the high-level subsummit magma reservoir which caused a bulging and steepening of the upper part of the edifice. Alternatively, the swell may result from accumulation of short-traveled lava flows related to repeated overflow of the summit caldera.

Erosion and Deposition

The most obvious stream-cut valleys on the island are the giant flat-floored canyons of northeast Kohala. These canyons were mostly cut when the volcano stood much higher, but their flat floors developed during subsidence. They can be traced 5 km offshore and were apparently cut subaerially before island subsidence drowned the present offshore parts and caused alluviation of the canyon floors above sea level (Moore, 1987). The restriction of the canyons to the amphitheater of the giant Pololu landslide (defined by the 3-km-wide, 18-km-long indentation of the shoreline shown in Figs. 1–3) suggests that canyon cutting was fostered by the landsliding processes. Apparently, canyon cutting was enhanced by slope steepening and removal of vegetation within the landslide amphitheater (Moore et al., 1989). The canyons (and associated giant sea cliffs) so dominate the topography that they have imposed a distinct bimodal slope distribution on the volcano (Fig. 5).

Belts of steep slopes aligned downslope on the southeast flank of Mauna Loa volcano resemble those of the Kohala canyons (Figs. 1 and 3). Lipman et al. (1990) suggested that these belts are the remnants of canyons, mostly buried by lava, that were originally about the same size as the Kohala canyons. Likewise, these canyons were cut in the oversteepened amphitheater of a giant landslide, directed southeast, that moved prior to the growth of Kilauea.

Other erosional canyons large enough to show on the slope map (Fig.

1) are not common. About six appear on the northeast flank of Mauna Kea, and one on the southwest flank of Kohala. Virtually no erosional features are evident on Hualalai, Kilauea, and Mauna Loa (except for the mostly covered southeast slope canyons mentioned), and surface running water is rare except during and immediately after torrential rainfall.

Sea cliffs are most prominent on the northeast Kohala coast where they have developed in the same region as the deep canyons, apparently because the steep landslide-generated offshore slopes permit aggressive marine erosion on this, the windward side of the island.

Two concentric arcuate belts of steep slope on the south side of Mauna Kea at elevations of 3360–3600 m and 2800–3050 m are conspicuous on the slope map (Fig. 1). These belts are close to the margins of the Pleistocene ice caps that occupied the summit of the mountain and correspond to the lower limits of the Makaanaka drift (3400 m) and the Waihu drift (3000 m) as mapped and defined by Porter (1979).

Landsliding

The major fault systems on the island, except for those bounding the summit calderas, were apparently generated in the upper, tensional regime of giant landslides that extend far below sea level on the submarine flanks of the volcanoes and out on the surrounding abyssal plain (Fig. 2). The systematic mapping of these landslides below sea level was accomplished with the GLORIA side-scan sonar system, and the assignment of subaerial structural features to the largely submarine landslides was based on this mapping (Moore et al., 1989). The epicenters of the three largest historic earthquakes in Hawaii (magnitude 7 and above; each of which produced tsunamis), are all near apparent landslide-induced fault systems (Fig. 2).

Perhaps the best example of faults related to landslides is the Hilina fault system on the south side of Kilauea volcano where there is a series of steep concave-seaward normal fault scarps near the upper part of a complex system of landslides that extend far offshore, collectively referred to as the Hilina landslide or slump (Moore et al., 1989). These faults were reactivated at the time of the November 1975 magnitude 7.2 earthquake (Fig. 2), when a 50-km-long section of the south coast of the island subsided as much as 3.5 m (Tilling et al., 1976).

A series of scarps and subtle slope changes are present on the southeast slope of Mauna Loa. At the southeast base of this slope and at the boundary between Mauna Loa and Kilauea volcanoes are the principal Kaoiki fault scarps marked by two southeast-facing scarps clearly visible on both the slope map and the shaded relief map. Above them, and extending almost all the way to the northeast rift zone of Mauna Loa, is a series of four or five subtle scarps best seen on the shaded relief map (Fig. 3). Hawaii's largest historic earthquake, the great Kau earthquake of April 2, 1868, estimated at magnitude 8, occurred in the southwestern part of the Kaoiki fault system (Wyss, 1988; see Fig. 2).

Several belts of steep terrain, commonly about 4 km apart, are directed downslope on the lower slopes of Mauna Loa, south of the summit caldera (Figs. 1 and 3). As previously discussed, they are interpreted as partly lava-filled erosional valleys of Kohala type that formed within the amphitheater

Hawaii continued on p. 262



Photo by Haraldur Sigurdsson.

GEOTRIP

Iceland: Fire and Ice

July 31–August 15, 1993
16 Days

Scientific Leaders

*Haraldur Sigurdsson,
Graduate School of
Oceanography,
University of Rhode Island,
Narragansett*

*Haukur Johannesson,
Museum of Natural History,
Reykjavik, Iceland*

Picture yourself here.

Haraldur Sigurdsson, professor of oceanography, is well known and respected as an expert on Iceland geology. He has led many trips there. Haukur Johannesson is considered the most experienced field geologist in Iceland and has a tremendous knowledge of regional and local geology and history. Both will be with the group throughout the trip. Other interpretive scientific leaders will also contribute to the group's understanding and enjoyment.

Program Schedule

July 31, Saturday Travel day from Baltimore to Reykjavik,
evening departure on Icelandic Airlines
August 1–15,
Sunday through Sunday Iceland GeoTrip
August 15, Sunday Travel day from Reykjavik to next gateway

Itinerary

This trip is an exceptional educational adventure with an enormous wealth of geologic features and outstanding leadership. The complete daily itinerary, available from GSA headquarters, includes geologic sites and lodging locations.

Transportation and Lodging

Travel will be by Mercedes Benz four-wheel-drive mountain trail bus. During most of the trip, the group will stay in country hotels, which are simple but comfortable, so-called Edda hotels, run by the Icelandic Tourist Bureau. They are basically secondary schools and high schools in rural areas which are operated as summer hotels. The group will spend three nights in mountain cabins and use sleeping bags. Food will be provided at all lodging locations, plus picnics during the day.

Cost

Estimated GSA Member Land Cost: \$2650 based on 30 people
(May be additional if there are fewer registrants)
Nonmembers: \$2800

(If you have previously traveled on a GSA GeoTrip, the \$150 additional will be waived.)

Fee includes almost all meals; double occupancy lodging; comfortable bus and ferry transportation; transfers and entrance fees; baggage handling; sleeping bags; geologic reading materials and guidebook; and, of course, the companionship of expert scientific leaders. **Not included** is airfare to and from Reykjavik. The current airfare is approximately \$750 from Baltimore. All participants must depart from this gateway. The Baltimore gateway has the best connecting flights to mid-America. Dave Bentzin, Cimarron Travel (Uniglobe), Littleton, Colorado, will be handling airline reservations. Dave will be happy to answer questions on flight schedules, airfares from your home city, and trip extensions. Call from 3:00 to 5:00 p.m. (MST), Monday through Friday at (800) 854-0872 (toll free), or 850-7711 (metro Denver). Also, a few meals are not included.

Please make your decision as soon as possible.

There is high interest in this trip, and several people have registered already.

If you decide to go, send \$350 per person to hold your place. The fee is refundable, less a \$50 processing fee, through February 28. Cancellation options after this date, together with a full itinerary, will be sent either on request or with confirmation of your deposit.

GEOHOSTEL

Geology, Paleontology, and Cultural History of North-Central and Northwestern New Mexico

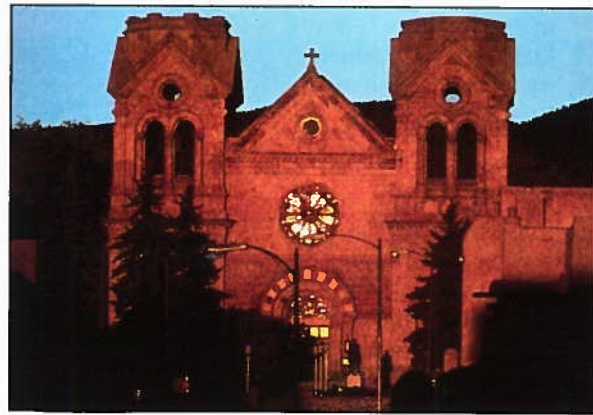
Plaza Resolana en Santa Fe, Santa Fe, New Mexico
Five Days and Six Nights: May 29–June 3, 1993

Scientific Leaders

*Donald L. Wolberg, New Mexico Bureau of Mines and Mineral Resources
Diane Bellis, U.S. Department of Agriculture, Forest Service*



Near Taos; Pilar looking down the Rio Grande.



St. Francis Cathedral,
Santa Fe.
Photo by
Jack Parsons.

GEOHOSTEL

Scenic Geology and Natural History of East Yellowstone, Beartooth, and Absaroka Country, Wyoming

Northwest College, Powell, Wyoming
Five Days and Six Nights: July 17–22, 1993

Scientific Leaders

Kenneth E. Kolm and Gregory S. Holden, Colorado School of Mines

Cody, Wyoming, the heart of the wild West, originally home to Buffalo Bill and now site of museums, rodeos, and other old West attractions, is just up the road from Powell



Fall Creek Falls—Clarks Fork. Courtesy of Wyoming Travel Commission.



Mountain wild flowers. Courtesy of Wyoming Division of Tourism.

At the base of the Sangre de Cristo Mountains lies the city of Santa Fe, founded in 1610 by Pedro de Peralta acting on instructions signed in Mexico City by Viceroy Luis de Velasco, the King of Spain's representative in New Spain. The romantic and historic aura of Santa Fe, "The City Different," is unique among American cities and is seen in all aspects of the Santa Fe experience. Santa Fe is also part of and central to a richly diverse geological (and cultural-historical) vista that is challenging both to contemplate and to visit.

Spanish settlers began to arrive in the vicinity of Taos Pueblo to the north of Santa Fe at about the same time that Santa Fe was being established. Through the early years of the 20th century, Taos developed into a haven for artists, potters, and writers, and it remains so today. The Rio Grande Gorge near Taos is 200 m deep and 400 m wide and developed in thick basalts. In the area, Precambrian rocks form the basement beneath late Paleozoic age marine and nonmarine sedimentary rocks.

The north-trending Sangre de Cristo Mountains are about 30 km wide and 320 km long and separate the late Cenozoic Rio Grande Rift on the west from the Raton Basin on the east. In the Santa Fe region, the basement rocks are Precambrian metasedimentary, igneous, and metaigneous rocks. The Jemez Volcanic Field separates the Espanola Basin on the north from the Albuquerque Basin on the south. Volcanism began after formation of the Rio Grande Rift. The Valles and Toledo calderas are major structures within the Jemez Volcanic Field. The Sandias, granitoid rocks capped by Paleozoic sedimentary rocks, rise majestically above Albuquerque.

To the west of Santa Fe lies the San Juan Basin, rich in mineral wealth, especially coal, oil, and uranium. Equally rich in fossil-containing rocks and cultural history, the San Juan Basin preserves the magnificent world-renowned archaeological ruins seen at Chaco Canyon.

Program Schedule

May 29, Saturday Welcoming get-together
 May 30-June 3,
 Sunday through Thursday Classes and field trips
 June 3, Thursday Farewell party

Fee and Deposit

Cost: \$550 for GSA members. Nonmembers \$595.
 \$125 deposit, due with your reservation, is refundable through March 30,
 less \$20 processing fee.
Total balance due: April 1
 Minimum age: 21 years. Limit: 28 persons.

Fee includes classroom programs and materials, field trip transportation, lodging for 6 nights (double occupancy, dormitory rooms), breakfast and lunch daily through Thursday, and welcoming farewell events. **Not included** are transportation to and from New Mexico, transportation during non-class and field trip hours, meals or other expenses not specifically included.

and will be the hub for this trip. Cody is the eastern gateway to the Yellowstone-Beartooth region, with its breathtaking scenery and incredible geologic diversity. Rocks of the area range from Precambrian gneiss (some over 3 billion years old) on the Beartooth Plateau to young lava flows and pyroclastic rocks in Yellowstone Park. We will drive the scenic Beartooth Highway, tour the sights of eastern Yellowstone, visit Laramide structures in the Bighorn Basin, examine the Absaroka volcanics, and just look at and try to understand this beautiful country.

The trip will be structured around daily field trips during which the group will see the elements of local geology, review hydrogeologic and geomorphic systems, and learn about the local ecology and history. Group walks will be short, but there will be opportunity to expand some into afternoon adventures. We will be able to accommodate every level of conditioning—from those who just want to sniff the flowers to peak baggers. Several afternoons will be free to see the local attractions, go rafting, go fishing on some of the best trout streams in Wyoming, or just to loaf in the clean, clear high-country air.

Program Schedule

July 17, Saturday Welcoming get-together
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 July 22, Thursday Farewell party

Fee and Deposit

Cost: \$425 for GSA members. Nonmembers \$475.
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1992 GSA Short-Course Notes For Sale

Limited supplies of the following short-course manuals/notes remain available from the Cincinnati Annual Meeting. These may be ordered, while supplies last, through GSA Publication Sales.

- SCN0012V:** *How To Do Anything with Mohr Circles (Except Fry an Egg): A Short Course About Tensors for Structural Geologists*, by W. D. Means, 1992. Two volumes: Workbook and Completed Workbook **\$18.75**
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- SCN003:** *Environmental/Engineering Geology and Land-Use Planning—An Interface between Science and Regulations*, by Charles W. Welby and Jerome V. DeGraff, 1992. **\$12.50**
- SCN004:** *Phase I Preliminary Site Assessments*, by Jeffrey L. Peterson, 1992. **\$18.75**
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theater of a major landslide (termed the Punaluu landslide, Lipman et al., 1990). This notion is supported by belts of steep slopes parallel to regional contours upslope from the canyons, belts that appear on both the slope map and shaded relief image. These scarps,

which resemble in a subdued fashion the fault-line scarps of the Hilina fault system, may mark the lava-buried headwall scarps of the landslide system, which perhaps was reactivated after canyon cutting.

A series of faults and zones of steep slope on the subaerial west flank of Mauna Loa (Figs. 1 and 2) is believed

to be the upslope expression of three of the four major slumps and debris avalanches directly offshore on the submarine flank (Lipman et al., 1988). The Kealakekua fault, curving southeast from the shoreline and downthrown on the southwest, was the site of a magnitude 7 earthquake (as determined at Berkeley, California) on August 21, 1951 (Macdonald and Wentworth, 1954; see Fig. 2). This fault apparently marks the upper, north boundary of a part of the North Kona slump. The principal movement that created this scarp occurred prior to 13 ka, because an offshore coral reef of that age shows no offset in the region of the offshore projections of the fault.

An anomalously steep zone extends north of the Kealakekua fault for 20 km to the steeper part of Hualalai (Fig. 1). This oversteepened region is directly upslope from the northern North Kona slump, and it may represent the upper part of a lava-buried amphitheater of a landslide involving a sector encompassing south Hualalai and part of west Mauna Loa.

The north-trending Kaholo fault, south of the Kealakekua fault, follows the coast for 25 km. It and the broad belt of steep slope that extends inland connect with the Kealakekua fault and seemingly mark a broad landslide amphitheater now entirely covered by younger lavas. This is the region from whence repeated downslope movement apparently fed the Alika debris avalanches and North and South Kona slumps that drape the submarine west flank and extend out into the Hawaiian Deep (Fig. 2).

The north-trending Kahuku fault produces a 20 km slope anomaly near the south cape of the island (Fig. 1). This apparent normal fault, downthrown on the west and mantled by lava on the north, is believed to be related to the landsliding of the south and west flank of Mauna Loa evident in the submarine topography. The East Kalae landslide, which moved south from a zone immediately west of the south cape of the island (Fig. 2), is one of the latest expressions of these widespread gravity failures. The head of this landslide is directly offshore from the terrain bounded on the east by the Kahuku fault, and the fault is regarded as the partly buried east wall of the amphitheater of this landslide.

CONCLUSIONS

The morphology of the five volcanoes that compose the island of Hawaii can be compared by using digital elevation data gridded at 30 m that includes nearly 12 million points. The resulting slope map, shaded relief map, and slope and elevation plots have led to the following general conclusions.

The volcanoes become steeper with increasing age. Their average slope from youngest to oldest is: Kilauea—3.3°, Mauna Loa—5.4°, Hualalai—6.6°, Mauna Kea—7.0°, and Kohala—11.3°. This increase probably results primarily from the late, steeper alkalic cap on the older volcanoes, a cap that includes viscous and thicker flows, lava flows that are smaller and hence pile up more near the summit vents, and volatile-rich lavas that more commonly produce sizable cinder cones near summit vents. The gentler slopes of younger volcanoes result from the predominance of more fluid tholeiitic lavas, the ponding of lava against earlier volcanoes, and the grading of lava to sea level; subsidence of the older volcanoes has caused these gently sloping near-sea-level lavas to subside below the sea. Finally, the oldest volcano (Kohala) has large areas of steep erosional canyons.

Virtually all of the major fault systems on the island except for those ringing the summit calderas seem to be related to the upper parts of giant landslides, most of which are hidden below sea level on the submarine flanks of the volcanoes. These arcuate normal-fault systems occur in the upper, tensional regime of the landslides. Subtle changes in slope hint that more such landslide-related fault scarps have been covered by subsequent lava flows.

There are major erosional canyons in only two places, each presumed to be in the amphitheatres of major landslides. They are probably present in this setting because stream erosion is favored by the landslide-induced increase in slope. The slope map displays two bands of steep slope high on Mauna Kea that mark the morainal edges of the last two advances of the Pleistocene ice cap.

ACKNOWLEDGMENTS

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Call for Nominations

Association for Women Geoscientists Outstanding Educator Award

This award honors high school, college, or university teachers who have played a significant role in the education and support of women students both within and outside the classroom. Support for women students may take a variety of forms, including encouraging them to enter and continue in a geoscience career and providing opportunities for field and laboratory experience. In addition, awardees are selected on the basis of their own contribution as professionals, including activities such as active research and publication (in the case of university faculty members), involvement in professional societies or groups, and contributions as educators in areas that extend beyond the classroom.

Deadline for nominations is January 15, 1993. All nominations should include a supporting letter, vita for the nominee, and names of at least six individuals who know the candidate well and who can provide letters in support of the candidate. In general, letters of support should come from students as well as professional colleagues of the nominee. Send nominations to the chair of the selection committee: Maria Luisa Crawford, Department of Geology, Bryn Mawr College, Bryn Mawr, PA 19010.

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Users of Apple Macintosh personal computers (PCs) will be happy to learn that they can use their PostScript printers to print journal pages from GSA's two new compact discs, *GSA Journals on Compact Disc* and *GSA Today on Compact Disc*, being introduced for 1993.

In the September 1992 issue of *GSA Today*, and in our recent subscription brochures and publications catalog, we stated that only PCL-compatible printers could be used, but the latest word from our supplier is that users of Macintosh PCs will be able to print to their normal PostScript printers.

For now, users of IBM-compatible PCs can print only to PCL-compatible printers. PCL (Printer Command Language) is a registered trademark of Hewlett-Packard Company. It is a language used by most LaserJet printers, and by other licensed printers. The owner's manual for your printer should tell you whether the printer is PCL-compatible. ■

Alternates Receive Research Grants

Each year the Committee on Research Grants selects recipients for grants up to the maximum amount of funding available for that year. An alternate group of recipients is also selected in the event that some of the grantees return part or all of their funds due to their having received funding elsewhere or a change in their research plans. As the returned funds become available they are re-awarded by the Research Grants Administrator to the alternates named by the committee.

In 1992 five alternates received funding following the initial awarding of grants: Holly E. Dodson, University of California, Santa Barbara; William H. Petty, University of Tennessee, Knoxville; Christopher H. Rose, University of Nevada, Reno; Tamra A. Schiappa, Boise State University; and Adam D. Woods, University of Cincinnati. ■

Symposium

Measuring and Interpreting VOCs in Soils: State of the Art and Research Needs

January 12-14, 1993
Aladdin Hotel, Las Vegas, NV

Volatile organic compounds (VOCs) are the most prevalent contaminants at sites across the United States. Substantial funds are being expended on VOC sampling and analysis and significant site assessment decisions and remedial actions are occurring. The conventional measurement and interpretation process, however, may not adequately address sources of error that can severely hamper the overall effectiveness of site assessment and remedial action at VOC-contaminated sites.

This symposium will consist of a mixture of platform and poster presentations, panel discussions, open microphone periods, and special interest group discussions. The program will explore the foundation of the conventional VOC measurement and interpretation process; examine results from research and practice that have advanced the understanding of this process, including sample collection, preservation and preanalytical handling, on-site and in situ measurement techniques, and data analysis and interpretation. The symposium will provide a forum to develop consensus on the state of the art, develop recommendations for current practice, and identify critical research needs.

This symposium has been sponsored by the U.S. Environmental Protection Agency. It has been organized by Oak Ridge National Laboratory, the University of Wisconsin, U.S. Environmental Protection Agency, U.S. Department of Energy, U.S. Army Toxics and Hazardous Materials Agency, and American Petroleum Institute in cooperation with the Geological Society of America.

Program information may be obtained from Robert L. Siegrist, Symposium Chair, Oak Ridge National Laboratory, Environmental Sciences Division, P.O. Box 2008, Oak Ridge, TN 37830-6038, (615) 574-7286, fax 615-576-8646. Registration information may be obtained from Pat Eagan, University of Wisconsin, 432 North Lake Street, Madison, WI 53706, (608) 263-7429, fax 608-263-3160.

FORUM

Bruce F. Molnia

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

ISSUE: Geologic Mapping: Implementing the National Geologic Mapping Act of 1992

This is the second half of a two-part Forum discussing the many facets of the National Geologic Mapping Act of 1992. The Act, which was described in detail in the September 1992 *GSA Today* Washington Report, was also the subject of a Committee on Geology and Public Policy forum at the 1992 Annual Meeting. The first half of this Forum was presented in the October 1992 *GSA Today*.

PERSPECTIVE 4: The University's Role in a New National Mapping Effort

Steven Esling, Southern Illinois University, Carbondale, IL

A real need for geologists with mapping skills will rapidly develop if the nation finds the funds to embark on a massive geologic mapping program. The National Geologic Mapping Act of 1992 includes an education component directed toward universities with degree-granting programs in the geological sciences. Financial support to strengthen summer field courses in geology is one obvious way for the Act to help improve mapping skills. In fact, one objective of the education component is to "provide for broad education in geologic mapping and field analysis through the support of field teaching institutes." Prior to most field courses, students have completed much of their undergraduate curriculum, taking a series of core courses, each exposing them to one of the traditional subdisciplines of geology. It is the intensive five to six week summer field course, however, that forces students to bring together all of their previous geological training to solve practical field problems.

A serious funding crisis in many states has impacted higher education. Frozen or declining budgets have forced geology programs to cut faculty and course offerings. This crisis in funding threatens the well-being of the field courses. Logistical factors make a field course in geology cost more per credit hour than other courses in geology, a red flag to university and state administrators looking for ways to save money. Some form of support from the Act could help preserve and enhance existing field courses. All undergraduate programs should require the successful completion of a summer field course for a baccalaureate degree in geology. With new external support, strong undergraduate programs now lacking a field course may be able to add one or to participate with an existing one.

In most field courses, students spend the bulk of their time on bedrock geology problems, working on mapping exercises in sedimentary, igneous, and metamorphic terrains. They become adept with basic mapping tools as they hone their skills in observation and interpretation. The traditional field courses, however, generally do not provide training in specialized mapping techniques—those required to produce surficial geologic maps or maps that detail the distribution of geophysical properties. Universities, supported in part by the Act, must accept responsi-

bility for teaching students the techniques and scientific understanding necessary to produce these types of maps, as well as the more traditional bedrock geologic maps. Many geology programs, like the one at Southern Illinois University at Carbondale (SIUC), offer courses in specialized mapping methods. Our course in field geophysics instructs students on how to interpret resistivity meter, magnetometer, and gravimeter data as well as the correct procedures for collecting these data in the field. Courses in geomorphology and Quaternary geology also provide some instruction in mapping surficial deposits. At SIUC, however, we have found a particularly successful means of developing surficial geology mapping skills.

Maps of surficial geology are important for engineers and geologists working on environmental problems. These maps also provide a valuable source of information for those dealing with land-use issues. For more than eight years, SIUC has had a program, developed in cooperation with the Illinois State Geological Survey (ISGS) and supported in part by the United States Geological Survey (USGS), to produce detailed surficial geology maps of selected 7.5 minute quadrangles in Illinois. While they receive training and gain experience in surficial geologic mapping techniques, students actually produce a quadrangle map for publication as part of their graduate thesis. Therefore, our program actually addresses two objectives of the Act: (1) students receive training in specialized mapping skills; and (2) the state receives a surficial geologic map of some quadrangle of choice. To date, students at SIUC have completed three surficial geology maps, each published by the ISGS as an open-file map. In these maps, surficial deposits are presented as stack units, a format that displays information on the three-dimensional distribution of unconsolidated materials down to the bedrock surface. Another three maps are in review. In addition, four more students are in the field mapping four new quadrangles as part of their thesis research.

A graduate thesis should not have geologic mapping as its sole objective. Mapping alone, especially in an area where large-scale geologic maps or maps in adjoining quadrangles already exist, may not provide the necessary scope for a graduate thesis. Under these circumstances, mapping may become too routine, following an established formula that does not sufficiently challenge the student. Mapping can be a major part of a thesis topic in areas of complex terrain. A thesis that includes

Forum continued on page 264

a map, along with a narrative on the stratigraphy, structural geology, or economic geology of a complex area can provide a rigorous exercise for the student. The first theses completed as part of our surficial geology mapping program had three basic objectives: (1) to produce a detailed stack-unit map of surficial deposits of a particular quadrangle; (2) to characterize the surficial deposits in terms of basic material properties; and (3) to summarize the

urated surficial materials. Another is looking at the engineering properties of a lacustrine unit covering extensive areas of southern Illinois. A map of the surficial geology of the quadrangle is just one objective of their thesis research.

Map quality is a concern, particularly to end-users of a map produced as a part of a student's thesis. Are students capable of producing a reliable geologic map as part of a graduate thesis? The answer to this question is yes, as long as the maps undergo a thorough review

Are students capable of producing a reliable geologic map as part of a graduate thesis?

stratigraphy and interpret the Quaternary history of the quadrangle. The first students to enter the field were breaking new ground. They developed a mapping procedure that has been refined by subsequent mappers. As students learned from the experiences of the first mappers, map quality improved. At the same time, mapping became more routine. Now, students must also address some other problem in geology, in addition to completing the original three basic objectives, for their graduate thesis. For example, past students have investigated the distribution of paleosols on the landscape, valley alluvial stratigraphy, and ice marginal lakes that developed as a consequence of Illinoian glaciation. More recently, two of our students are studying the spatial distribution of the saturated hydraulic conductivity of unsat-

by the student's advisory committee and the sponsoring agency. The maps produced at SIUC were reviewed by experienced mappers with the ISGS. Survey personnel went in the field with the mappers, sharing their experience recognizing stratigraphic units and instructing them on proper methods for describing unconsolidated surficial materials. Every aspect of mapping was discussed with ISGS personnel, including unit definitions, locating approximate contacts, matching adjoining map edges, and preparing detailed descriptions. Perhaps, in the near future, the USGS, with input from professionals across the United States, could define national standards for map accuracy. All published geologic maps could adhere to these standards, including those produced as part of a graduate thesis.

A graduate education program that helps develop specialized mapping skills really does kill two birds with one stone; students acquire new capabilities that will serve them well after graduation, and the state obtains a detailed map of a vital quadrangle. Other cooperative programs between universities, state geological surveys, and the USGS, similar to the one described above, could produce geophysical or bedrock maps as well as help educate a generation of geologists with specialized mapping skills. The National Geologic Mapping Act can promote these programs by helping to defray the costs associated with spending extended time mapping in the field.

PERSPECTIVE 5: The Geologic Mapping of Kentucky—A Success Story

Donald C. Haney, Kentucky Geological Survey, Lexington, KY

In 1960, the Kentucky Geological Survey (KGS) entered into a cooperative agreement with the USGS to map the geology of Kentucky at a scale of 1:24,000. A task of this magnitude had not previously been accomplished. The ambitious program was promoted by Wallace W. Hagan, then Director and State Geologist of the KGS, and encouraged by Thomas B. Nolan, Director of the USGS. Hagan represented Kentucky throughout the duration of the project, and the USGS was represented by Directors Nolan, Pecora, McKelvey, and Menard. The mapping was accomplished primarily by USGS geologists, with assistance from university faculty and KGS personnel. This project resulted in the preparation of 707 geo-

logic quadrangle maps, as well as approximately 150 professional articles and reports. The last map was published October 30, 1978.

Even though geological studies in Kentucky appeared to have reached their zenith prior to completion of the project, it is now evident that the mapping program has stimulated ever-increasing geological activity relative to coal, oil and gas, industrial mineral, water resources, geologic hazards, and urban planning. It is doubtful that Hagan fully realized the importance of his ambitious plan; however, it is now obvious that it was one of the most significant statewide geologic undertakings in the history of the United States!

Economic benefits of the product of the 18-year, \$22 million project exceeded even the most optimistic expectations. The maps are now an indispensable tool in the modern search for much-needed fossil fuels and other mineral resources, and, in addition, they provide geologic baseline data for engineering studies for roads, bridges, buildings, and other structures, and provide documented geologic data for environmental and industrial-development projects. Since the first of these maps became available in the 1960s, the KGS has distributed in excess of 250,000 copies. In addition, the Kentucky Economic Development Cabinet and the USGS each have sold an equal number, or more.

The availability of detailed geologic maps has proved to be of inestimable value to the KGS and to the Commonwealth of Kentucky. For example, in 1976 when the United States was reacting to a perceived worldwide energy crisis, it was thought that the

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nation would turn to coal for transportation fuel, as well as increased production of electricity. The KGS was called upon to assess Kentucky's coal resources in a degree of detail that had never before been attempted. At that time geologic mapping in Kentucky was still in progress, but the maps that had already been completed showed the major coal beds in significant detail. Therefore, these maps provided the basis for a detailed coal-resource assessment. All that remained to be done before making resource assessments was verification of occurrences and coal-bed identification, and detailed measurements of coal thicknesses. Kentucky now has the most extensive coal-quantity data base in the United States, and possibly the world. It would not have been possible to develop this data base if the geologic maps had not already existed, because the expense of such a mapping project would have been prohibitive for the purpose of making a coal-resource assessment.

During the same period when there was great speculation about the development of synfuel facilities to help lessen the energy crisis, the need for coal-quality information was recognized. With the availability of detailed geologic maps, and the ongoing effort to determine the amount of available coal resources, it was a rather simple matter to initiate a coal-quality study. Coal-quality information also composes a significant part of our coal-resources data base, and provides another direct testimony to the value of detailed geologic maps.

Waste disposal is unquestionably one of the major issues facing our country today, especially at the state and local levels. Kentucky and some other states appeared to be on the verge of becoming dumping grounds for out-of-state waste that was being generated by densely populated northeastern areas. As a result, the governor of Kentucky requested a solid-waste-management study for the Commonwealth, and the KGS was asked to assist in developing guidelines concerning the risk involved in siting landfills in various areas of the state. More than 60% of the surface rock in Kentucky is limestone, as attested to by vast sink-hole plains and numerous major cave systems. Obviously, these areas would require special consideration if selected for landfills. Fortunately, with the aid of existing geologic maps, we were able to develop in a short period of time a statewide map relating bedrock conditions to the probable suitability of areas for solid-waste landfill sites. This map serves as a guide for state and local governments in the preliminary process of landfill siting.

The 1990 amendments to the Clean Air Act have presented some very real problems for our country, especially the coal-producing states. Standards for the emission of sulfur dioxide became significantly more stringent, and ways must be found to reduce these emissions if eastern coal is to continue to be used for the generation of electricity. Eastern coal will continue to be used for many reasons, one being the fact that it would be too expensive to revamp the infrastructure in the east to utilize western low-sulfur coal. In order for utility plants to be able to meet the new clean air standards, large quantities of suitable limestone must be identified for use in flue-gas scrubbers and for fluidized-bed combustion. The existence of detailed geologic maps delineating limestone outcrop areas in Kentucky provides both the stone producers and the utility companies a head start in meeting this challenge.

One final note: Preparation of geologic maps for the entire state of Kentucky cost about \$22 million. It can easily be argued that the cost of this program has already been repaid many times over through the discovery of new mineral resources. On the basis of the assumption that 1 acre of 6-foot-thick coal yields 5,400 tons from an underground mining operation, at \$20 per ton the coal has a value of \$108,000 per acre. Therefore, the discovery of about 200 acres of 6-foot coal at an underground site would have a gross value of about \$22 million, the approximate cost of the total mapping program. This example is very insignificant compared to actual discoveries that have resulted from the use of detailed geologic maps in Kentucky.

On the environmental side, the low-level nuclear waste disposal facility at Maxey Flats, Kentucky, was sited before detailed geologic maps were available. Maxey Flats is now on the Superfund list for cleanup at an estimated cost of \$100 million. If detailed geologic maps had been available sooner, it is very unlikely that the facility would have been located where it was.

Geologic maps have been a tremendous asset to the Commonwealth of Kentucky, and time and again the state's investment in this program has been justified. This investment becomes very insignificant when compared to the eventual savings that will be realized by the taxpayers. The geologic mapping of Kentucky was, and is, a success story.

PERSPECTIVE 6: Calculating the Benefits and Costs of Geologic Mapping

Subhash B. Bhagwat, Illinois Geological Survey, Champaign, IL

The cost of a geologic mapping program, like any other business investment, must be justified by expected future returns. Unlike the usual business investment, however, geologic mapping programs cannot be appraised solely on the basis of entries registered in financial accounts.

A bicycle helmet factory or a television repair service, for example, produces goods or services for the exclusive use of the individuals who purchase them. As long as individuals or groups of individuals are willing to pay the necessary price, these private products or services will be provided. On the other hand, public goods or services, such as a hydroelectric dam, the national defense, or the local fire department, benefit many people at once. Individuals or communities may have various opinions about the desirability of the dam or the size of the armed forces, and some may not consider such expenses worthwhile, but even those who so object derive benefits from the results of the collective decisions to invest public funds for these goods and services. Geologic mapping is just such a public investment.

Despite these differences between private and public goods, the rationales behind their economic evaluation do not differ greatly. In either case, the basic evaluation approach requires that positive and negative effects of the goods and services on the well-being of society be identified and quantified in terms of some common unit so that the positive effects (benefits) can be compared with the negative effects (costs). As long as the benefits exceed the costs, (i.e., the investment is economically efficient), the providing of the goods or services is worth carrying out. How do we reconcile the fact that the benefits may accrue to one group

of individuals and the costs to others? Under most circumstances, such reconciliation requires public financing of the project because only the government, through its powers of taxation and incentives, can even out the distribution of benefits and costs and do distributive justice. In principle then, economic evaluation of both private and public goods depends on the overall "profitability" of the investment. Despite this basic similarity, the methods used to evaluate a private investment differ from those for a public investment.

In a free and competitive market the value of a product, its price, cannot be determined by an individual producer or buyer. The collective response of consumers and producers determines what price a product will sell

pleted, the maps and other information that are the results of a publicly funded geologic mapping program generally are available to all for a small fee, even to those who may have actively opposed spending on mapping programs.

It can be argued that geologic mapping should be conducted and paid for by interested private parties. However, a private party interested, for example, in finding mineral resources may not sufficiently attend to the aspects of geology that may benefit regional planners interested, for example, in protecting the ground-water resources. This can lead to duplication of efforts and higher costs to society. Furthermore, geologic maps of some quadrangles may find buyers, each willing to pay a different price, that will collectively cover the cost of the mapping pro-

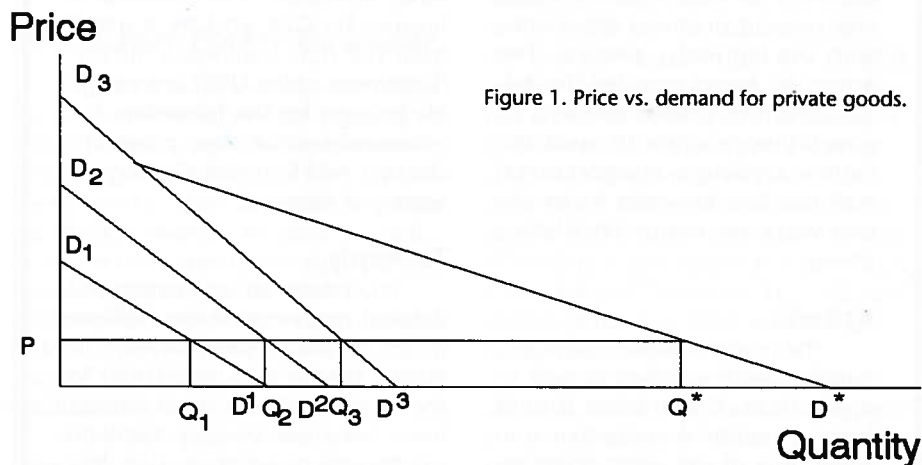


Figure 1. Price vs. demand for private goods.

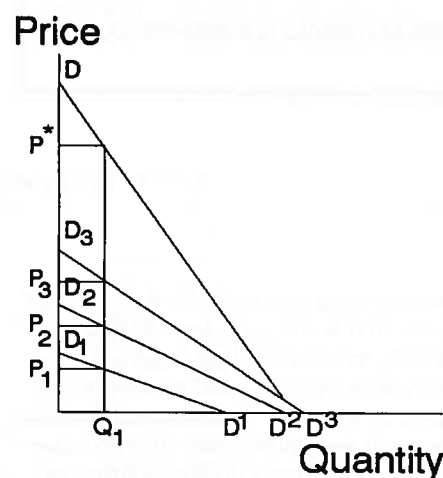


Figure 2. Price vs. demand for public goods.

for. Individuals can only respond by varying the quantity they are willing to produce or buy depending upon the price. In Figure 1, the market demand Q^* is the sum of individual demands Q_1, Q_2, Q_3 , etc., at the market price P .

For a public good, the situation is quite the opposite. Public goods generally are offered in large units: either we have an adequate national defense or we don't, either we have the necessary geologic knowledge or we don't, regardless of how many individuals want them. Therefore, we must determine how many individuals want the public good and what price each one is willing to pay for it. The value (P^*) of a quantity of public good Q_1 is the sum of the prices P_1, P_2, P_3 , etc., that individuals are willing to pay for it (Fig. 2). This sum determines how valuable the project is and what can be invested in the project.

A geologic mapping program produces public knowledge about the physical and chemical attributes of the Earth's strata to great depths and about the mineral and water resources essential for all economic activity and, indeed, for life itself. It also provides public knowledge essential for the protection of the environment. Once com-

pleted, in some other quadrangles there may not be enough buyers to justify private mapping, although such mapping may be essential for useful interpretation of geology in the quadrangles in demand. Because of this, only public funding of geologic mapping programs makes it feasible to balance total costs against total benefits.

Uses of Geologic Maps. In 1991, a survey of potential users of geologic maps in Illinois conducted by the Illinois Geological Survey (IGS) identified at least 24 general and 20 specific projects in which users described geologic maps as either critical or useful. The survey was conducted on a limited sample of 80 potential users. The actual number of users and potential users is likely to be much higher. The general uses included such undertakings as highway soil surveys, engineering construction, zoning decisions, ground-water protection, mineral exploration, public education, and the like. Specific projects using geologic maps included siting the Superconducting Super Collider (SSC), several water reservoir studies, remedial assess-

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Congressional Science Fellowship 1993-1994



The Geological Society of America is accepting applications for the 1993-1994 Congressional Science Fellowship. The Fellow selected will spend a year (September 1993-August 1994) in the office of an individual member of Congress or a congressional committee for the purpose of contributing scientific and technical expertise to public policy issues and gaining firsthand experience with the legislative process. The American Association for the Advancement of Science conducts an orientation program to assist the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

Criteria

The program is open to highly qualified earth scientists in early or mid-career. Candidates should have exceptional competence in some area of the earth sciences, cognizance of a broad range of

matters outside the Fellow's particular area, and a strong interest in working on a range of public policy problems.

Award

The GSA Congressional Science Fellowship carries with it a \$38,000 stipend, and limited health insurance, relocation, and travel allowances. The fellowship is funded by GSA and by a grant from the U.S. Geological Survey. (Employees of the USGS are ineligible to apply for this fellowship. For information about other programs, contact AAAS or the Geological Society of America.)

To Apply

Procedures for application and detailed requirements are available in the geology departments of most colleges and universities in the United States or upon request from: Executive Director, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

DEADLINE FOR RECEIPT OF ALL APPLICATION MATERIALS IS FEBRUARY 15, 1993

Iowa Survey Celebrates Centennial

The year 1992 marks 100 years of continuous, state-supported geological investigations in Iowa, first as the Iowa Geological Survey, and since 1986 as the Geological Survey Bureau within the Iowa Department of Natural Resources (DNR). The observance was marked in Iowa City April 30-May 1, during the annual meeting of the GSA North-Central Section. This milestone in the history of the Iowa Survey was officially recognized at the evening banquet in remarks by GSA President E-an Zen, University of Iowa President Hunter Rawlings, and DNR Director Larry Wilson. A plaque commemorating 100 years of geological research and service in Iowa was presented by E-an Zen, on behalf of the Geological Society of America, to Donald L. Koch, state geologist and chief of the Geological Survey Bureau.

Zen emphasized that state geological surveys provide a vital linkage between science and public policy. They are able to disseminate to a wide public audience what geologists already know about a state's vital and delicately balanced environmental relations. He pointed out that geological research and information provide a means to identify and locate mineral, soil, ground-water, and energy resources. They also provide a sound framework for assessing and coping with floods,

landslides, subsidence, waste disposal, and pollution. He further noted that geological knowledge gives us an opportunity to prepare for rational and optimal use of our land, both for human activities and for habitat protection and preservation. Because of this special role, the health and strength of state geological surveys is a concern of all geologists, Zen said.

In recent years, the Iowa Survey has assumed significant roles in the synthesis of midcontinent stratigraphy and structural geology, and in research on agriculturally related, non-point source degradation of ground-water supplies. Other significant areas of activity include mapping of abandoned-mine lands, the Manson meteorite impact crater, the Des Moines Lobe glacial advances, the state's fluvial stratigraphy, the Plum River fault zone, completion of the USGS 7.5' topographic map coverage, analysis of a 17,851 ft. oil and gas test in Carroll County, a discovery of abundant, well-preserved Mississippian amphibian fossils in Keokuk County, development of a municipal water-supply inventory, and expansion of computer applications, including a Geographic Information System.

Jean C. Prior,
Greg A. Ludvigson,
and George R. Hallberg ■

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ment of ground-water contamination in Champaign County, a management plan for the Shawnee National Forest, siting a low-level nuclear waste facility in Clark and Wayne counties, and many others.

Benefit Assessment. For a majority of these uses, it is impossible to quantify retroactively the benefits of geologic mapping. The approach to

be evaluated indirectly by determining costs that could have been partially or wholly avoided had geologic information been available and used appropriately in the past. To obtain information on such avoidable costs, the IGS benefit-cost study used documentation of state and federal spending on cleanup efforts at federal Superfund sites, State Remedial Action Priority list sites and voluntary industrial cleanup sites in the study area. Another source of

geologic mapping in Boone and Winnebago counties.

The quantifiable benefits of geologic mapping related to preventable ground-water contamination from the two-county case study, discounted as discussed above, were used to project the results statewide. Scientists from the IGS and the Illinois State Water Survey used a statewide map of ground-water recharge areas and a map showing the numbers of potential sources of pollution per ZIP code area to develop a 1 to 10 scale of vulnerability of ground-water to contamination. The scale was used in conjunction with the square miles of affected area to relate the vulnerability of ground water in the study area to that in the rest of the state. The method used for this statewide projection is valid only with regard to ground-water contamination potential. Other cost projection techniques will have to be developed when other types of benefits of geologic mapping become quantifiable.

Costs of Geologic Mapping. The obvious quantifiable costs to be compared to the value of the benefits are those of the mapping program itself. The actual costs incurred in the mapping of Boone and Winnebago counties in Illinois were known. Luckily, geologic mapping is a nonintrusive activity which causes little physical disturbance or damage to the environment or property, and therefore no other direct costs. However, the statewide cost projection required more than a simple linear extrapolation from the area of Boone and Winnebago counties to the area of the entire state. The estimated costs of a statewide pro-

gram were adjusted upward to account for cost experiences from mapping in other counties with different geological conditions and the published information from Kentucky's statewide mapping program.

Concluding Observations. As the discussion above indicates, calculating the benefits and costs of geologic mapping programs involves both a scientific approach and scientifically based innovations. Although quantifiable data on the benefits of mapping are few, they are quite reliable. Many other benefits from geologic maps are either very difficult to quantify or not quantifiable at all—for example, their use in schools to educate future generations about how to effectively use geology for planning purposes. Likewise, some social costs of geologic mapping are not quantifiable at this time. Such costs may be involved, for example, when the use of geologic information may force a new business away from the most economically advantageous location, resulting in loss of jobs and tax revenues. Decisions about feasibility of publicly funded programs can not always be made on the basis of benefit/cost ratios alone. Nonquantifiable benefits and costs must be listed and weighed before final decisions are made. In some instances, they can justify a final decision contrary to the one indicated by the benefit/cost ratio. Even so, systematic assessments of the benefits and costs of geologic mapping programs can yield useful and reliable results. Such efforts should be undertaken in the interest of the prudent use of taxpayer dollars in a national geologic mapping program. ■

Most geologic map users lack documentation of quantifiable benefits from the availability of geologic information.

benefits assessment used at the IGS involves the estimation of time or money saved by the map user because of having the geologic information available. One obvious benefit is that not having such information would force users to spend money to generate it on their own, leading to wasteful multiple expenditure for the same information. A less obvious, but potentially more valuable, benefit is the assistance geologic information provides in avoiding future costs for cleaning up contaminated industrial and waste disposal sites that are potentially dangerous to health or the ground-water supply.

Most geologic map users lack documentation of quantifiable benefits from the availability of geologic information. Consequently, benefits must

avoidable cost information was the amounts spent by city and county administrative offices to clean up underground problems from septic systems and leaking fuel tanks or to provide bottled drinking water to residents whose ground-water supplies have been contaminated.

Clearly, some of these expenses would be avoidable through environmental regulations already in place requiring some site-specific geologic considerations. Conversely, some of the costs of environmental cleanups may not be avoidable despite the availability of geologic information, because either the information is inadequate or it is improperly used. In order to account for such uncertainties, it was necessary to discount some of the avoided costs when assessing the total benefits of

In Memoriam

Willis L. Burnham

Boise, Idaho
July 13, 1992

V. R. Chamberlain

Great Falls, Montana
April 3, 1992

Robert I. Hill

Canberra, Australia
July 1992

Harry M. Mikami

Pleasanton, California
August 7, 1992

Robert R. Phillips

Monroe, Louisiana
December 24, 1991

John Sutton

Dorset, England
September 6, 1992

Memorial Preprints

The following memorial preprints are now available, free of charge, by writing to GSA, P.O. Box 9140, Boulder, CO 80301.

Charles Alfred Anderson

Harold L. James

Ralph Alger Bagnold

M. J. Kenn

Bennet Frank Buie

J. K. Osmond

Madeleine Alberta Fritz

John Monteith

Edwin Carter Galbreath

Mary R. Dawson,
Robert W. Wilson

Mackenzie Gordon, Jr.

J. Thomas Dutro, Jr.

Heber D. Lessig

Bonnie Lessig,
Charles B. Hunt

Stanley William Lohman

Thad G. McLaughlin

Carl A. Moritz

L. L. Sloss

Walter S. Newman

Rhodes W. Fairbridge

Robert E. Radabaugh

William C. Peters

R. Dana Russell

David B. MacKenzie

Charles Wainwright

Stuckey, Jr.

Jack Colle

Ralph Emerson Taylor

Edward McFarlan, Jr.

Paul Charles Tychsen

Albert B. Dickas

Warren Brinson Weeks, Sr.

Edwin Van den Bark,
Robert O. Dunbar

Hunter Yarborough

Grover E. Murray

GSAF UPDATE

Robert L. Fuchs

Foundation Cash Flow— What Goes In, Comes Out

Recently I prepared the GSA Foundation's 1993 disbursement budget, which will total slightly over \$100,000. I was struck with the variety of needs for funding in earth science that can only be met by the kind of money that is available from GSA. The categories within which GSA Foundation money is applied are numerous—awards and scholarships, research grants, student travel grants, internships, SAGE, IEE, and Penrose Conferences.

I was also reminded once again that Foundation cash flow is a two-way street. Considerable time and effort are expended during the year raising money—letters, flyers, conversations, trips, meetings—occupying not only the Foundation staff but also trustees, members, and even outsiders. While cash in-flow is generally the focus of attention, cash out-flow moves inexorably onward. Every dollar that comes in to the Foundation inevitably finds its way out again, either as direct program support or into Foundation endowment, from which investment income does the financial work.

Your contribution is a vital part of this cash flow, and now is an important time for your personal financial review. December is the most popular time for tax planning, because most of one's numbers for the year are known, and most options to minimize taxes disappear on January 1. This planning in-

volves a review of the current year's results, a preliminary tax calculation, and a look at next year's situation.

Charitable contributions are one of the few available devices that can be used to reduce personal tax liability on short notice. Year-end donations to the GSA Foundation can be used to minimize 1992 income tax. Gifts of cash are the most common gift form, but don't overlook other types of contributions such as real and personal property, life insurance, and appreciated securities. Whatever the final form of your gift, it is important to remember that the funds will ultimately flow through the Foundation to one or more important and unique applications in earth science.

1992 Great Poster Escapade

In honor of GSA's 104th birthday, the 60th anniversary of the research grants program, a record number of research grant awards, the birth of *GSA Journals on Compact Disc*, and for a myriad of other reasons, we have decided to send a complimentary copy of the Foundation's striking western U.S. landscape poster to every contributor of \$92 or more between the time this issue of *GSA Today* is distributed and midnight on December 31, 1992.

As with all promotions, a few rules apply. Your contribution of \$92 or more must be accompanied by the coupon with this article and must be postmarked no later than December 31,

1992 (see more detailed reasons below). Void where prohibited by law, but open to all GSA members and their families, and just about everyone else.

Watch Out for New Year's Eve

Take a special precaution this December 31st. No, this isn't the no drinking—no driving warning, although that is certainly a directive to be followed. The special precaution you are asked to heed at the end of 1992 concerns the timely posting of contributions for 1992 credit.

Every year the Foundation receives many contributions in January, some late in the month, in the form of checks dated December 31 of the prior year. Both the IRS and our auditors point out that gifts made in January are gifts made in the current year, not the year just ended as some contributors seem to believe. The rules of the game are clear, a charitable gift of cash is complete when delivered or mailed to the recipient. If you mail a check, the day of mailing is the date of the gift. Thus, a check dated December 31, 1992, and mailed January 5, 1993 will be a gift in the year 1993.

So pay special attention to the calendar late in the year and complete your charitable contributions before you don evening gowns and tuxedos on the Big Night. And don't forget to stop at the mail box on your way to the ball. ■

Donors to the Foundation, September 1992

History of Geology Division Award

C. G. Winder

Hydrogeology Division Award Fund

Leonard F. Konikow*
Leonard Alton Wood*

GEOSTAR Funds

Claude C. Albritton, Jr. Fund

James A. Biggs*
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CADY Fund

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Kurt Servos*

Doris M. Curtis Memorial

Kathryn H. Lohmeyer
Sarah J. Stoll

John T. Dillon Alaska Scholarship

Maria Luisa Crawford*
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Ian S. E. Carmichael
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Rhonda L. Knupp
Daniel B. Sass
Jill S. Schneiderman
Kathleen M. White*

Young Scientist Award

Ronald J. Clendening

*Second Century Club members—gifts of \$100 or more.



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- Here is my check for at least \$92. Please send me the great western poster by return mail.
- Enclosed please find my contribution of \$ _____.
- Please contact me about a gift of appreciated securities before the end of 1992.

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SOUTH-CENTRAL SECTION, GSA 27th Annual Meeting

Fort Worth, Texas
March 15-16, 1993



The South-Central Section of the Geological Society of America, the Mid-Continent Section of the National Association of Geology Teachers, and the South-Central Section of the Paleontological Society will meet in Fort Worth, Texas, March 15-16, 1993. The meeting is sponsored by the Department of Geology of Texas Christian University and will take place on the campus of Texas Christian University.

FORT WORTH

Fort Worth was built on cattle and grain, and it is still known as Cowtown to its 400,000 residents and its neighbors to the east in Dallas, but now the petroleum, aerospace, and electronics industries dominate the city's economy.

The western flavor of Cowtown can be sampled by taking in the Amon Carter Museum and the Sid Richardson Collection of Western Art, both of which house premier collections of Western art, and by sightseeing in the Stockyards district in north Fort Worth. Visitors with more cosmopolitan tastes can enjoy the world-renowned Kimbell Art Museum, the Japanese Gardens at the Fort Worth Botanic Center, or the Water Gardens in downtown Fort Worth. The city's newly renovated zoo will appeal to all visitors.

The average daily temperature in Fort Worth in March ranges from lows in the lower 40s to highs in the upper 60s. The average rainfall in March is 2.5 inches.

Texas Christian University is a private, self-governing, endowed institution founded in 1873. The university's six schools and colleges enroll about 6500 students, including almost 1100 graduate students. The university occupies an attractive 237 acre campus in a largely residential neighborhood about three miles from downtown Fort Worth. The Department of Geology is housed in the modern Sid W. Richardson Physical Sciences Building, designed by award-winning architect Paul Rudolph. The department maintains a broad and varied program of teaching and research while offering degree programs in geology, environmental earth resources, and environmental sciences. At present faculty members and students are pursuing research interests ranging from carbonate petrology and environmental geology to igneous geochemistry, and from meteorites and remote-sensing to subsurface geology and vertebrate paleontology. The department is a recognized leader in computer applications in geology and environmental earth resources.

REGISTRATION

Preregister today! Preregistration deadline is *February 19, 1993*.

Preregistration will be handled by GSA Headquarters. Use the registration form provided in this announcement. **For lower registration fees and to assist the local committee in planning, please preregister.**

Preregistrants may pick up their registration materials at the Marriott Courtyard Hotel from 4:00 to 8:00 p.m., Sunday, March 14, or outside the ballroom of the Brown-Lupton Student Center during general registration.

On-site registration will begin on Monday, March 15, at 7:30 a.m. outside the ballroom in the Brown-Lupton Student Center on the Texas Christian University (TCU) campus and will continue until 4:30 p.m. On Tuesday, March 16, on-site registration will be held outside the ballroom from 7:30 a.m. until 12:00 noon.

Please note:

- Badges must be worn for access to all activities.
- Registration discounts are given to members of GSA and to members of societies associated with GSA. Associated societies that qualify for this discount are indicated on the registration form. Please indicate your affiliation(s) and member number to register at member rates. Students and secondary school teachers are given a special discount.
- Full payment must accompany registration. Unpaid purchase orders are not accepted as valid registration. Charge cards are accepted, as indicated on the preregistration form. If using a charge card, please be sure the card number is correct, as errors will delay your registration. Your confirmation letter from GSA will be your receipt. No other receipt will be sent.
- Each professional or student registering for the meeting must send a separate registration form. Copy the form for your records.
- Guests must register to attend the Welcoming Party or any guest activity. Guest registrations must be

accompanied by a regular professional or student registration. A guest is defined as a nongeologist spouse or friend of a professional or student registrant.

- A current student ID is required to obtain student rates. Students must show their current ID when registering or picking up preregistration materials, or they will be required to pay the regular registration fee for professionals.

CANCELLATIONS, CHANGES, AND REFUNDS

All requests for refunds resulting from changing or canceling registration must be made in writing and must be received by *February 26, 1993* (faxes accepted). **NO REFUNDS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER THIS DATE.** Refunds will be mailed from GSA after the meeting. Refunds for fees paid by credit card will be credited to the card number on the preregistration form. No refunds will be given for on-site registration.

HOUSING

Blocks of rooms have been reserved at two nearby hotels. Reservations can be made by calling or writing the hotels directly. You must ask for the TCU/GSA rate when reserving a room to receive the discount rate. Normal room rates are significantly higher than the meeting rate, and the hotels are often full. The rooms will be held until February 20, 1993. A shuttle will run between the meeting hotels and the campus. **Reserve your room before February 20.**

- Marriott Courtyard
3150 Riverfront Drive
Fort Worth, TX 76107
(817) 335-1300 [Worldwide reservations: 1-800-321-2211]
\$68, single or double
- Residence Inn by Marriott
1701 South University Drive
Fort Worth, TX 76107
(817) 870-1011
\$69, studio; \$79, double; \$89, penthouse (will hold four people)

TECHNICAL PROGRAM

Papers will be presented in technical sessions, symposia, and poster sessions. Abstracts for symposia should be submitted directly to the convener(s) listed below.

- Microcomputer Applications in Geology.** Arthur B. Busbey, Department of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.
- Shallow Ground-water Systems.** Sponsored by the GSA Hydrogeology Division. Joe C. Yelderman, Jr., Department of Geology, Baylor University, Waco, TX 76798-7354, (817) 755-2673.
- Environmental Concerns in the Dallas/Fort Worth Metroplex.** Sponsored by the NAGT Texas Section. Donald F. Reaser, Department of Geology, University of Texas, Box 19049, Arlington, TX 76019-0049, (817) 273-2987.
- Precambrian Connections across Southern North America.** Kent C. Nielsen, Programs in Geosciences, University of Texas, Dallas, TX 75083, (214) 690-2537; Richard E. Hanson, Department of Geology, Texas Christian University.
- Geologic Problems to be Solved by Scientific Drilling.** M. Charles Gilbert, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019, (405) 325-3253; R. Nowell Donovan, Department of Geology, Texas Christian University.

6. Fractionation Processes in High-Temperature Systems.

David London, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019, (405) 325-3253; Barry L. Weaver, School of Geology and Geophysics, University of Oklahoma.

7. Petroleum Geology of the South-Central United States.

R. Nowell Donovan, Department of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270; John A. Breyer, Department of Geology, Texas Christian University.

8. Carbonate Rocks of the Southern Mid-Continent.

R. Nowell Donovan, Department of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

9. **Caves and Karst.** Kenneth S. Johnson, Oklahoma Geological Survey, Energy Center, 100 E. Boyd, Norman, OK 73019, (405) 325-3031.

10. **Sequence Stratigraphy of Cratonic Cycles.** Arthur W. Cleaves, School of Geology, Oklahoma State University, Stillwater, OK 74078-0451, (405) 744-6358.

11. Geographic Information Systems (GIS) and Land Use Planning.

Ken M. Morgan, Department of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

12. The Role of Planetary Geology in Teaching Geology Today.

Sponsored by the NAGT Texas Section. Donald H. Lokke, 7721

Dallas, TX 75248, (405) 352-1111. The symposium was canceled. Papers presented at the symposium "Environmental Concerns in the Dallas/Fort Worth Metroplex."

POSTER SESSIONS

Poster sessions will be in standard format and will be held in the Brown-Lupton Student Center, in the same area as the exhibits, and conveniently located relative to technical sessions and symposia.

Special Poster Session on Undergraduate Research

The Geology Division of the Council on Undergraduate Research will sponsor a special poster session specifically to highlight undergraduate research. Posters may be coauthored by graduate students, faculty members, or other professionals. The results of research in any discipline of geology or related fields, such as water resources, hydrology, or environmental science, may be presented in the session.

General questions and comments should be addressed to Robert Shuster, Department of Geography and Geology, University of Nebraska, Omaha, NE 68182, (402) 554-2457.

FIELD TRIPS

Premeeting trips will take participants to Trans-Pecos Texas to see Precambrian rock along the Grenville Front and to central Texas to study the sequence stratigraphy of Pennsylvanian strata on the Eastern Shelf of the Midland Basin. Postmeeting trips will examine the northern boundary of the Wichita Uplift in the Slick Hills of southern Oklahoma and the hydrogeology and environmental geology of a large metropolitan area.

PREREGISTRATION IS REQUIRED FOR ALL FIELD TRIPS. Participants are accepted on a first-come, first-served basis through GSA headquarters.

All field trips begin and end in Fort Worth, except the premeeting trip to west Texas, which begins and ends in

REGISTRATION FEES

	Advance (by Feb. 19)	On-Site	One-Day Advance	One-Day On-Site
Professional—Member	\$50	\$60	\$35	\$40
Professional—Nonmember	\$65	\$75	\$35	\$40
Student—Member	\$25	\$30	N/A	N/A
Student—Nonmember	\$30	\$35	N/A	N/A
Secondary School Teacher	\$12	\$14	N/A	N/A
Guest	\$12	\$12	N/A	N/A
Nonregistrant Fee (Field Trips and Short Courses)	\$10	\$10		

El Paso. For further details contact the field trip leaders. General questions should be directed to the field trip coordinator, Arthur B. Busbey, Department of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

PREREGISTRATION DEADLINE: February 19, 1993. The registration form is provided in this announcement. Participants registering for a field trip *only* must pay a \$10 service fee in addition to the field trip charge.

CANCELLATION DEADLINE: February 26, 1993. No refunds will be given for cancellations received after this date. All cancellations must be in writing. If GSA must cancel a field trip due to logistics or registration requirements, a full refund will be issued after the meeting. Be aware of cancellation deadlines and possible penalties imposed by airlines. You may wish to change or cancel flight arrangements if a trip you have registered for is canceled.

Premeeting

1. Sequence Stratigraphy of Middle and Late Pennsylvanian Cycles: North-Central Texas (2 days, March 13-14). Arthur W. Cleaves, School of Geology, Oklahoma State University, Stillwater, OK 74078-0451, (405) 744-6358; Darwin Boardmann; Merlynd Nestell, University of Texas at Arlington. Cost: \$125. Price includes lunch and dinner on the first day, one night's stay in a motel, breakfast and lunch on the second day, and transportation to and from the field.

2. Structural and Stratigraphic Correlations across the Grenville Deformational Front in West Texas (3 days, March 11-14). Kent C. Nielsen, Programs in Geosciences, University of Texas, Dallas, TX 75083, (214) 690-2537; Calvin G. Barnes, Texas Tech University; Kathleen M. Marsaglia, University of Texas at El Paso; Kristian Soegaard, University of Texas at Dallas. Trip will start and end in El Paso. Cost: \$150. Price includes three nights in a motel, three sack lunches, a mixer in El Paso on the first night, transportation in the field and a guidebook. The trip will convene Thursday evening in El Paso, with a meeting in the Department of Geological Sciences building on the UTEP campus. The field trip will return to El Paso by the middle of the afternoon on Sunday.

3. Geology of the Slick Hills of Southern Oklahoma: The Northern Boundary of the Wichita Uplift (2 days, March 17-18). R. Nowell Donovan, Richard E. Hanson, Ken M. Morgan, and Arthur B. Busbey, Department of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270. Cost: \$125.

Postmeeting

4. Environmental Geology and Hydrogeology of the Dallas/Fort Worth Metroplex (1 day, March 17). Sponsored by the GSA Hydrogeology Division. Joe C. Yelderman, Jr., Department of Geology, Baylor University, Waco, TX 76798-7354, (817) 755-2673. Cost: \$25.

5. Sequence Stratigraphic Framework of Valley-Fill Systems: A Core Workshop (1 day, March 17). Lee F. Krystinik and Beverly Blakeney DeJarnett, Union Pacific Resources, 801 Cherry Street, Mail Stop 3900, Fort Worth, TX 76102, (817) 877-6702. Fees: Professionals, \$60; Students, \$20. Limit: 40.

Lecture and core workshop discussing the variable characteristics of sequence boundaries and incised valleys in an intracratonic basin subject to glacio-eustatic fluctuations in sea level (Lower Pennsylvanian Morrow Formation, eastern Colorado). Emphasis will be on the sequence-stratigraphic implications that can be derived directly from the rocks.

2. Subsurface Facies Analysis from Well Logs and Core (1 day, March 14). John A. Breyer, Department of Geology, P.O. Box 30798, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270. Fees: Professionals, \$60; Students, \$20. Limit: 25.

Lecture and core workshop intended for students or practicing geologists with little or no experience in subsurface facies analysis. Topics include interpreting lithology and facies from well logs, defining and using electrofacies, recognizing sedimentary structures in cores, and the relation between regional geological studies, including seismic studies, and detailed facies analysis.

PROJECTION EQUIPMENT

Two slide projectors, one overhead projector, and two screens will be set up for each technical session and symposium. All slides must be 2" x 2" and fit in standard carousel trays. A room equipped with projectors will be open for speakers to view and load slides and rehearse their talks. Only a small number of slide trays will be available. Please bring your own slide trays if at all possible.

EXHIBITS

Exhibits of interest to geologists in industry, academia, and public service will be on display in the Ballroom of the Brown-Lupton Student Center on the campus of Texas Christian University. The exhibits will be open for viewing on Monday and Tuesday, March 15 and 16, from 8:30 a.m. until 5:00 p.m. Exhibit fees are \$35 for educational institutions and nonprofit organizations and \$60 for commercial exhibitors. Potential exhibitors should contact Ken Morgan or Dena Hanson, South-Central GSA, 1993 Annual Meeting, Exhibits Coordinators, P.O. Box 30798, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

Organizations and institutions already planning to exhibit include the GSA Bookstore, the Texas Bureau of Economic Geology, the Oklahoma Geological Survey, the Arkansas Geological Survey, the City of Dallas, EOSAT, EISYS, Hewlett Packard, Image Transform, and geology departments of the University of Texas at Dallas, the University of Oklahoma, the University of Texas at Arlington, Baylor University, Rice University, and Texas Christian University.

STUDENT AWARDS

Cash awards of \$200, \$100, and \$50 will be made to the three best student papers given at the meeting, including both oral presentations and poster sessions. Awards for outstanding papers will be based on quality of research and effectiveness of presentation. To be eligible, the abstract form may list only students as authors and must identify the abstract as a student

paper. For further information, contact Richard E. Hanson, program chairman, Department of Geology, P.O. Box 30798, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

STUDENT SUPPORT

Funds are available for grants to GSA Student Associates of the South-Central Section who are making presentations at the meeting. Students are encouraged to apply for these grants, and we hope to be able to provide some support to all students who are eligible. Application for support should be made to John A. Breyer, Department of Geology, P.O. Box 30798, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270. Letters of application should include a copy of the abstract and certification that the student is a GSA Student Associate of the South-Central Section. Applications for support must be received by February 19, 1993.

SPECIAL EVENTS

Welcoming Party

A welcoming party will be held at the Marriott Courtyard Hotel from 5:30 to 8:00 p.m., Sunday, March 14. A cash bar will be open and light snacks will be served.

Daily Lunches

The main cafeteria in the Brown-Lupton Student Center will be open from 8:00 a.m. to 6:00 p.m. during the meeting, and several restaurants are within a short walk of the campus and hotels. Weather permitting, light lunches will be available in the courtyard adjoining the Sid Richardson Building.

Monday Reception

Following the technical sessions on Monday, February 15, a reception and open house will be held from 4:30 to 6:00 p.m. in the courtyard adjoining the main floor of the Sid Richardson Building, which houses the Department of Geology. Please stop by to visit and to view the extensive meteorite and mineral collections on display in the showcases. Prints of many of the famous "lost drawings" intended to illustrate James Hutton's great work are displayed in the Hutton Room. The integrated local area network and other computer facilities in the department, including those in the Center for Remote Sensing, will be demonstrated for those who are interested.

Banquet

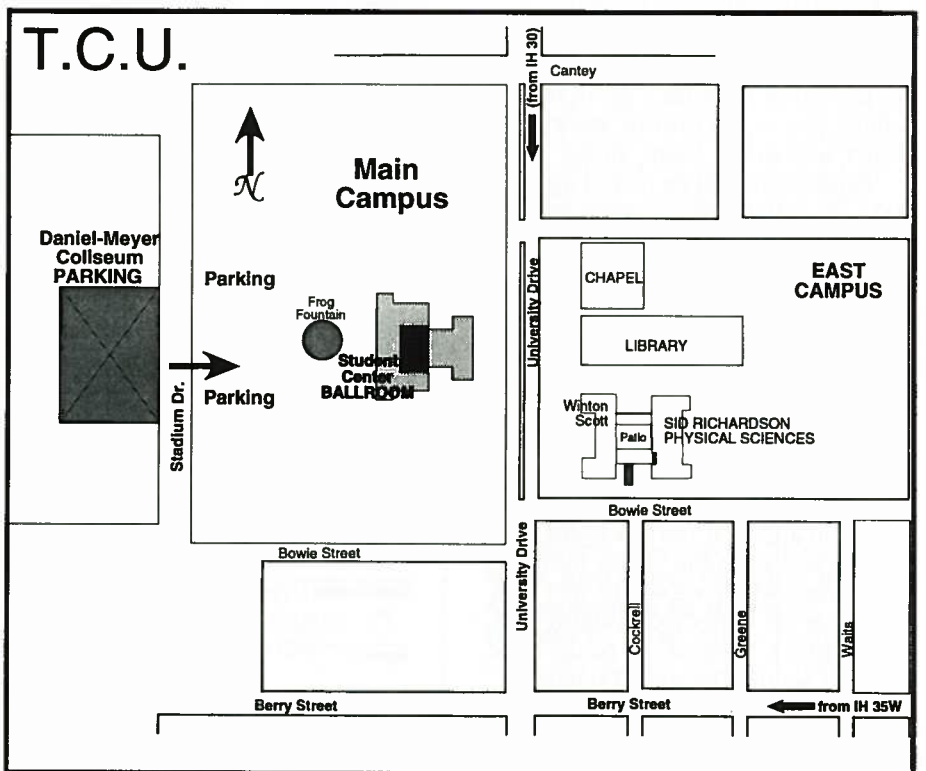
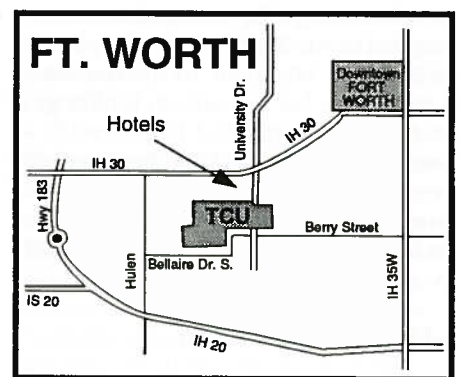
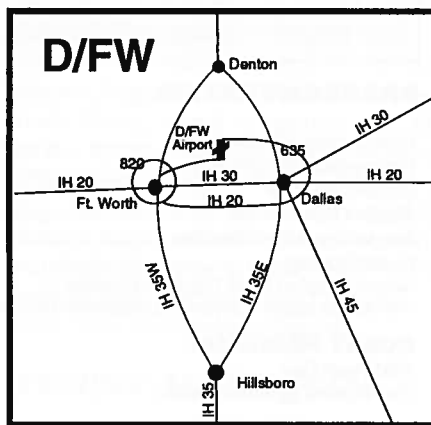
The annual banquet will be held at the unique turn-of-the-century Yellow Rose Saloon on the grounds of the Fort Worth Zoo, just across the street from the hotels, on Monday, March 15, 1993. The cash bar will open at 6:30 p.m. and dinner will begin at 7:00. After the banquet, R. Nowell Donovan, holder of the Charles B. Moncrief Chair of Geology and leader of the AAPG field seminar GeoRoots, will treat those in attendance to a spellbinding program on the geology of Scottish castles. Purchase tickets on the preregistration form for \$20 (preregistration is required).

NAGT Luncheon

The Texas Section of the National Association of Geology Teachers will hold a luncheon at noon on Tuesday, March 16, in the Brown-Lupton Student Center. The annual business meeting will follow immediately. For

South-Central continued on p. 270

Dallas, Fort Worth, Texas Christian University



more information, contact Donald F. Reaser, Department of Geology, University of Texas, Arlington, TX 76019, (817) 273-2987. Purchase tickets by checking the appropriate box on the preregistration form. The cost of lunch will be \$12. Preregistration is required.

Paleontological Society Luncheon

The South-Central Section of the Paleontological Society will hold a luncheon at noon on Tuesday, March 16, in the Brown-Lupton Student Center. The annual business meeting will follow immediately. For more information, contact Arthur B. Busbey, Department of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270. Purchase tickets by checking the appropriate box on the preregistration form. The cost of lunch will be \$12. Preregistration is required.

TRANSPORTATION

Travel. Fort Worth is served by the Dallas/Fort Worth Airport. After landing you can arrange to take either the Super Shuttle or a taxi to the hotels or meeting site. The Super Shuttle costs \$22. Cab fare from the airport will be about \$35. The trip from the airport takes 30 to 45 minutes.

Parking. The students will be on spring break during the meeting, so parking should not be a problem. People attending the meeting will be able to park free in any of the lots on campus in spaces marked with white lines. Reserved spaces are marked with red lines. Do not park in these spaces.

BUSINESS MEETINGS

GSA South-Central Section Management Board. The management board will meet on Sunday, March 14, at 4:30 p.m. in the Hutton Room in the Sid Richardson Building on the TCU campus.

GSA South-Central Section Business Meeting. The annual business meeting of the Section will take place on Monday, March 15, in the Hutton Room in the Sid Richardson Building on the TCU campus.

Texas Section of NAGT. See Special Events.

South-Central Section of the Paleontological Society. See Special Events.

GUEST PROGRAM

We look forward to seeing you in Fort Worth, a city of "Cowboys and Culture." We have two days of appropriate activities planned for your enjoyment.

Monday, March 15, 1993: Wild West day, including a ride on a steam train, a walking tour of the historic Stockyard district, and shops, shops, shops!

Participants will be picked up at 9:00 a.m. at the Brown-Lupton Student Center on the TCU campus and at 9:10 at the Marriott Courtyard Hotel and will be taken to the 8th Street Station of the Tarantula Railroad. At 10:00 participants will board the Tarantula, a completely restored and renovated 1896 steam engine and passenger cars, which will wend through neighborhoods and parks on its way to the Fort Worth Stockyards Historical District.

Upon arrival at the Stockyard Station, we will go to the Visitor Information Center, where we will be met by a tour guide for a one-hour walking tour of the district. Some of the places to be explored are the Livestock Exchange Building built in 1902 and seen on the TV show *Dallas*, the Cowtown Coliseum (the world's first indoor rodeo

arena) and Billy Bob's Texas—The World's Largest Honky Tonk.

After the tour the group will break up, allowing everyone to explore the restaurants, theme shops, and galleries located on Exchange Street and in the renovated hog and sheep pens (!) of the Market Center.

The train "home" will depart from Stockyard Station at 3:30 p.m. and arrive at the 8th Street Station at 4:00. Transportation will be furnished from the station to the Marriott Courtyard Hotel and the TCU campus. Preregister using the form in this announcement. Cost: \$15.

Tuesday, March 16, 1993: Once again we will gather at the Brown-Lupton Student Center on the TCU campus or at the Marriott Courtyard Hotel. Departure times are 10:00 and 10:10 a.m., respectively. Our destination will be *Fort Worth's museum district*.

Our first stop will be the Kimbell Art Museum, where at 10:30 we will be given a docent-guided tour of the per-

manent collection. Widely considered one of America's best small museums, the building itself is a work of art, designed by internationally acclaimed architect Louis Kahn. The permanent display includes works from the beginning of civilization to the 20th century. We will view masterpieces of Egyptian, Asian, Mesoamerican, and African art, as well as paintings of old masters such as El Greco, Caravaggio, Rembrandt, Goya, Cezanne, and Picasso.

At the conclusion of the tour we will be on our own to eat lunch and explore any or all of several other museums in the cultural district, all within walking distance of the Kimbell. You can also choose to visit the special exhibit on display at the Kimbell. We will gather at the Kimbell at 4:00 p.m. to be taken back to the Marriott Courtyard Hotel and the TCU campus. There is no cost for this event but preregistration is required.

Museum hours are 10:00 a.m. to 5:00 p.m.; there is no admission charge.

Other institutions in the museum district to explore on your own as you please include: The **Modern Art Museum of Fort Worth**, the first art museum in Texas, which houses an outstanding 2000-piece collection of paintings, sculptures, drawings, and prints of 20th century art, specializing in American art after 1940 and European art after 1920. (Tuesday through Saturday—10:00 a.m. to 5:00 p.m.; Sunday—1:00 p.m. to 5:00 p.m.; free admission.) The **Amon Carter Museum** houses the noted publisher and philanthropist's collection of paintings and sculptures by the premier artists of the American West, who embodied in their work a pioneer spirit that Carter admired and wanted to share with the public. The museum has extensive collections of work by Frederic Remington and Charles Russell and other work by 19th century and early 20th century artists, including Winslow Homer and

Preregistration Form

Preregistration deadline is February 19, 1993.

GSA South-Central Section
Fort Worth, Texas • March 15-16, 1993

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State or Country

Business Phone

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Mailing Address (use two lines if necessary)

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State

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Country (if other than USA)

Please indicate if you will need services to accommodate a disability:
 Yes No

Circle member affiliation (to qualify for registration discount): (A) GSA Member # _____ (B) NAGT (C) PS

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	Full Meeting		One Day		Amount
	Qty		Qty		
Professional Member*	(01)	\$ 50 <input type="checkbox"/>	1	(02) \$ 35 <input type="checkbox"/>	\$ _____
Professional Nonmember	(03)	\$ 65 <input type="checkbox"/>	1	(04) \$ 35 <input type="checkbox"/>	\$ _____
Student Member*	(05)	\$ 25 <input type="checkbox"/>	1	N/A	\$ _____
Student Nonmember	(07)	\$ 30 <input type="checkbox"/>	1	N/A	\$ _____
Secondary School Teacher	(42)	\$ 12 <input type="checkbox"/>	1	N/A	\$ _____
Guest/Spouse	(09)	\$ 12 <input type="checkbox"/>	1	N/A	\$ _____
Nonregistration Field Trip/Short Course	(98)	\$ 10 <input type="checkbox"/>	1	N/A	\$ _____

*Member fee applies to any existing professional OR Student Member of GSA or Associated Societies listed above. Discount does not apply to guest registrants.

GUEST PROGRAM

Wild West Day	March 15	(20) \$ 15	_____	\$ _____
Fort Worth's Museum District	March 16	(21) FREE	_____	\$ _____

SPECIAL EVENTS

Banquet	March 15	(56) \$ 20	_____	\$ _____
NAGT Luncheon	March 16	(60) \$ 12	_____	\$ _____
Paleontological Society Luncheon	March 16	(61) \$ 12	_____	\$ _____

FIELD TRIPS

1. Sequence Stratigraphy: North Central Texas	March 13-14	(100) \$125	1	\$ _____
2. Structural & Stratigraphic Correlations	March 11-14	(101) \$150	1	\$ _____
3. Geology of Slick Hills	March 17-18	(102) \$125	1	\$ _____
4. Environmental Geology & Hydrogeology	March 17	(103) \$ 25	1	\$ _____

SHORT COURSES

1. Sequence Stratigraphic Framework	March 17	Professional (150) \$ 60	1	\$ _____
		Student (151) \$ 20	1	\$ _____
2. Subsurface Facies Analysis	March 14	Professional (152) \$ 60	1	\$ _____
		Student (153) \$ 20	1	\$ _____

TOTAL FEES \$ _____

Remit in U.S. funds payable to: 1993 GSA South-Central Section Meeting (All preregistrations must be prepaid. Purchase Orders not accepted.)

Payment by (check one):

- Check American Express VISA
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MAIL TO: GSA SOUTH-CENTRAL SECTION MEETING, P.O. BOX 9140, BOULDER, CO 80301

South-Central continued from p. 270

Georgia O'Keeffe. (Tuesday through Saturday—10:00 a.m. to 5:00 p.m.; Sunday—noon to 5:00 p.m.; free admission.) The **Fort Worth Museum of Science and Industry** is the Southwest's largest museum and draws more than one million visitors each year. The museum houses over 120,000 artifacts and the permanent exhibitions include Man and His Possessions, Your Body, History of Medicine, Calculators and Computers, Geology and Paleontology, and Texas History. (Monday through Saturday—9:00 a.m. to 9:30 p.m.; Sunday—1:00 p.m. to 5:00 p.m.). The 356-seat **Fort Worth Omni Theatre** utilizes the most advanced 70 mm film and multi-image projection systems in the world. The screen is a dome 80 feet in diameter, tilted at a 30° angle to the horizontal, enveloping the viewer in sight and sound. Several different films show at different times of day. Tickets for a particular film can be purchased in advance (shows are often sold out). Seating is on a first-come, first-served basis. Ticket cost at theater: \$4.75.

For those who would like to explore Fort Worth on their own, there will be a table with brochures and a person to assist you at the Welcoming Party at the Marriott Courtyard Hotel on Sunday, March 14, from 5:30 to 8:00 p.m. There will also be an information booth located in front of the ballroom on the second floor of the

Brown-Lupton Student Center on Monday, March 15, and Tuesday, March 16, from 8:30 to 11:30 a.m. For further information, contact Carol Ehlmann, Spouse/Guest Program Committee Chair, Department of Geology, P.O. Box 30798, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

ADDITIONAL INFORMATION

For additional information concerning the technical program, please contact Richard E. Hanson, program chairman, Department of Geology, P.O. Box 30798, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270. Inquiries about field trips should be directed to the field trip leader or to Arthur B. Busbey, field trip chairman, Department of Geology, P.O. Box 30798, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270. Please call the hotels directly for information about the availability of rooms. All other questions should be directed to John A. Breyer, General Chairman, at the address or number listed above. ■

Stop and Visit the
**GSA Mini
Bookstore**
at each of the
1993 GSA Section Meetings

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Complete this form and return it by *January 12, 1993*, for advance-copy purchases of the South-Central Section, *GSA Abstracts with Programs*. **Members**, check your records carefully to make sure that you have not previously purchased a copy of this publication on either your dues statement or through GSA Publication Sales. **No refunds for duplicate orders.** *Abstracts with Programs* books will be mailed about three weeks prior to the meeting. Please copy this form for your records.

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Due to prohibitive postal costs and delays in overseas mailings, this offer for the advance copies is for U.S., Canada, and Mexico only.

Final Announcement

NORTHEASTERN SECTION, GSA 28th Annual Meeting

**Burlington, Vermont
March 22-24, 1993**



The University of Vermont, Middlebury College, Norwich University, Vermont State Colleges at Johnson, Lyndonville, and Castleton, the State University of New York at Plattsburg, the Vermont Geological Society, and the Vermont Geological Survey will host the Northeastern Section of the Geological Society of America meeting at the Sheraton Hotel and Conference Center in Burlington, Vermont. The Eastern Section of SEPM, the Northeastern Section of the Paleontological Society (NE-PS), the Eastern and New England Sections of the National Association of Geology Teachers (ES-NAGT), and the Association for Women Geoscientists will be meeting with the GSA Northeastern Section.

The meeting will be held from 8:00 a.m. Monday, March 22, to noon Wednesday, March 24. Short courses and field trips will be held Saturday, March 20, and Sunday, March 21.

REGISTRATION

Registration is required for everyone participating in any event connected with the meeting.

Preregistration. All participants are strongly urged to preregister as early as possible. Your preregistration form and payment must be received no later than *February 22, 1993*. Complete the preregistration form and return it with a check or money order in U.S. currency (made payable to Northeastern Section GSA) to Rolfe Stanley, Perkins Hall, Dept. of Geology, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247; fax 802-656-0045. Refunds on canceled preregistration will be made in full until March 1, 1993. No refunds will be made after this date.

On-Site Registration. On-site registration and pick-up of meeting

materials for those who have preregistered will be from 5 to 10 p.m. on Sunday, March 21; 7 a.m. to 9 p.m. on Monday, March 22; 7 a.m. to 5 p.m. on Tuesday, March 23; and 7 a.m. to noon on Wednesday, March 24. On-site registration and packet pick-up will be held in the entrance lobby of the Sheraton Burlington Convention Center. No on-site refunds will be made unless specific ticketed events are canceled.

The Northeastern section of GSA is unable to accept credit cards for preregistration. Visa and Mastercard will be accepted for on-site registration.

Additional copies of the *Abstracts with Programs* for the meeting will be available at the registration desk. Preregistrants may pick up their copies of *Abstracts with Programs* at the registration desk.

LOCATION

The Burlington area is on the eastern shore of Lake Champlain, which is bordered to the east by the Green Mountains and to the west by the Adirondack Mountains. The metropolitan area of approximately 120,000 people is conveniently located near many of the major ski areas of the east (Stowe, Sugarbush, Bolton). Temperatures during March range from the 30s to the 50s and sufficient snow is usually available for excellent spring skiing. The area is conveniently served by several major airlines, and rail and an excellent highway system connect with central and southern New England, New York, and eastern Canada.

TECHNICAL PROGRAM

General technical sessions (oral and poster), symposia, and theme sessions will begin at 8:00 a.m. Monday, March 22, and close at noon Wednesday, March 24. Oral and poster sessions will be held in the Sheraton Convention Center. Questions should be addressed to Symposium Coordinator Rolfe Stanley, Dept. Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247, fax 802-656-0045.

SYMPOSIA

Scheduled symposia and theme sessions are listed below with the conveners.

- 1. Allochthonous Terranes in the Northern and Central Appalachians: A Symposium in Honor of E-An Zen.** Barry Doolan, Dept. Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0248, fax 802-656-0045.
- 2. Thermobarometric Studies and P-T Path Determinations in Mountain Belts.** Robert Tracy, Dept.

Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 951-6521; Frank Spear, Dept. Geology, Rensselaer Polytechnic Institute, Troy, NY 12181, (518) 276-6103.

3. Graphic Correlation: The Method and Its Application. Keith Mann, Dept. Geology, Juniata College, Huntingdon, PA 16652, (814) 643-4310, ext. 602.

4. Rivers and Lakes: A Tribute to Brian Rust. Sponsored by the Eastern Section of SEPM. Martin Gibling, Dept. of Geology, Dalhousie University, Halifax, Nova Scotia, B3H 3J5, Canada, (902) 494-2358, fax 902-494-6889; Elizabeth Gierlowski-Kordes, Dept. Geological Sciences, Ohio University, Athens, OH 45701, (614) 593-1101, fax 614-593-4229.

5. Mineralogy and Geochemistry of Precambrian Gneisses: A Symposium in Honor of Howard W. Jaffe. David Elbert, Dept. Geology, Middlebury College, Middlebury, VT 05753, (802) 388-3711, ext. 5652; James Olmsted, Center for Earth and Environmental Sciences, SUNY, College at Plattsburg, Plattsburg, NY 12901, (518) 564-2028.

6. Advances in the Geology of Vermont and Adjacent Regions: A Tribute to Norman L. Hatch, Jr. Rolfe Stanley, Dept. Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247, fax 802-656-0045; Nick Ratcliffe, U.S. Geological Survey, Reston, Virginia, (703) 648-6939.

7. Tectonics of the Appalachians, Cordillera, the Earth, Moon, Mars, and Other Celestial Bodies: A Symposium in Honor of Donald U. Wise. Arthur Goldstein, Dept. of Geology, Colgate University, Hamilton, NY 13346, (315) 824-7201; Michael Williams, Dept. Geology and

Northeastern continued on p. 272

Geography, Morrill Hall, University of Massachusetts, Amherst, MA 01003, (413) 545-0745.

8. Practical Methods for Evaluation of Ground Water in Fractured Bedrock. Kenneth Hardcastle, Emery and Garrett Groundwater, Inc., 170 Waukegan St., Meredith, NH 03253, (603) 279-4425, fax 603-279-8717.

9. Comparison of Glacial-Marine and Glacial-Lacustrine Environments. Sponsored by the Eastern Section of SEPM. Daniel Belknap, Dept. Geological Sciences, University of Maine, Orono, ME 04469-0110, (207) 581-2159, fax 207-581-2202; Gail Ashley, Dept. Geological Sciences, Rutgers University, New Brunswick, NJ 08903, (908) 932-2044, fax 908-932-3374.

10. Bedrock Studies in the Northern Appalachians: A Symposium in honor of Philip Osberg. David C. Roy, Dept. Geology and Geophysics, Boston College, 140 Commonwealth Ave., Devlin Hall 209, Chestnut Hill, MA, 02167, (617) 552-3641 or (617) 552-3647, fax 617-552-2462; Henry N. Berry IV, Dept. Geological Sciences, University of Maine, Orono, ME 04469-0110, (207) 581-4493.

12. Exceptional Fossil Assemblages of Eastern North America: Evolutionary and Ecological Significances. Sponsored by the Eastern Section of the Paleontological Society. Cathryn Newton, Dept. Geology, Syracuse University, Syracuse, NY 13244-1070, (315) 443-3710 or 443-2672.

13. The Glacial, Lacustrine, and Marine Environment in the St. Lawrence and Champlain Lowlands. David Franzi, Center for Earth and Environmental Sciences, SUNY, College at Plattsburgh, Plattsburgh, NY 12901, (518) 564-4033; Donald Pair, Dept. Geology, University of Dayton, Dayton, OH 45469, (513) 229-2921.

THEME SESSIONS

The following theme sessions will be held if enough relevant papers are submitted.

1. **Applied Environmental Geology.** Ronald Parker, Heindel and Noyes, Inc., 285 North St., Burlington, VT 05401, (802) 658-0820, fax 802-860-1014
2. **Studies of Recent Lakes.** Allen Hunt, Dept. Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0241, fax 802-656-0045; Patricia Manley, Dept. Geology, Middlebury College, Middlebury, VT 05753, (802) 388-3711, ext. 5430.
3. **The Use of Geochemistry in Understanding Tectonics of the Appalachians.** Raymond Coish, Dept. Geology, Middlebury College, Middlebury, VT 05753, (802) 388-3711, ext. 5423.
4. **Magma Genesis in the Appalachians.** Judith Hannah, Dept. Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0245, fax 802-656-0045.
5. **New Advances in Earth Science Education K-12.** Leslie Kanat, Environmental and Health Sciences, Johnson State College, Johnson, VT 05656, (802) 635-2356, ext. 325; Russell Agne, College of Education and Social Services, University of Vermont, Burlington, VT 05405-0160, (802) 656-3356.
6. **Mineral Deposits of the Northern Appalachians.** Stephen Howe, Dept. Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0388, fax 802-656-0045; Peter Nielson, Division of Science, Keene State College, Keene, NH 03431-4183, (603) 358-2554.

POSTER SESSIONS

Poster Booths (8' x 8') will be framed by pipe and drape and have three 4' x 8' tack boards. All poster

sessions are located in the Lake Champlain Exhibition Hall of the Sheraton Convention Center. For general information and suggestions regarding poster sessions, contact David Bucke, Poster Session Chairperson, Dept. Geology, Perkins Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0246, fax 802-656-0045.

Special Poster Sessions

1. **Undergraduate Research.** The Geology Division of the Council on Undergraduate Research will sponsor this special poster session specifically to highlight undergraduate research. Posters may be coauthored by graduate students, faculty members, or other professionals. Topic emphasis will focus on undergraduate research in any discipline of geology or such related fields as water resources, hydrology, or environmental science. General questions and comments should be addressed to Barbara Tewksbury, Department of Geology, Hamilton College, Clinton, NY 13323, (315) 859-4713, fax 315-859-4185.

NOTE: Papers submitted to Undergraduate Research Poster Sessions must be so designated on the abstract form.

2. **New Advances in Earth Science Education K-12.** The Northeastern and New England sections of NAGT are cosponsoring this special poster session on earth science education. Posters are invited from K-12 teachers or other educators and professionals involved with earth science education. For general information, contact either Leslie Kanat, Environmental and Health Sciences, Johnson State College, Johnson, VT 05656, (802) 635-2356, ext. 325, or Russell Agne, College of Education and Social Services, University of Vermont, Burlington, VT 05405-0160, (802) 656-3356.

UNDERGRADUATE AWARDS

A separate award will be given for the best paper and the best poster session presented by an undergraduate student. Although the name of the faculty mentor may appear as the junior author, a major part of the paper or poster session must represent original work by the student.

NOTE: Papers submitted by undergraduates must be so designated on the abstract form.

Housing Form

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Northeastern Section GSA, March 22-24, 1993

Arrival Date _____ Departure Date _____

Arrival Time _____

By Car _____ Airline, Flight Number _____

Person Requesting Housing (type or print)

Last name _____ First _____

Institution or firm _____

Address or P.O. Box Number _____

City _____ State _____ ZIP _____

Phone () _____ () _____

Sharing room with _____

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Double	\$79	_____
Triple	\$89	_____
Quad	\$89	_____
Extra adult	\$10	_____
Cot	\$10	_____

_____ one bed _____ two beds _____ smoking _____ nonsmoking

*Rates do not include 8% tax.

- All reservations must be accompanied by a credit card guarantee or a deposit of one night in advance.
- Rooms may not be available for occupancy until 3 p.m. on the day of arrival. Check out time is 12:00 noon.
- If your reservation is not received by February 21, 1993, availability cannot be guaranteed.

Telephone reservations accepted: 1-800-677-6576

Type of card _____ Card No. _____

Exp. Date _____ Signature _____

Send this form and remittance or credit card information to:
Reservations Department
Burlington Sheraton Hotel and Conference Center
870 Williston Road, Burlington, VT 05403

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PROJECTION EQUIPMENT

All slides must fit a standard 35 mm carousel tray. Two projectors and two screens will be provided in each of the technical sessions. Overhead projectors will not be used in the technical program. Speakers are expected to bring their own loaded tray to the meeting. Please label trays with your name, session, left or right screen, and time of paper; give trays to the projectionist at least 20 minutes before the beginning of the session. A speaker-ready room for previewing slides will be provided. Extra trays will be available.

SHORT COURSES

Four short courses will be offered on the Saturday and Sunday before the meeting. **Preregistration is required for all the short courses.** For further information, please contact the leaders of the appropriate short course. Individual courses may be canceled on **March 1** if the enrollment is low. Interested participants should contact the instructor for the appropriate short course for further information. Enroll early!

1. Hydrogeochemistry. John Tewhey, Tewhey Associates, Inc., P.O. Box 86 DTS, Portland, ME 04112, (207) 772-2242.

This course will introduce a broad range of hydrogeology and hydrochemistry. Originally presented at Portland, Maine, in 1989, it has been updated substantially since then. Topics include weathering and water chemistry, geochemical processes in ground water (redox equilibria, mineral equilibria, clay-mineral adsorption and desorption), and geochemical processes influencing the fate and transport of organic and inorganic solutes in ground water. No participant limit. *Saturday, March 20, 9:00 a.m. to 5:00 p.m.*

2. Kriging: Theory and Applications for the Novice User. William Parker, Dept. Geology, Florida State University, Tallahassee, FL 32306, (904) 644-5860, E-mail parker@geomag.gly.fsu.edu.

Topics include: what kriging is and how it works, the nature of regionalized data, sampling strategies for better data, the effects of nonstationary data, the robustness of kriged estimates, rules for standard error estimates, the effects of sample location errors, semivariance modeling, cross-validation for improved model fit, and recognition of outliers. Participants will receive course notes and a package of computer programs. Computer sessions will be available. Participants may bring their own data. No participant limit. *Sunday, March 21, 9:00 a.m. to 5:00 p.m.*

3. Cathodoluminescence in Sedimentary Petrology. Mike Owen, Dept. Geology, 22 Romoda Dr., Brown Hall, St. Lawrence University, Canton, NY 13617-1475, (315) 379-5804, BitNet MROWEN@STLAWU.

This course will examine the application of cathodoluminescence (CL) to sedimentary petrology. The morning session will discuss instrumentation, cement stratigraphy, discrimination of altered and unaltered skeletal material, sandstone framework mineralogy, porosity occlusion, pressure solution, and diagenesis, using actual samples. The afternoon session will involve hands-on experience with CL equipment. Participants are encouraged to bring their own samples, which should be uncovered, uncoated, epoxy-cemented thin sections of standard dimensions. Limit: 20. *Sunday, March 21, 9:00 a.m. to 5:00 p.m.*

4. System Dynamics in Geology, Water Resources, and the Life Sciences. Rolfe Stanley, Jack C. Drake,

E. A. Cassell, and Kenneth Williams, University of Vermont. For further information, contact Rolfe Stanley, Dept. Geology, Perkins Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247, fax 802-656-0045.

This course is designed for college teachers, high school teachers, and other professionals who are interested in systems analysis in the geological and life sciences. The course will focus on the use of STELLA (Systems Thinking Experimental Laboratory with Animation), a Macintosh-based, object-oriented computer program written by High Performance Systems of Hanover, New Hampshire. Limit: 22. *Sunday, March 21, 9:00 a.m. to 5:00 p.m.*

FIELD TRIPS

Three full-day field trips are planned for Sunday, March 21. Five short field trips will also take place

during the meeting. Except for Trip 1, all trips begin and end at the Sheraton Hotel in Burlington and include a field trip guide, transportation, and lunch. Trip 1 cost includes a field guide. Please address specific questions to the individual field trip leaders. General questions should be addressed to the field trip coordinator, Stephen F. Wright, Dept. Geology, University of Vermont, Burlington, VT 05405-0122, (802) 656-3396, fax 802-656-0045.

All of the field trips are in areas that are usually free of snow by late March. Nevertheless, anything is possible in March and participants should dress warmly and wear appropriate footwear. Trips will be canceled only in the most inclement weather. Preregistration for the field trips is highly recommended because participants will be accepted on a first-come, first-served basis. The individual field trip descrip-

tions state deadlines for registration and cancellation. If a field trip must be canceled because of insufficient enrollment or inclement weather, a full refund will be issued after the meeting.

The field trip guidebook will be published by the Vermont Geological Society as a volume of *Vermont Geology*. Copies of the guidebook can be purchased during the meeting at the registration desk. Please note registration deadlines.

Full-day Trips

1. Early Cretaceous Igneous Features in the Northern Taconics: A Field Trip to the Unknown. Sunday, March 21, 9 a.m. to 5 p.m. J. Gregory McHone, Graduate Liberal Studies Program, Wesleyan University, Middletown, CT 06459, (203) 344-7930 or jmchone@willet.wesleyan.edu.

Northeastern continued on p. 274

Preregistration Form

GSA Northeastern Section
Burlington, Vermont • March 22-24, 1993

IMPORTANT

1. PREREGISTRATION MUST BE RECEIVED NO LATER THAN *February 22, 1993*.
2. Full payment must accompany all preregistration. Purchase orders are not acceptable.
3. Cancellation deadline: **March 1, 1993. No refunds after this date.**
4. Register only one person per form. A receipt for your payment will be in your packet at the registration desk.

PLEASE PRINT OR TYPE

Name (last, first) _____
 Name for badge _____
 Affiliation for badge _____
 Mailing Address _____
 City _____ State _____ ZIP _____

Membership Affiliation:
 A. _____ GSA Member no. _____
 B. _____ NAGT C. _____ SEPM
 D. _____ PS E. _____ SIA F. _____ AWG
 G. _____ GSA Student Associate

Nonmember Affiliation _____
 Student Verification _____

Signature
 department head or GSA Campus Representative _____

Business Phone _____
 Home Phone _____

PREREGISTRATION

	Postmarked on or before February 22, 1993	Postmarked after February 22, 1993	Amount
Professional Member	\$ 55	\$ 75	\$ _____
Professional, Nonmember	\$ 70	\$ 90	\$ _____
K-12 Science Teacher	\$ 25	\$ 35	\$ _____
Student Member	\$ 20	\$ 30	\$ _____
Student, Nonmember	\$ 30	\$ 40	\$ _____
One day, Professional, Member	\$ 30	\$ 45	\$ _____
One day, Professional, Nonmember	\$ 40	\$ 55	\$ _____
One day, Student Member	\$ 15	\$ 25	\$ _____
One day, Student, Nonmember	\$ 25	\$ 35	\$ _____

FIELD TRIPS (meeting registration required)

Full Day	Date	Amount	Amount
1 Early Cretaceous Igneous Features in the Northern Taconics	Sun., March 21	\$ 12	\$ _____
2 Crown Point Section, Crown Point, New York	Sun., March 21	\$ 32	\$ _____
3 Altona Flat Rock, Jack Pine Barrens	Sun., March 21	\$ 30	\$ _____
Half-day (2.5 hours), shuttles provided			
4 Champlain Thrust Fault at Lone Rock Point	Sun., March 21	\$ 10	\$ _____
5 Champlain Thrust Fault at Lone Rock Point	Mon., March 22	\$ 10	\$ _____
6 Salmon Hole/Redstone Quarry	Mon., March 22	\$ 10	\$ _____
7 Champlain Thrust Fault at Lone Rock Point	Tues., March 23	\$ 10	\$ _____
8 Salmon Hole/Redstone Quarry	Wed., March 24	\$ 10	\$ _____

SHORT COURSES

Hydrogeochemistry	Sat., March 20	Professional \$ 70	Student \$ 35	\$ _____
Kriging	Sun., March 21	Professional \$ 70	Student \$ 35	\$ _____
Cathodoluminescence in Sedimentary Petrology	Sun., March 21	Professional \$ 70	Student \$ 35	\$ _____
Systems Dynamics in Geology, Water Resources, and Life Sciences	Sun., March 21	Professional \$ 70	Student \$ 35	\$ _____

SPECIAL EVENTS

Welcoming Reception	Sun., March 21	FREE	\$ _____
Combined Eastern Section and New England Section of NAGT Business Meeting and Luncheon	Mon., March 22	\$ 15	\$ _____
Public Forum: "The Crisis in Science Education: Ramifications for Geology"	Mon., March 22	FREE	\$ _____
Eastern Section of SEPM Annual Business Meeting—Presidential Address by Harry Cook	Mon., March 22	FREE	\$ _____
Public Forum: "Ground-Water Contamination: Does Public Policy ignore Science?" 7:00 p.m.	Mon., March 22	FREE	\$ _____
Association for Women Geoscientists Breakfast, 7:00 a.m.	Tues., March 23	\$ 10	\$ _____
Northeastern Section of Paleontological Society Luncheon, 12:00 noon	Tues., March 23	\$ 15	\$ _____
28th Annual GSA Northeastern Section Reception and Banquet, after-dinner talk by President James McLelland, "Island Arcs, Anorthosites and Himalayan Mountain Ranges: The Mid- to Late Proterozoic Evolution of Northeastern North America"	Tues., March 23		
Dinner choices for banquet (Indicate choice when preregistering):			
Prime rib of beef au jus, baked potato, seasonal vegetables		\$ 27	\$ _____
Chicken St. Jean, rice, seasonal vegetables		\$ 23	\$ _____
Pasta primavera		\$ 23	\$ _____

TOTAL FEES

..... \$ _____

MAIL TO: Rolfe Stanley
Perkins Hall, Department of Geology
University of Vermont
Burlington, VT 05405-0211
(802) 656-0247

Check events you or your spouse/guest are interested in:
 Skiing 3/20 Skiing 3/21 Skating* 3/22
 Ice Hockey* 3/23 Fun Run 3/24
 *Only if enough interest is expressed.

Transportation for this trip will be by private car. Participants will convene in Proctor, Vermont, at the Vermont Marble Exhibit parking lot (unpaved part) located on the east side of Main Street (west off Rt. 3, over the Marble Bridge) at 8:45 a.m. The field trip will make a lunch stop, but lunches are not provided. Cost: \$12. No limit. Registration-cancellation deadline: March 15.

Participants on this trip will see Lower Cretaceous alkalic igneous rocks that intrude the northern Taconics of western Vermont and adjacent New York. Field stops include small bostonite and camptonite dikes near Rutland, Vermont; sulfide-rich quartz syenite at Cuttingsville; a spectacular intrusive breccia of basement rocks at Shrewsbury; and the massive Lake Bomoseen basaltic dike, which exceeds 100 m across its unusual lens shape. Discussions will include (1) the petrologic and intrusional features that distinguish these intrusions, (2) the stress fields and tectonic regime that existed at the time of intrusion, and (3) the genetic relations between these intrusions and others in the New England-Quebec igneous province.

2. The Crown Point Section, Crown Point, New York. Sunday, March 21, 9 a.m. to 5 p.m. Lucy E. Harding, Dept. Geology, Middlebury College, Middlebury, VT 05753, (802) 388-3711, ext. 5444 (work) or 388-3934 (home). Cost: \$32. Limit: 30. Registration-Cancellation deadline: March 8.

A classic sequence of Middle Ordovician carbonates, beginning with the Chazy limestone and extending through the Orwell and Glens Falls limestones, is exposed at the Crown Point Historic site along the western shore of Lake Champlain. A nearly complete sequence of strata, displaying abundant fossils, sedimentary structures, and carbonate rock textures, outline changing sedimentary environments at the onset of the Taconic orogeny. This is a one-stop walking field trip over mostly level ground. No collecting is allowed at this site.

3. The Altona Flat Rock, Jack Pine Barrens: A Legacy of Fire and Ice. Sunday, March 21, 8:30 a.m. to 5 p.m. David Franz and Kenneth Adams, Center for Earth and Environmental Science, SUNY, College at Plattsburgh, Plattsburgh, NY 12901, (518) 564-4033. Cost: \$30. Limit: 25. Registration-Cancellation deadline: March 8.

Altona Flat Rock is the largest (~32 km²) of a discontinuous, 5-km-wide belt of bare sandstone areas that extend approximately 30 km southeastward into the Champlain Valley from Covey Hill, near Hemmingford, Quebec. Created by catastrophic floods from the drainage of glacial Lake Iroquois more than 12,000 years B.P., the exposed sandstone today provides habitat for one of the largest jack pine (*Pinus banksiana*) barrens in the eastern United States. Although born of ice, the relatively low diversity jack pine community is maintained by fire, which plays an important role in nutrient cycling. This field trip will address ongoing efforts to understand the link between the hydrology and ecology of the Jack Pine Barrens and will document the recent history of anthropogenic development in this unique ecosystem.

Half-day Trips

4. The Champlain Thrust Fault at Lone Rock Point. Sunday, March 21, 1 to 3:30 p.m., University of Vermont staff. Cost: \$10. Limit: 14.

This short field trip consists of

a 1.2 km walk to the shore of Lake Champlain to visit a classic exposure of the Champlain thrust fault. Along this shoreline cliff the Early Cambrian Dunham dolostone is thrust over the Middle Ordovician Iberville Formation—a stratigraphic throw of some 2700 m. The fault plane and deformational features within the Iberville Formation are beautifully exposed.

5. The Salmon Hole/Redstone Quarry. Monday, March 22, 1 to 3:30 p.m., University of Vermont staff. Cost: \$10. Limit: 14

The Salmon Hole and Redstone Quarry both present outstanding exposures of the Middle Cambrian Monkton Formation. This trip will focus on the wide variety of sedimentary structures and lithologies within the Monkton Formation and interpretations regarding the depositional environment along this part of the North American shelf. The provenance of sediments within the Monkton Formation and the history of shelf sedimentation in western Vermont will also be discussed.

6. The Champlain Thrust Fault at Lone Rock Point. Monday, March 22, 1 to 3:30 p.m., University of Vermont staff. Cost: \$10. Limit: 14. Repeat of Trip 4, above.

7. The Champlain Thrust Fault at Lone Rock Point. Tuesday, March 23, 1 to 3:30 p.m., University of Vermont staff. Cost: \$10. Limit: 14. Repeat of Trip 4, above.

8. The Salmon Hole/Redstone Quarry. Wednesday, March 24, 1 to 3:30 p.m., University of Vermont staff. Cost: \$10. Limit: 14. Repeat of Trip 5, above.

EXHIBITS

Exhibits will be located in the Champlain Room of the Sheraton Convention Center; snacks and refreshments will be continuously available for exhibit visitors. The cost of standard booths will be \$400 for commercial exhibitors and \$200 for educational or nonprofit groups or institutions. For further information and space reservations, contact Exhibits Coordinator David Bucke, Dept. Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0246, fax 802-656-0045.

PHOTO EXHIBIT

A photographic competition and exhibit will be held at this meeting. Entries will be judged on the basis of impact, content, composition, and overall presentation. Photographs will be exhibited during the entire meeting.

Northeastern Section Photo Contest Entry Form

Name _____
 Institution _____
 Address _____
 City _____ State _____ ZIP _____ Country _____
 Daytime phone () _____
 Description of photo: _____

Mail to: Richard Villamil, Dept. of Natural Science,
 Trinity College, Burlington, VT 05401

First, second, third, and honorable mention prizes will be awarded for color and black and white prints.

Guidelines: Photographs must be taken within the boundaries of the GSA Northeastern section. Photographs must be either color or black and white. Prints must be 8" x 10" or larger, firmly matted (with border), not to exceed 16" x 20". Your name, address, and telephone number must be on the back of each matte board. No more than three entries per photographer. Entries must be picked up from the display area between 8:00 a.m. and noon on Wednesday, March 24.

To enter, fill out the entry form above and send it with your photos to Richard Villamil, Dept. Natural Science, Trinity College, Burlington, VT 05401, (802) 879-7604 (home), (802) 658-0337, ext. 319 (work).

GSA will not be responsible for any damage or loss of photographs.

SPECIAL EVENTS

NAGT Two-Day Program for K-12 Earth Science Teachers. Sunday, March 21 and Monday, March 22.

We encourage all who are interested in K-12 education to attend. In order to attract a diverse range of talents and abilities we offer numerous options for attendees as participants and/or leaders. The program, which is cosponsored by the GSA SAGE program, begins with field trips and a welcoming reception on Sunday, March 21, 1993, and a full day of activities including oral and poster technical sessions, workshops, and demonstrations on Monday March 22, 1993. We urge all K-12 science teachers to attend any of the events that are of interest to you at special reduced rates (see Registration). Participants wishing to present a poster session, lead a demonstration, or run a workshop directed toward earth science

education on levels K-12 and/or those wishing to register for the full two-day NAGT event for one college credit must notify either of the following people to obtain further details and special registration materials: Leslie Kanat, Environmental and Health Sciences, Johnson State College, Johnson, VT 05656, (802) 635-2356, ext. 325, or Russell Agne, College of Education and Social Services, University of Vermont, Burlington, VT 05405-0160, (802) 656-3356.

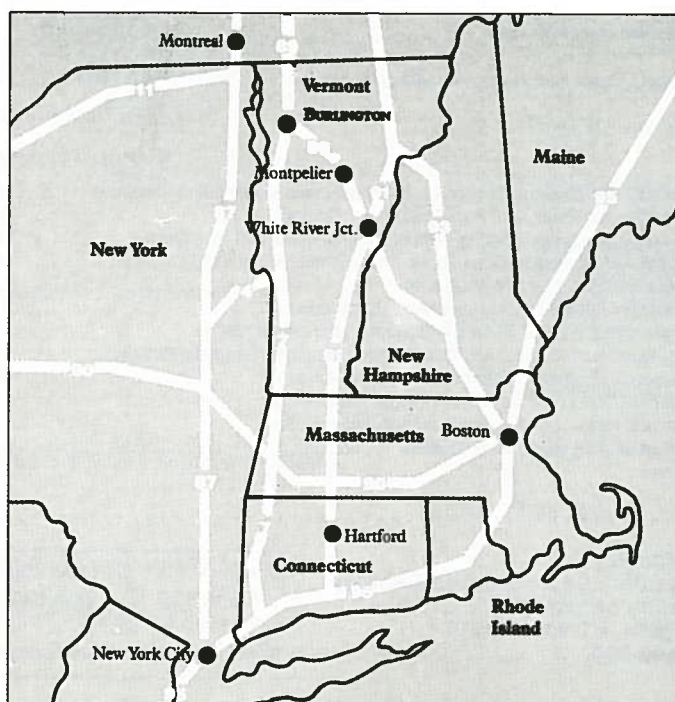
Saturday, March 20, 1993

Short Course. "Hydrogeochemistry" will be presented by John Tewhey from 8:00 a.m. until 5:00 p.m. in Kalkin 1 (UVM campus). Preregistration required (cost of registration includes lunch and short course notes). This course will be offered at a reduced rate when combined with one of the other short courses on Sunday, March 21. See Short Courses section for further details.

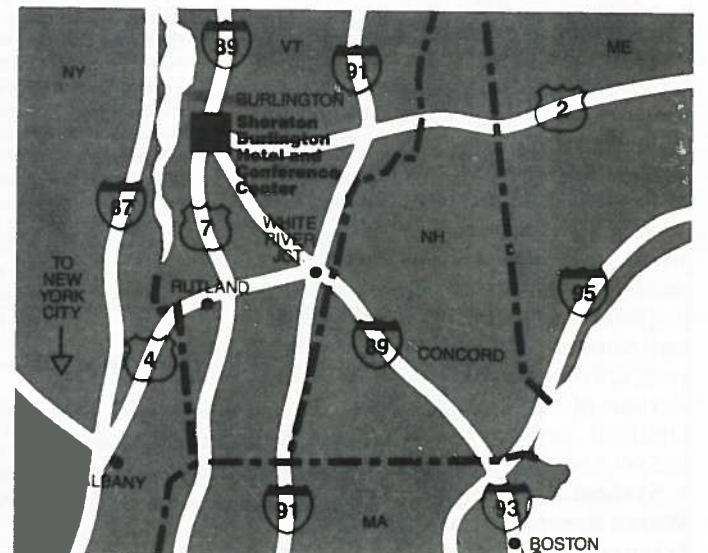
Spring Ski Weekend. Spring skiing will be offered at package discount rates (two days for \$33) at Bolton Valley Ski Area. Discounts will be available for both days or single days. A shuttle bus has been arranged to leave the Sheraton Hotel and Conference Center at 9:00 a.m. both Saturday and Sunday mornings. The shuttle will return to the Sheraton by 5:00 p.m. Discount rental packages will be available for those who don't want to bring their skis. Check off the box on the preregistration form to receive informational materials.

Sunday, March 21, 1993

Short Courses. Three short courses will be offered during the day: "Kriging," "Cathodoluminescence in Sedimentary Petrology," and "System Dynamics in Geology, Water Resources, and the Life Sciences." All begin at



Northeastern U.S. and Vermont



8:00 a.m. and conclude at 5:00 p.m. Preregistration required (cost of registration includes lunch and short course notes). See Short Course section for further details.

Spring Ski Day. See announcement for Saturday, March 20 (one day of skiing for \$17). Check off the box on the preregistration form to receive informational materials.

GSA Northeastern Section Management Board Meeting will be held from 4:30 to 6:00 p.m. in the Carleton Board Room.

Welcoming Reception. A welcoming reception will be held in the Grand Emerald Ballroom of the Sheraton Convention Center from 6:00 to 10:00 p.m. Liquid refreshment and hors d'oeuvres will be served. A cash bar will be available for mixed drinks. Institutional reunions will be held in the same area during the reception. Please contact Ron Parker at (802) 658-0820, fax 802-860-1014, to schedule a reunion. The exhibit hall will be open on the first floor of the convention center during the reception. NAGT will host a special exhibit booth in the Promenade.

Monday, March 22, 1993 Combined Eastern Section and New England Section of NAGT Business Meeting and Luncheon will be held in the Shelburne Room immediately following the NAGT Symposium "New Advances in the Earth Sciences" (12:00 noon to 1:15 p.m.). Please preregister for this event. Cost is \$15.

The NAGT and the Geological Society of America's SAGE (Science Awareness through Geoscience Education)

program will host a **Public Forum** as a wrap-up session immediately following the conclusion of the symposium. The topic of discussion will be "The Crisis in Science Education: Ramifications for Geology."

The **Eastern Section of SEPM** will hold its **Annual Business Meeting** immediately following the last oral presentation of the SEPM symposia. The program will include an address by the SEPM President Harry Cook. The meeting and Presidential address will be accompanied by a keg of refreshing liquid and is open to all.

A **Public Forum** will be held in Emerald III from 7:00 to 9:30 p.m. The topic discussed by panelists will be "Groundwater Contamination: Does Public Policy Ignore Science?" Featured panelists include Donald I. Siegel (Syracuse University), Gary Robbins (University of Connecticut), George Pinder (University of Vermont), and Michael Barcelona (Western Michigan University). Light refreshments will be available during the forum discussion. A reception with refreshing liquid, cash bar, and mellow jazz will immediately follow the panel discussion and will last until 11:30 p.m.

Attendees and guests are welcomed to attend an evening of **musical entertainment** which will be provided from 9:00 p.m. to midnight at Tuckaway's Lounge.

Tuesday, March 23, 1993 Association for Women Geoscientists Breakfast will be held in the Shelburne Room from 7:00 to 9:00 a.m. Please register for this event in advance when completing the preregistration form. Cost is \$10.

The **Northeastern Section of the Paleontological Society** will host a **luncheon** for members in the Shelburne Room from 12:00 noon until 1:15 p.m. Please register in advance for this function. Cost is \$15.

The local committee welcomes all interested participants and spectators to join in a brisk game of **Ice Hockey** to be held in Leddy Arena from 6:00 to 7:30 p.m. Transportation to and from Leddy Arena will be arranged. Please indicate on the preregistration form if you are interested in participating. Contact Ron Parker at (802) 658-0820 (days) for more information.

The **28th Annual GSA Northeastern Section Reception and Banquet** will be held from 7:00 to 9:00 p.m. in Emerald III. GSA Northeastern Section President James McLelland will present an after-dinner talk, "Island Arcs, Anorthosites and Himalayan Mountain Ranges: The Mid-to Late Proterozoic Evolution of Northeastern North America." The doors will be opened following the banquet in order that the presidential address may be heard by all.

Wednesday, March 24, 1993

A free, noncompetitive **5 kilometer fun run** will be held in the morning prior to the start of the technical sessions. The course will start at Burlington's waterfront park and will follow the scenic lakeshore to Leddy Park. Transportation will be provided for interested participants. Meet at 6:30 a.m. in front of the hotel main entrance canopy. Light refreshments will be provided to participants afterward.

HOUSING

A large block of rooms has been reserved for meeting participants and their guests at the **Burlington Sheraton Hotel and Conference Center**. The Sheraton has provided us with very attractive room rates, and we urge participants to take advantage of the offer. Parking is free and abundant next to the conference center. Shuttle service from the airport to the hotel will be provided by the Sheraton. For conference planning purposes and to insure guaranteed room rates, it is imperative that you reserve your room(s) before February 21, 1993. If you make telephone reservations it is important that you state you are attending the Northeastern Section GSA meeting in order for the Northeastern Section to receive credit against session room charges. **Mail the Housing Form directly to the hotel.**

Other accommodations within 5-10 minutes walking distance: Ramada Inn, (802) 658-0250; Holiday Inn, (802) 863-6363; Comfort Inn, (802) 865-3400.

TRANSPORTATION

The Sheraton Burlington Hotel and Conference Center is conveniently located at exit 14W off Highway I-89, which will be the major access to the Burlington area by car from southern New England or Quebec. Ample free parking for all guests of the hotel is provided. A major recent expansion of the Burlington International Airport makes this a first-class jetport served by United, USAir and Continental. Guests are 10 minutes from the airport with the hotel's own free shuttle service.

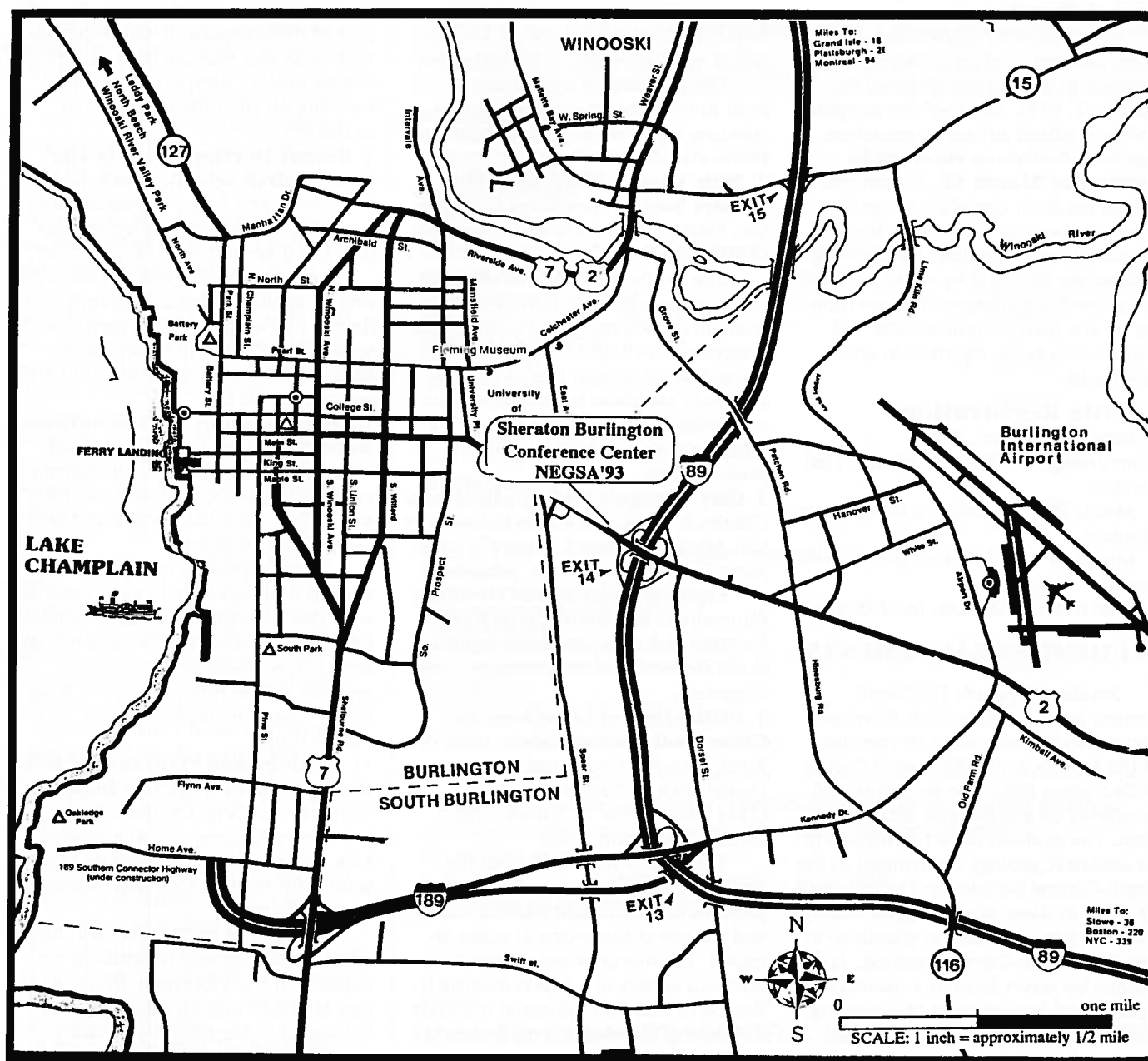
SCIENCE THEATER

A wide variety of scientific films of interest to K-12 science teachers, college professors and students, professionals and guests will be available for viewing throughout the meeting. The Science Theater will be set up in the Lake Champlain Exhibition Hall in video format. A complete listing of all films available for viewing will be included in the registration packet.

FURTHER INFORMATION

Questions and suggestions should be addressed to the appropriate chairs listed above. Other questions should be addressed to either Co-chair Barry Doolan or Co-chair Rolfe Stanley, Dept. Geology, University of Vermont, Burlington, VT 05401, (802) 656-0248, or (802) 656-0247, fax 802-656-0045. ■

Burlington Area Map



Stop and Visit
THE
**GSA
Mini
Bookstore**
at each of the
1993 GSA Section Meetings

NORTH-CENTRAL SECTION, GSA 26th Annual Meeting

Rolla, Missouri
March 29–30, 1993



The North-Central Section of the Geological Society of America will meet in Rolla at McNutt Hall at the University of Missouri–Rolla (UMR) campus. The meeting will be hosted by the UMR Department of Geology and Geophysics, the Missouri Geological Survey, Department of Natural Resources, the UMR Department of Geological Engineering, and the Rolla offices of the National Mapping and Water Resources Divisions of the U.S. Geological Survey. Several associated societies will be meeting in conjunction with the GSA North-Central Section: the International Geological Correlation Programme Project 315 (Correlation of Rapakivi Granites and Related Rocks on a Global Scale), the Pander Society, the North-Central Section of the Paleontological Society, the Central Section of the National Association of Geology Teachers, the Great Lakes Section of SEPM (Society for Sedimentary Geology), Region 2 of the National Earth Science Teachers Association, and the Louis Infer Mid-Mississippi Valley Region group.

TRAVEL ARRANGEMENTS

Rolla and the University of Missouri–Rolla are easily accessible by automobile via Interstate 44 and Highway 63. McNutt Hall is located at the corner of Highway 63/72 and 14th Street at the northwest corner of the University of Missouri–Rolla. Motels are available along Interstate 44, Highway 63, City Route 44, and Martin Spring Drive. Rolla also can be reached by commercial airplane to the St. Louis Lambert Airport and then by Greyhound bus from the airport to Rolla, a distance 110 miles west.

Transportation and Parking

No shuttle vehicles will be provided between motels and the McNutt Hall conference center. Motels at exit 186 are about 15 minutes walk from McNutt; it is suggested that individuals without transportation stay at those motels and make their reservations early. Motels on Martin Springs Drive are within moderate to fairly long walking distance (30 plus minutes walk) from McNutt; it is suggested that individuals with transportation stay at these motels, leaving the closer ones for people lacking transportation.

Free parking for the conference will be in the University Parking lots immediately south of McNutt Hall (lot 13) and a short distance west of McNutt Hall (lot 9). Overflow parking may use lot 7 on the south side of lot 13 (opposite 12th street at Highway 63–Taco Bell). Do not use the Bureau of Mines parking lot (narrow strip between lots 13 and 7, east of five-story brick building).

REGISTRATION

Registration is required for all who participate in any event at the meeting, including technical sessions, symposia, exhibits, planned social events, and field trips.

PREREGISTRATION deadline is March 5, 1993.

Advance registration is encouraged to aid the local committee in making the final plans for the meeting. A pre-registration discount is available to those who register using the registration form provided in this announcement. Advance registration is required for those who plan to attend a field trip. Return the completed registration form with full payment (purchase orders NOT accepted) to the GSA North-Central Section, P.O. Box 9140, Boulder, CO 80301-9140. Late registration will be charged at the on-site rate.

Register one professional or student per form. Copy the form for your records.

Guest registration is required for those attending guest activities. Guest registrants MUST be accompanied by either a registered professional or a student. A guest is defined as a nongeologist spouse or friend of a professional or student registrant.

Charge cards are accepted as indicated on the preregistration form. If using a charge card, please recheck the card number given—errors will delay your registration. The confirmation received from GSA will be your receipt for charge card payments. No other receipt will be sent.

Badges must be worn for all activities Sunday, March 28, through Tuesday, March 30.

Cancellations, Changes, and Refunds

All requests for registration additions, changes, and cancellations must be made in writing and received by March 12, 1993. Faxes will be accepted. GSA will refund advance registration fees for cancellations received in writing by March 12. NO refunds will be made on cancellation notices received after this date. Refunds will be mailed from GSA after the meeting. Refunds for fees paid by credit card will be credited according to the card number on the preregistration form. NO refunds for on-site registration and ticket sales.

On-Site Registration

University of Missouri, Rolla,
Miner Lounge, 2nd Floor, Centennial Hall
Sunday,
March 28 5:00 p.m. to 9:00 p.m.
Monday,
March 29 7:30 a.m. to 5:00 p.m.
Tuesday,
March 30 7:30 a.m. to 12:00 noon

STUDENT ARRANGEMENTS

Student Travel. The North-Central Section will provide travel assistance to students who are members of the North-Central Section of GSA as of December 1992. The assistance will be offered on a first-come, first-served basis. The students must be enrolled in an academic geology department in the North-Central Section, and priority will be given to those presenting an oral or poster paper (as author or coauthor) at the 1993 North-Central meeting. Applications for travel assistance awards may be obtained by writing to the meeting chairman, Richard D. Hagni, Department of Geology and Geophysics,

125 McNutt Hall, University of Missouri–Rolla, Rolla, MO 65401. Applications must be received by January 7, 1993.

Student Paper Awards. The North-Central Section of GSA will award \$50 for each of the eight best papers (oral or poster) whose principal author and presenter is a graduate or undergraduate student. Abstracts submitted for these awards should be clearly indicated. Also, the SEPM Great Lakes Section will award \$50, a certificate, and an SEPM publication to the best student paper in the fields of stratigraphy, sedimentation, and paleontology.

TECHNICAL PROGRAM

Technical sessions are scheduled as oral and poster presentations on Monday, March 29, and Tuesday, March 30. The meeting will present technical symposia on several topics and will continue the North-Central Section tradition of presenting symposia for consultants, to provide an opportunity to share new ideas and developments with other consultants, other geologists, and geology students. The meeting also will continue the tradition of including an aspect dedicated to educators in geology; this year the focus will be a premeeting field conference on historical and physical geology (field trip 1). All 1993 North-Central GSA symposia are listed and described below. Volunteered papers are invited for all of these symposia and for additional general sessions.

SYMPOSIA

The following symposia will include both invited and volunteered papers. Interested potential speakers are encouraged to contact the individual symposia organizers for further information.

1. Midcontinent Carbonate: Depositional Systems and Diagenesis. *Cosponsored by Great Lakes Section of SEPM.* Jay M. Gregg, University of Missouri–Rolla, (314) 341-4664.

The symposium will consist of both invited and volunteered papers covering topics in carbonate sedimentation and diagenesis.

2. 26th Annual Meeting of the Pander Society. Raymond L. Ethington, University of Missouri—Columbia, (314) 882-6470.

The Pander Society is an international organization dedicated to the study of conodonts. Participants in the symposium will discuss their current research dealing with these Paleozoic and early Mesozoic fossils. Reports on taxonomy and on applied uses of conodonts are welcome, as are student presentations.

3. Clay Minerals and Applications. Charles E. Stack, A.P. Green Refractories Co., Mexico, Missouri, (314) 473-3302; James F. Westcott, Mexico, Missouri.

Expected topics include chemistry, mineralogy, and analytical methods for clays and soils, industrial applications, depositional environments, and diagenesis.

4. Utilization of Limestone in Clean Coal Technologies. Ardel W. Rueff, Missouri Geological Survey, Department of Natural Resources, (314) 368-2139; A. C. Spreng, University of Missouri–Rolla.

This symposium will cover the issues of clean coal technologies, comparisons of eastern and western coals, and the use of limestone in sulfur removal. The intent of the session is to discuss a variety of subjects relating to the use of coal and industrial minerals in meeting the energy requirements of the Midwest.

5. Crustal Genesis Processes on Terrestrial Planets and Moons. Raymond E. Arvidson and Mohamed I. Sultan, Washington University, St. Louis, Missouri, (314) 935-5652.

Using a comparative planetology approach, speakers will address aspects of crustal genesis on Earth and its moon, Venus, and the icy moons of outer planets.

6. Pennsylvanian History of Ozark Uplift. Wallace B. Howe and Thomas L. Thompson, Missouri Geological Survey, Department of Natural Resources, (314) 364-1669.

Invited participants will update traditional perceptions and advance new concepts of the Pennsylvanian increment of the evolution of this large and long-lived feature. Discussion will include analysis of the region's history as reflected in contiguous basinal areas; current concepts of Ozark uplift definition and that of its principal elements; and identification of significant questions, problems, and issues. Individual papers will address many of the key topics within the broad spectrum of factors that determined the distribution and character of Pennsylvanian strata in the Ozark region.

7. Educators Symposium. Robert C. Laudon and Marian Smith, Western Michigan University, (616) 383-1775.

In this symposium we will discuss aspects of geology that are important to earth science and geology teachers in K–12 and colleges. All educational aspects of geology will be involved.

8. Petroleum and Mineral Exploration of the Midcontinent Rift Zone. Pieter Berendsen, Kansas Geological Survey, (913) 864-3965; Albert B. Dickas, University of Wisconsin—Superior.

Geologic, geochemical, and geophysical studies of Proterozoic and younger igneous, metamorphic, and sedimentary rocks contribute significantly to our understanding of the development and subsequent history of the Midcontinent Rift System. The intent of the symposium will be to present ideas and relevant data of rift studies and to interpret the results focusing on the mineral potential of the rift.

9. Recent Developments in the New Madrid Seismic Zone. James D. Vaughn and James R. Palmer, Missouri Geological Survey, Department of Natural Resources, (314) 368-2185.

Participants will present results of diverse geological studies recently conducted in the New Madrid earthquake region. Emphasis will be on late Tertiary and Quaternary deformation and associated effects.

10. Hydrogeology of Midcontinent Karst Terranes. Jerry D. Vineyard, Missouri Geological Survey, Department of Natural Resources, (314) 368-2190; Kenneth C. Thomson, Southwest Missouri State University.

The symposium will focus on applied hydrogeology in karst terranes, with special emphasis on environmental aspects, including ground-water and spring-flow characteristics, terrane analysis, geomorphic evolution, innovative experimental techniques, and related topics.

11. Geology and Structure of Mississippi Valley-type Ore Deposits. Norman Paarlberg, Doe Run Co., Viburnum, Missouri, (314) 626-4855; Rick Dingess, ASARCO, Bunker, Missouri; Milt Bradley, Cominco American, Bixby, Missouri.

Symposium participants will discuss the geology and structure of ore deposits in the Viburnum Trend, south-east Missouri, and on other deposits belonging to the Mississippi Valley type. The focus will be upon structural

controls that determine the loci of economic ore deposits.

12. Mineralogy and Geochemistry of Mississippi Valley-type Ore Deposits. Kevin L. Shelton, University of Missouri—Columbia, (314) 882-6568; Richard D. Hagni, University of Missouri—Rolla.

This symposium will consider a wide variety of new geochemical and mineralogical research on Mississippi Valley-type (MVT) ore deposits. Possible topics include studies of entire mineral districts, individual mines, metal source rocks, and geochemical studies of rocks affected by the passage of MVT fluids.

13. Olympic Dam-type Deposits in the Midcontinent: Research and Exploration. Eva B. Kisvarsanyi, Missouri Geology Survey, Department of Natural Resources, (314) 368-2146; Warren C. Day, USGS, Denver.

The symposium will review progress of research conducted during the past five years on mineralization in the Middle Proterozoic granite-rhyolite terranes of the region, compare Paleozoic and Proterozoic iron-apatite deposits, present recent developments on the Olympic Dam deposit, and address changes in exploration concepts pertaining to this group of ore deposits.

14. Consultant's Symposium: Interdisciplinary Environmental Consulting. John D. Rockaway, University of Missouri—Rolla, (314) 341-4799; Jeffrey D. Cawfield, University of Missouri—Rolla.

Participants will discuss environmental projects integrating geology with engineering and other sciences. Environmental projects may include hazardous material remediations, land-fill sitings, hydrology, wetland delineation, and geoarcheology.

15. Hazardous and Low-level Nuclear Waste. Dale C. Elifrits, University of Missouri—Rolla, (314) 341-4847; David J. Barr, University of Missouri—Rolla.

This symposium will provide an opportunity to examine the impact of geologic conditions on past disposal sites for hazardous waste. Additionally, site characterization and remediation will be addressed. Evaluation techniques for sites for use in future disposal operations will be examined.

16. Geologic Site Characterization: Essential to Waste Facility Siting and Remediation. Allen W. Hatheway, University of Missouri—Rolla, (314) 341-4777; Richard A. Nussbaum and Bruce Stuart, Department of Natural Resources—Waste Management Program, Jefferson City, Missouri.

Never before has there been such a demand on geologists in site exploration as the present-day efforts to characterize sites for waste management and cleanup. Far more attention is given to small-area and near-surface detail, in terms of lithologic, stratigraphic, structural, and geomorphic interpretation, than for any other form of applied geology. Practitioners have been invited to divulge and discuss successes and problems encountered in site characterization.

17. Agricultural Chemicals and Their Effects on Ground Water. James H. Barks, USGS, Rolla (314) 341-0827; Marvin G. Sherrill, USGS, Rolla.

This symposium will focus on the movement and fate of agricultural pesticides and nitrate in soils and ground water. Results of recent studies at U.S. Department of Agriculture Management Systems Evaluation Areas and other studies in the midcontinent region will be reported.

18. New Automated Techniques for Topographic and Geologic

Map-Making. Michael J. Starbuck, USGS, Rolla, (314) 341-0847.

Participants will discuss new and innovative techniques for the production of topographic and geologic maps. Topics will include the use of computerized work stations and digital technology in the automation of the map-making process and the use of advanced software to perform sophisticated map editing and graphic production.

19. Geographical Information Systems. Michael J. Starbuck, USGS, Rolla, (314) 341-0847.

Participants will discuss new developments in the use of geographic information systems, especially as they relate to the solving of geology-related problems. Topics will include the development of project databases, methods of geographic analysis, and how various forms of remotely sensed data may be incorporated into the analysis.

20. Applied Mineralogy. Richard D. Hagni, University of Missouri—Rolla, (314) 341-4616; David G. C. Robertson

and Robert E. Moore, University of Missouri—Rolla.

This symposium will consider the application of mineralogical techniques to various industrial problems, including applications to beneficiation and to pyrometallurgical and ceramic products and problems.

21. Paleontological Perspectives on Global Change. Roy E. Plotnick, University of Illinois, Chicago, (312) 996-2111.

Paleontology provides the only long-term record of the biotic consequences of global environmental change. The goals of this symposium are to bring this unique perspective to the attention of the wider scientific community and to encourage paleontological research into this area of vital human interest.

THEME SESSIONS

Theme sessions are composed entirely of volunteered papers. Partici-

pants are encouraged to submit papers for the following sessions:

22. Coalbed Methane Resources in Sedimentary Basins. Joy Bostic, Missouri Geological Survey, Department of Natural Resources, (314) 368-2156.

This session will focus on exploration and development techniques utilized by industry and government agencies to delineate and quantify coalbed methane resources and reserves in geologic basins. Of particular interest will be techniques utilized in basins where data on the quality, thickness, and lateral persistence of the coal resources are limited.

23. Second Unfer Conference on the Geology of the Mississippi Valley Region. Gary R. Lowell, Southeast Missouri State University, (314) 651-2351; C. W. Clendenin, Salem, Missouri.

The intent of this theme session is to promote exchange of ideas among

North-Central continued on p. 278

Preregistration Form

GSA North-Central Section
Rolla, Missouri • March 29–30, 1993

Preregistration deadline is March 5, 1993.

Please print clearly • THIS AREA IS FOR YOUR BADGE

Name as it should appear on your badge _____

Employer/University Affiliation _____

City _____ State or Country _____

() Business Phone _____

() fax _____

() Home Phone _____

Mailing Address (use two lines if necessary) _____

City _____ State _____ ZIP Code _____ Country (if other than USA) _____

Please indicate if you will need services to accommodate a disability:
 Yes No

Circle member affiliation (to qualify for registration discount): (A) GSA Member # _____ (B) NAGT (C) PS (D) NESTA (E) SEPM

GUEST INFORMATION • Please print clearly • This area is for badge

Name as it should appear on your badge _____ City/State or Country _____

		Qty	Amount
GSA Member, Professional	(01) \$ 40	<input type="checkbox"/> 1	\$
Nonmember Professional	(02) \$ 45	<input type="checkbox"/> 1	\$
GSA Student Associate	(05) \$ 10	<input type="checkbox"/> 1	\$
Nonmember Student	(06) \$ 15	<input type="checkbox"/> 1	\$
Teacher (K-12)	(42) \$ 10	<input type="checkbox"/> 1	\$
Spouse/Guest	(09) \$ 5	<input type="checkbox"/>	\$
Abstracts with Programs (reserved, pick up at registration table)	(302) \$ 10	<input type="checkbox"/>	\$

		Qty	Amount
Tour of Maramec Spring Park	(20) \$ 6	<input type="checkbox"/>	\$
Tour of Historic Hermann, Missouri	(21) \$ 22	<input type="checkbox"/>	\$

		Qty	Amount
Annual Banquet	(56) \$ 25	<input type="checkbox"/>	\$
Combined Paleo Society, Pander Society, and Great Lakes SEPM Luncheon	(60) \$ 15	<input type="checkbox"/>	\$
NAGT and GSA N-C Section Education Committee Luncheon	(61) \$ 15	<input type="checkbox"/>	\$
GSA Campus Representatives Breakfast	(62) FREE	<input type="checkbox"/>	\$

		Qty	Amount
Precambrian Core Workshop	(63) \$ 5	<input type="checkbox"/>	\$
Automated Mapping Workshop	(64) \$ 5	<input type="checkbox"/>	\$

		Qty	Amount
FIELD TRIPS (meeting registration required)			
Premeeting			
1 Field Conference, K-12 Teachers	(100) \$ 45	<input type="checkbox"/> 1	\$
2 Environmental Aspects of Mining	(101) \$ 45	<input type="checkbox"/> 1	\$
During meeting			
3a Mid-Continent Mapping Center, USGS	(102) \$ 5	<input type="checkbox"/> 1	\$
3b Mid-Continent Mapping Center, USGS	(103) \$ 5	<input type="checkbox"/> 1	\$
Postmeeting			
4 Geohydrology and Waste Disposal	(104) \$ 55	<input type="checkbox"/> 1	\$
5 Viburnum Trend Lead-Zinc Deposits	(105) \$ 55	<input type="checkbox"/> 1	\$
6 IGCP—Rapakivi Granites and Related Rocks	(106) \$300	<input type="checkbox"/> 1	\$

TOTAL FEES \$

Remit in U.S. funds payable to: 1993 GSA South-Central Section Meeting

(All preregistrations must be prepaid. Purchase Orders not accepted.)

Payment by (check one):

- Check American Express VISA
 Diners Club/Carte Blanche MasterCard

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MAIL TO: GSA NORTH-CENTRAL SECTION MEETING, P.O. BOX 9140, BOULDER, CO 80301

midcontinent researchers. The theme of the session will be stratigraphy, structure, and fluid migration in the midcontinent.

EQUIPMENT AND FACILITIES FOR PRESENTATIONS

Oral Presentations

All slides used in oral presentations must be 2" x 2" and fit in a standard 35 mm carousel projector. Only one projector, screen, and pointer will be available in each meeting room. Please bring your own loaded carousel tray, identified with your name, session, and speaker number, to the appropriate session projectionist 15 minutes prior to the beginning of the session. A speaker ready room equipped with projectors will be available for review and practice. Carousel trays will not be available. Any questions or special requests should be

A geological guidebook of I-44 from the Oklahoma border to the Illinois border will be available for meeting attendees to use along the way either to or from the meeting site. You may purchase the book at the meeting, or call the MGS-DNR—Rolla, (314) 368-2150. The book will be shipped to you in February 1993.

directed to Kerry Grant, Department of Geology and Geophysics, University of Missouri—Rolla, (314) 341-4618.

Poster Presentations

Poster sessions will be housed in and near the second-floor Commons Area of McNutt Hall, and will be available for viewing for one-half day. Poster booths will consist of three 4' x 4' display panels set on tables: tacks and masking tape will be provided. Any questions or special requests should be directed to Kerry Grant, Department of Geology and Geophysics, University of Missouri—Rolla, (314) 341-4618.

SOUND EQUIPMENT AND SMOKING POLICY

Annual meeting policy prohibits the use of cameras or sound-recording equipment at technical sessions. A no-smoking policy has been adopted by the Program Committee in conjunction with the University of Missouri—Rolla and will be followed in all rooms at the university.

FIELD TRIPS

Registration. Field trip registrants must register for the meeting. Registration procedures, deadlines, and forms are provided in this announcement. Registration at the meeting for the postmeeting field trips may be possible if trip logistics and space permit. If trips are under-enrolled and a trip must be canceled, participants will be notified no later than ten days before

the start of the meeting, and all registration fees will be refunded. There will be no refunds if participants fail to show on time. Sponsoring agencies assume no liability whatsoever for failure of participants to show for a trip, for missed connections, or for injury, loss or damage during or resulting from participation in the field trips. Because the number of participants in most field trips will be limited, you should get your registration in as soon as possible to ensure a seat. Further information, if required, will be sent to trip participants. Field trip coordinator is Keith Wedge, Missouri Geological Survey, Department of Natural Resources, (314) 368-2141.

Premeeting

1. Field Conference for K-12 Teachers: Evolution of the Ozark Region of Missouri: Historical and Physical Geology. Jay M. Gregg, University of Missouri—Rolla, (314) 341-4664. March 28, 1992.

This field conference will involve premeeting discussions and visits to points of geological interest in the Ozark region of Missouri. Topics covered will include historical geology, sedimentary rocks, igneous rocks, structural geology, economic geology, and environmental geology. The field conference will be designed especially for K-12 educators. An educational background in geology will not be necessary for teacher participation. Cost: \$45, includes transportation, lunch, and guidebook.

2. Environmental Aspects of Mining in Eastern Missouri. James C. Brown, Jr., Missouri Geological Survey, Department of Natural Resources, (314) 368-2130. March 28, 1992.

Participants will visit several mining districts in the Big Springs region. The trip will include examples of iron, barite, lead, granite, and clay mines. Some properties are abandoned (inactive) and may be included in future reclamation efforts. Some properties are active and have plans to address environmental effects on hydrology and ecology of the area. Cost: \$45, includes lunch and refreshments.

During Meeting (March 29 or 30, 1993)

3. Mid-Continent Mapping Center, USGS, Rolla. Michael J. Starbuck, USGS, Rolla, (314) 341-0847.

Tours of the U.S. Geological Survey Mid-Continent Mapping Center will be scheduled at various times during the day on Monday and Tuesday, March 29 and 30. Cost: \$5, includes transportation and handout materials.

Postmeeting

4. Geohydrology and Waste Disposal in Eastern Missouri. Bill Duley, Missouri Geological Survey, Department of Natural Resources, (314) 368-2163; Mike Kleeschulte, USGS, Rolla. March 31, 1992.

We will visit Times Beach and other "famous" dioxin and hazardous waste sites of eastern Missouri, focusing on geohydrologic issues pertinent to

MOTELS PROVIDING SPECIAL NORTH-CENTRAL GSA RESERVATIONS (*)

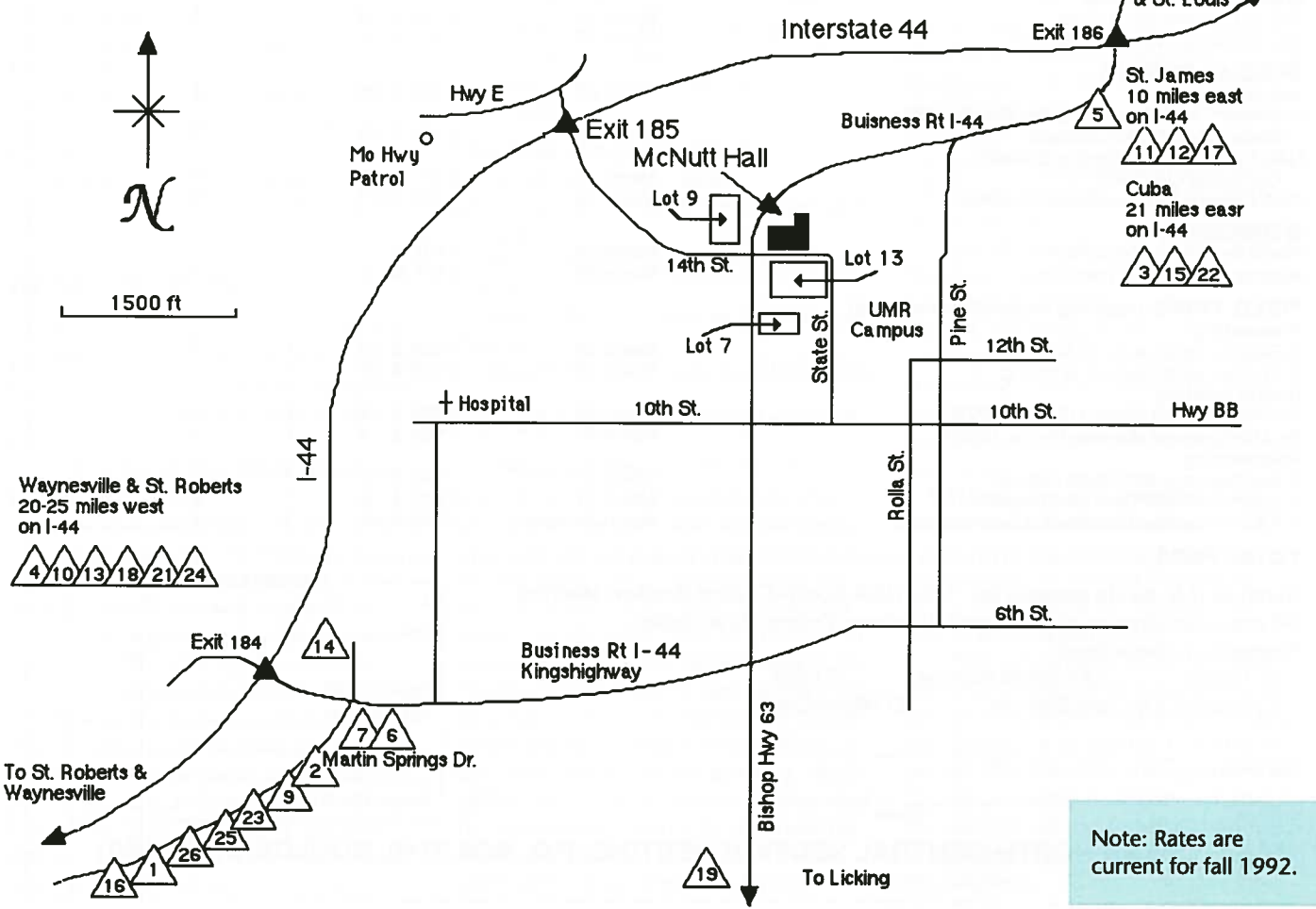
Rooms not taken by GSA participants will be released no later than February 28, 1993. Please identify yourselves as Geological Society registrants.

Motels in Rolla and Nearby Towns (numbers keyed to map)

- *1. Bestway Inn \$15-20
1631 Martin Springs Drive, Rolla, MO 65401, (314) 341-2158
- *2. Best Western Coachlight Inn ... \$35-40
1403 Martin Springs Drive, P.O. Box 826, Rolla, MO 65401, (314) 341-2511
- 3. Best Western Cuba Inn \$30-35
I-44 & Hwy 19, Rt. 2, Box 2983, Cuba, MO 65453, (314) 885-7707
- *4. Best Western Montis Inn \$35-40
I-44 & Hwy 28, HC 2, Box 97, St. Robert, MO 65583, (314) 336-4299
- 5. Budget Deluxe Inn \$20-25
1908 N. Bishop, Rolla, MO 65401, (314) 364-4488
- 6. Chalet Motel \$20-25
1201 Kingshighway, Rolla, MO 65401, (314) 364-4156
- 7. Daystop-Rolla Inn \$30-35
1207 Kingshighway, Rolla, MO 65401, (314) 341-3700
- *8. Drury Inns \$35-45
I-44 & Hwy 63, P.O. Box 130, Rolla, MO 65401, (314) 364-4000
- *9. EconoLodge \$30-35
1417 Martin Springs Drive, Rolla, MO 65401, (314) 341-3130
- *10. Family Inn Motel \$20-25
RR 2, Box 180 B, Waynesville, MO 65583, (314) 336-3285
- 11. Finn's Motel \$20-25
I-44 & Hwy 68, St. James, MO 65559, (314) 265-7200
- 12. Forest City Motor Lodge \$25-30
I-44 & Hwy 68, St. James, MO 65559, (314) 265-3256
- 13. Hi-Way Motel \$15-20
RR 2, Box 59, St. Robert, MO 65583, (314) 336-4114
- *14. Howard Johnson Lodge \$30-35
127 HJ Drive, I-44 & Business Route 44, Rolla, MO 65401, (314) 364-7111
- 15. Midway Motel \$20-25
107 N. Franklin, Cuba, MO 65453, (314) 885-7421
- 16. National 9 Inn \$20-25
1701 Martin Springs Drive, Rolla, MO 65401, (314) 364-7977
- 17. Ozark Motel \$20-25
Rt 3, Box 3007, St. James, MO 65559, (314) 265-8809
- *18. Ramada Inn \$45-50
I-44 Fort Wood Spur, P.O. Box L, Waynesville, MO 65583, (314) 336-3121
- 19. Rustic Motel \$25-30
812 S. Bishop, Rolla, MO 65401, (314) 364-6943, 1-800-458-9279
- 20. Sooter Inn \$15-20
Rt 5, Box 735, Hwy 63 North, Rolla, MO 65401, (314) 364-1333
- 21. Village Inn Motel \$30-35
I-44 Fort Wood Spur, Rt 6, Box 46, Waynesville, MO 65583, (314) 336-5115
- 22. Wagon Wheel Motel \$15-20
901 E. Washington, Cuba, MO 65453, (314) 885-3411
- *23. Wayfarer Inn \$20-25
1505 Martin Springs Drive, Rolla, MO 65401, (314) 364-3333
- 24. Waynesville Super 8 Motel \$35-40
I-44 & Hwy 28, P.O. Box 157, Waynesville, MO 65583, (314) 336-3036
- 25. Western Inn \$20-25
1605 Martin Springs Drive, Rolla, MO 65401, (314) 341-3050
- *26. Zeno's Motel \$25-30
Martin Springs Drive, I-44 West, P.O. Box 70, Rolla, MO 65401, (314) 364-1301

Note: Rates are current for fall 1992.

ROLLA, MISSOURI



cleanup, storage, and treatment. The karst aquifers of this region will be discussed, along with the impact of other hazardous waste sites on ground-water quality. We will also tour a commercial cave and discuss the potential impact of hazardous waste on water quality in the cave stream. Cost: \$55, includes lunch, refreshments, and cave tour.

5. Viburnum Trend Lead-Zinc Deposits (Underground Tour) and Ozark Region Carbonate Depositional Environment. Richard D. Hagni, University of Missouri—Rolla, (314) 341-4616; Jay M. Gregg, University of Missouri—Rolla. March 31, 1992 (early morning departure).

Participants will visit underground in one of the operating mines in the Viburnum Trend, the world's largest lead-producing district and a very significant producer of zinc, copper, and silver. The underground tour will focus upon the character of the sulfide mineralization, structural and stratigraphic controls for the ore deposits, and variations of ore types. The afternoon will be devoted to an examination of surface outcrops illustrating variations in the character of the Cambrian Bonnetterre Formation, host rock for the ore deposits. Cost: \$55, includes transportation, lunch, and guidebook.

6. IGCP Field Trip to the Rapakivi Granites and Related Rocks in the St. Francois Mountains. Eva B. Kisvarsanyi, Missouri Geological Survey, Department of Natural Resources, (314) 368-2146. March 31—April 2, 1992.

This field trip is designed primarily for International Geological Correlation Programme (IGCP) participants attending the IGCP Technical Sessions in conjunction with the GSA meeting in Rolla. We expect to accommodate all registrations; however, in case of over-subscription, IGCP members will receive preference. Cost: \$300, includes two nights' lodging, transportation, all meals.

CORE WORKSHOP

Precambrian Core Workshop.

Eva B. Kisvarsanyi and James R. Palmer, Missouri Geological Survey, Department of Natural Resources, (314) 368-2146, will host a drill-core workshop on Monday, March 29, to examine core from the Precambrian Boss-Bixby iron-copper-cobalt deposit and Cambrian carbonates. The focus will be on lithofacies and analysis of environments of deposition. Transportation to the McCracken Research facility will be by private car or van. Cost: \$5, includes handout materials.

MAP WORKSHOP

Automated Map-Making Techniques Workshop. Michael J. Starbuck, USGS, Rolla, (314) 341-0847, will host a workshop Tuesday, March 30, from 1:00 to 4:00 p.m. at the USGS Mid-Continent Mapping Center to focus on the use of USGS digital map data to produce new map products tailored to meet specific needs. Participants will be guided through an exercise in which they will use newly developed work stations to process digital cartographic data and generate high-quality map graphics. Cost: \$5, includes transportation and handout materials.

HOUSING

Motels in Rolla available to North-Central Section meeting attendees are located and listed on the accompanying map (p. 278). Ten of the motels (see list) will be providing special North-Central GSA reservations (rooms not taken by GSA participants will be released no

later than February 28). Please specify that you are attending the GSA meeting. Information on reservations at these and other motels is given with the maps. All reservations are on a first-come, first-served basis. We advise making motel room reservations early because motel capacity is limited in Rolla, and there will be another conference overlapping the North-Central Section meeting.

EXHIBITS

Space will be available for educational, research, and commercial exhibits. Exhibits will be located in a lockable room on the second floor of McNutt Hall near the meeting rooms and posters. A single booth is 10' x 10'; costs will be: Commercial Exhibitors—\$50; Nonprofit Exhibitors (educational and service organizations)—\$15 (\$30 if selling); Collective Commercial—\$20 (\$40 if materials need to be returned). For additional information on exhibits, contact Kerry Grant, Department of Geology and Geophysics, 125 McNutt Hall, University of Missouri—Rolla, Rolla, MO 65401, (314) 341-4616, fax 314-341-6935.

SPECIAL POSTER SESSION ON UNDERGRADUATE RESEARCH

The first annual undergraduate research poster session will be sponsored by the Council on Undergraduate Research. These papers are to be written and presented by undergraduate students on their research. Coauthored papers for which the student is senior author will also be considered. The session will form a separate poster session or be part of another poster session, depending on the response. Undergraduate students who have been involved in research are strongly urged to submit abstracts on their research projects, activities, techniques, and/or preliminary results for this session. Abstracts should be sent by *December 2, 1992*, to Robert D. Shuster, Dept. of Geography and Geology, University of Nebraska, Omaha, NE 68182-0199; additional information can be obtained by contacting him at (402) 554-2457 or fax 402-554-3518 or E-mail bshuster@cwis.unomaha.edu.

SPECIAL EVENTS

Welcoming Reception. A welcoming reception will be held for all registrants on the evening of Sunday, March 28, in the Miner Lounge on the second floor of Centennial Hall from 5:00 to 9:00 p.m. Preregistration is required.

GSA NORTH-CENTRAL SECTION MANAGEMENT BOARD BREAKFAST and business meeting will be held on Monday, March 29, at 7:00 a.m. in the Silver and Gold Room, Centennial Hall, University of Missouri—Rolla.

Great Lakes Section of SEPM, North-Central Section of Paleontological Society, and Pander Society will hold a joint luncheon on Monday, March 29, at 12:00 noon in the Meramec Room, Centennial Hall, University of Missouri—Rolla. Cost: \$15. Please preregister for this event.

The **North-Central GSA Campus Representatives** will hold a **breakfast** on Tuesday, March 30, in the Silver and Gold Room, Centennial Hall, University of Missouri—Rolla, at 7:00 a.m. Please preregister for this event.

On Tuesday, March 30, the **National Association of Geology Teachers and the GSA North-Central Section Education Committee**

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will hold a joint **luncheon** in the Silver and Gold Room, Centennial Hall, University of Missouri—Rolla, at 12:00 noon. Cost: \$15. Please preregister for this event.

The **UMR student C. L. Dake Association** will conduct a special rock and mineral **auction** on Sunday afternoon and evening. Everyone is invited to attend this enjoyable event beginning at 4:00 p.m. in the University Center.

ANNUAL BANQUET

The GSA North-Central Section Annual Banquet will be held on Monday, March 29, at 7:00 p.m. at Centennial Hall, University of Missouri—Rolla. After the banquet, a short business meeting will precede the banquet speaker, USGS Director Dallas L. Peck, who will speak on "Future Directions of the U.S. Geological Survey." He will discuss how the U.S. Geological Survey has evolved in response to both changing national needs and new technology, including an emphasis on developing and understanding the quality of the nation's ground and surface water because of growing concern about waste disposal, agricultural chemicals, and water pollution; the rapidly increasing use of geographic information systems that has led to the burgeoning demand for USGS digital map data; the continuing focus on programs to reduce losses from geologic hazards; increasing efforts in geologic mapping; and the great value of domestic and international partnerships with other federal and state agencies, industry, and academia in all USGS activities. The banquet will be preceded by a social hour scheduled to begin at 6:00 p.m. in the Miner Lounge, Centennial Hall. Cost: \$25. Please preregister for this event.

GUEST ACTIVITIES

The following tours have been organized for the guests and spouses of North-Central GSA meeting registrants.

Please preregister for the tours. These tours will be flexible and may be adjusted to encompass participant interest. Tour organizer is Art Hebrank, Missouri Geological Survey, Department of Natural Resources, (314) 368-2127.

- Tour of Maramec Spring Park,** March 29 (1:00 to 4:00 p.m.). This beautiful privately owned park, about 18 miles from Rolla, features Missouri's seventh largest spring (93 million gallons per day average) and a partially restored historic iron furnace and forge complex. Established in 1826, Maramec was the first economically successful iron works west of the Mississippi River. Cost: \$6, includes transportation and admissions to park and interpretive center.
- Tour of Historic Hermann, Missouri,** March 30 (8:00 a.m. to 4:00 p.m.). This quaint Missouri River town, founded in 1836, was the seat of early German immigration to Missouri. Participants will tour historic German residences, explore local antique shops, and visit Missouri's best known winery (before prohibition, the third largest in the world!). Cost: \$22, includes transportation about 65 miles each way, admissions, and lunch at the winery's German restaurant.

ADDITIONAL INFORMATION

For more information on program content, call Richard Hagni, Geology and Geophysics, University of Missouri—Rolla, (314) 341-4616, fax 314-341-6935, or 314-341-4192, E-mail on the BITNET 2 System: Geology2@UMRVMB.UMR.EDU; for registration call Kathy Ohmie Lynch, GSA Coordinator (303) 447-2020 or fax 303-447-0648. ■

New GSA Members

The following 400 Members were elected to membership by Council action during the period from February 1992 through September 1992 (* indicates transfer from Student Associate to Member).

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Pawel Aleksandrowski
*Rita J. Alexander
D. Mark Allamong
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Francisco M. Alonso-Chaves
Charles J. Ammon
Adrienne L. Amos
Steven Amter
*Sally I. Andersen
Charles J. Anderson, Jr.
Robin V. Anthony
Luis M. Rios Aragues
*Eric D. Arenberg
James L. Aronson
Lawrence J. Artman II
Andrew Y. Austin
Kevin M. Axe
*Jennifer C. Aydelotte
*L. Joseph Bachman
Eileen Bailiff
Cathy Baker
Robert E. Baker
*Edward M. Baltzer
*Istvan Barany, Jr. | *Marion M. Barber
James E. Barclay
David A. Barker
Rene A. Barker
N. Lajan Barnes
Stephen F. Barnett
G. Robert Barry
Karen S. Bartels
Richard B. Bascom
Hugo E. Bastias
*L. Darlene Batatian
Bruce D. Beale
P. A. Berge
*Barrie L. Bernstein-Taylor
*Peter E. Bittenbender
Thomas A. Black
Michael S. Blair
*Wouter Bleeker
*Roger B. Bloch
*David M. Bloom
*Stacy J. Bohannon
Cristy L. Brenner
Harry S. Brenton, Jr.
*Andrew L. Brill
Bruce M. Brown
Lewis M. Brown | Steven M. Bruer
Scott L. Brumagin
Bernhard Buehn
Robin L. Burgess
*Mohamed N. Bushara
John F. Busse
*Christopher S. Byerman
*Mary-Louise Byrne
*Garry W. Cannon
Vincent J. Carnegie
*Alan R. Carroll
*Brian L. Carter
Michael A. Chamberlain
John M. Chatoian
*Gail L. Chmura
Robert E. Choate
Kenneth W. Clark
Elizabeth K. Clonts
*Drew S. Coleman
Bruce C. Comstock
Curtis C. Conner
James C. Coogan
*Thomas F. Corbet
Robin C. Corzatt
June A. Cramer
*Robert G. Crisman | James K. Crouch
Russ D. Cunningham
*Melissa G. Cureton
*Alan H. Cutler
Gregory L. Cutshall
Douglas S. Cwienk
Michael C. Daly
Autje M.F. Danielson
*Cameron M. Davidson
Thomas E. Davis
*Mark W. de Wit
Michael D. DeAngelis
Linda M. Debrewer
Teri A. DeMaio
Shanaka L. DeSilva
*James P. Dixon
*Paul K. Doss
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Michael R. Dunaway
John L. Dwyer
Frederick C. Edmunds
*Stephen J. Edwards
James A. Eluskie
*Jean-Luc Epard
Thomas B. Ervin
*Levent L. Eskicakit
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Joseph P. Fagan, Jr.
*Billy E. Faggart, Jr.
Behnam Farahdel
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Carlos Fernandez-Rodriguez
Charles W. Fetter
Terry T. Fisk
Catherine A. Flack | *Frank P. Florence
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Vince W. Gaby
*Weera Galong
Juan Garcia Dobarganes-Bueno
Ian R. Garden
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Joe L. Hanna
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*Scott W. Hassler
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*Mahlon T. Hewitt III
*Glenn B. Hieshima
David V. Hill
Daiji Hirata
Donald W. Hladiuk
*Anthony R. Hoch
Roger K. Hoffmore
Steven M. Holland
A. Wayne Holt
Andreas Hoppe
*Andy Horn
*Lisa N. Hu
Dudley J. Hughes
Mark D. Hughston
*Donna Meyerhoff Hull
*Meer T. Husain
John H. Huston
Michael F. Infanger
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Pascal Jeanbourquin |
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New GSA Fellows

The following 12 Members were advanced to Fellowship in October 1992.

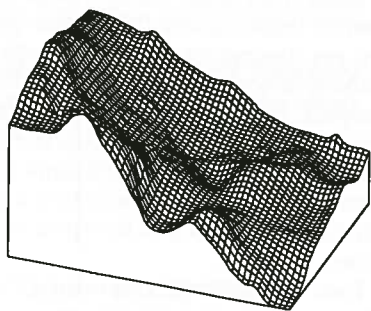
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New GSA Student Associates

The following 572 Student Associates became affiliated with the Society during the period from February 1992 through September 1992.

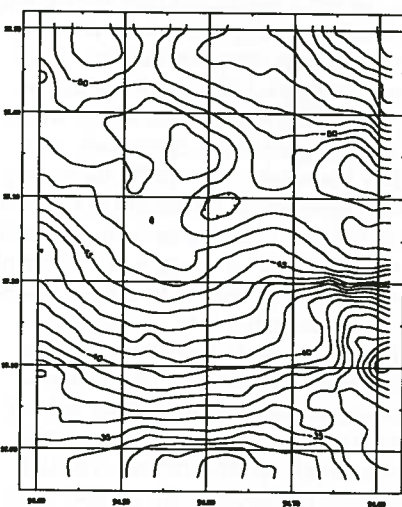
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Submit proposals to Technical Program Chairman: Heinrich D. Holland, Dept. of Earth & Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138, or Teresa S. Bowers, Gradient Corp., 44 Battle St., Cambridge, MA 02138.

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"Geology and Health" will be the scientific theme of the 1993 GSA Annual Meeting in Boston. The health of humanity requires adequate natural resources and a benign environment. Achieving these requirements will depend ever more heavily on advances in the geologic sciences. The human family will need new insights, new techniques, and solutions to a wide range of local, regional and global problems. The symposia and theme sessions devoted to "Geology and Health" at GSA 1993 will address these needs. A GSA-wide symposium concerned with major environmental and resource issues is planned. It will be followed by several specialized symposia dealing with the health effects of minerals and of anthropogenic changes in the composition of the atmosphere, soils, surface waters, and ground waters. These symposia and a number of related theme sessions will focus attention on some of the human dimensions of the geologic sciences. The Boston Committee hopes that these sessions will also supply answers to some vexing questions and solutions to important problems.

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GSA SECTION MEETINGS

South-Central Section, Texas Christian University, Fort Worth, Texas, March 15-16, 1993. John A. Breyer, Department of Geology, P.O. Box 30798, Sid Richardson Building, Corner of Bowie and Cockrell, Texas Christian University, Ft. Worth, TX 76129-0001, (817) 921-7270. *Abstract deadline was November 20, 1992.*

Northeastern Section, Sheraton Inn Conference Center, Burlington, Vermont, March 22-24, 1993. Barry L. Doolan or Rolfe S. Stanley, Department of Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247. *Abstract deadline was November 24, 1992.*

North-Central Section, University of Missouri, Rolla, Missouri, March 29-30, 1993. Richard D. Hagni, Department of Geology & Geophysics, 125 McNutt Hall, University of Missouri-Rolla, Rolla, MO 65401-0249, (314) 341-4616. *Abstract deadline was December 2, 1992.*

Southeastern Section, Florida State Conference Center, Tallahassee, Florida, April 1-2, 1993. James F. Tull, Department of Geology, B-160, Florida State University, Tallahassee, FL 32306-3026, (904) 644-1448. *Abstract deadline was December 7, 1992.*

Cordilleran and Rocky Mountain Sections, Reno Hilton (formerly Bally's Hotel), Reno, Nevada, May 19-21, 1993. Richard A. Schweickert, Department of Geological Sciences, Mackay School of Mines, University of Nevada-Reno, Reno, NV 89557-0138, (702) 784-6050; or Walter S. Snyder, Department of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645, fax 208-385-4061. *Abstract Deadline: January 26, 1993*

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Department of Geology and Geophysics
Boston College

The Department invites applications for an anticipated tenure-track faculty position, at the Assistant Professor rank, in geophysics or tectonophysics beginning the fall semester, 1993. We are seeking a person who can conduct an active research program as well as teach courses at undergraduate and graduate levels. A Ph.D. is required; post-doctoral research experience is desirable. We are interested in candidates who can apply geophysical methods to contemporary problems and whose background complements our present research efforts in one or more of the following area: seismology, gravity and magnetism, structural geology and rock physics, regional geology, and geochemistry. Teaching duties could include courses in exploration geophysics, environmental geophysics, or in applications of physics and geophysics to problems in geology. Please send resume and the names and addresses of three professional references by January 18 to David C. Roy, Chairman, Department of Geology and Geophysics, Boston College, Chestnut Hill, MA 02167. Boston College is an affirmative-action/equal opportunity employer.

CHAIRPERSON, DEPARTMENT OF GEOLOGY INDIANA UNIVERSITY-PURDUE UNIVERSITY AT INDIANAPOLIS (IUPUI)

Applications for the tenured position of Professor and Department Chairperson are solicited. This position is also expected to include responsibility for the development of the planned interdisciplinary program for earth and environmental sciences. We seek a senior-level recognized scholar with a doctorate in the geological sciences, demonstrated leadership ability, and a proven record of teaching, research, and funding. The candidate's area of specialization should be hydrogeology, low-temperature geochemistry, or biogeochemistry. Preference will be given to a candidate who has a background in interdisciplinary research and teaching relevant to developing cooperative relationships with other academic units at IUPUI and with professional environmental scientists in and beyond the Indianapolis area.

Indianapolis is the twelfth largest city in the United States. The city uniquely combines the cultural amenities of urban life with the residential qualities of smaller communities. IUPUI is the third largest university in Indiana, with about 28,000 students. It is affiliated with one of the nation's leading health care centers. The Geology Department is part of the School of Science, and offers B.S., B.A., and M.S. degrees in geology. There are 7 full-time faculty and 5 adjunct faculty, with about 50 undergraduate and 15 graduate majors. We have occupied a new science building for about 1 year, which has excellent teaching facilities and well equipped research laboratories in mineralogy and petrology, sedimentology, and soils. Major equipment items include an electron microprobe, an AA spectrometer, a cathodoluminescence microscope, and an x-ray diffractometer. Opportunities exist for research and teaching interactions with faculty in other departments of the School of Science, particularly Biology and Chemistry, and with units in other Schools such as Engineering, Public and Environmental Affairs, and Medicine. Salary is competitive, and we anticipate substantial set-up funds will be available.

The initial appointment will be July 1, 1993. Interested candidates should send a resume, statements of administrative experience and academic philosophy, and the names and phone numbers of at least four referees. Deadline for receipt of applications: February 15, 1993. Applications and correspondence should be addressed to: Robert D. Hall, Chairman, Search and Screen Committee, Department of Geology, Indiana University-Purdue University at Indianapolis, 723 W. Michigan Street, Indianapolis, IN 46202-5132.

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FLORIDA INTERNATIONAL UNIVERSITY GEOPHYSICS

The Department of Geology at Florida International University invites applications for a tenure-track position in geophysics at the assistant or associate professor level. We seek an individual to develop a vigorous research program and courses in field-based geophysics and who can interact with ongoing programs and projects, many of which are based in the Caribbean/Latin American region. The department's geophysical instrumentation includes a Lacoste-Romberg gravimeter, 12 channel seismograph, magnetometers, resistivity equipment, data loggers, and more.

The Ph.D. degree is required for the position. Please send a complete resume, statement of research and teaching interests, transcripts and 3 letters of recommendation to Dr. Bradford Clement, Chair of Geophysics search committee, Department of Geology, Florida International University, Miami, FL 33199.

Closing date for applications is January 21, 1993. Florida International University is a member of the State University System of Florida and is an equal opportunity, affirmative action employer.

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The successful applicant will be expected to teach introductory courses in Physical Geology, and Marine Geology or Evolution of the Earth, an upper-level course, Igneous and Metamorphic Petrology, and Introduction to Hydrology. The applicant should also be willing to teach courses in geochemistry or mineralogy on an alternate year basis, should the need arise.

The successful applicant will be expected to initiate and maintain an active undergraduate research program.

Mary Washington College is a selective, public undergraduate institution with an emphasis on excellence in teaching, the importance of undergraduate research, and a growing focus on the environmental sciences. Applicants should submit a resume, official transcripts, reprints, a statement of research experience and interests, and the names, addresses, and telephone numbers of at least three referees who are fully capable of evaluating the applicant's background, accomplishments, and potential for excellence in undergraduate education.

Correspondence should be addressed to Dr. Raymond Scott, Chair, Department of Chemistry and Geology, Mary Washington College, P.O. Box 615, Fredericksburg, VA 22401-5358. Closing date for applications is February 1, 1993. Mary Washington College is deeply committed to affirmative action and encourages minorities and women to apply. AA/EOE

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Summer Research Program for Undergraduates at Columbia University's Lamont-Doherty Geological Observatory. Eight students will be selected to participate in a 10-week long research program using Ocean Drilling Program (ODP) cores, well-logs and seismic profiles. Current sophomore and junior

science majors who are citizens or permanent residents of the U.S. are eligible. Students will receive \$2,200 stipend and housing. Some money is available to defray cost of travel between home institution and Lamont. Program is sponsored by JOI-US Science Support Program associated with ODP. Application deadline is March 1, 1993. For further information contact: Dr. Suzanne O'Connell, Program Coordinator, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06457, Tel. (203) 347-9411, ext. 2044, fax 203-343-3903.

Fellowships. University of Texas at Austin Institute for Geophysics, Ewing/Worzel Fellowship in Geology/Geophysics, Seismic Processing, Seismology, Neotectonics, and Regional Tectonics. Graduate fellowships are available from the Institute for Geophysics of the University of Texas at Austin. The Ewing/Worzel Fellowship Fund was established by Palisades Geophysical Institute in 1987 and is named after Maurice Ewing and J. Lamar Worzel, two former directors of the geophysical laboratory. Candidates are expected to have a bachelor's or masters degree in geology, geophysics, physics, computing, mathematics, electrical engineering, or other related field, and must be accepted in a graduate program of one of the University academic departments.

The Institute for Geophysics is an organized research unit of the University of Texas and employs approximately 25 full-time researchers. Fellows are expected to ally themselves with a member of the Institute for Geophysics research staff and either generate an original research project or join an existing project during their first year.

The Fellowship amount is \$12,000 per nine month academic year, which is intended to provide for tuition and fees, as well as a generous stipend. Fellowship recipients are eligible for in-state tuition. Additional support, including summer support, may be awarded after the first year, depending on the research performance of the individual.

Facilities available for graduate research in marine geology/geophysics, seismic processing, seismology, and tectonic reconstructions include an integrated computer system: Cray YMP 8/864 Supercomputer operated by the UT Center for High Performance Computing, numerous Sun SPARCstations, Apple Macintosh personal computers, and peripheral plotters and printers. These are interconnected by AppleTalk™ and Ethernet™ with national and international connections to Internet and Bitnet. About 13 Gbytes of disk is attached to the more powerful Suns, with 3 Gbytes concentrated on one Sun 4/380/32Mb server. Installation of Geovecture® software on the Cray allows us to process 2D and 3D seismic data; GeoQuest® interactive software assists in 2D and 3D seismic interpretation. The Institute also has available 4-component ocean bottom seismometers capable of recording up to 155 Mbytes of data for use in wide angle reflection and refraction studies.

Questions about the fellowship program, and requests to be considered for a Fellowship should be directed to Dr. Thomas A. Davies, Chairman, UTIG Fellowship Committee, 8701 N. MoPac Expressway, Austin, Texas 78759 (tel. 512-471-6156, fax 512-471-8844). Application materials for admission as a graduate student may be obtained from the Graduate Studies Office of the appropriate academic department of The University of Texas at Austin. The Dept. of Geological Sciences application materials may be obtained and submitted through Ms. Ann Page, Dept. of Geological Sciences, The University of Texas, Austin, Texas 78712 (tel. 512-471-6098, fax 512-471-9425).

The Fall 1993 deadline for completed applications for admission as a graduate student and for requests to be considered for a fellowship is February 1, 1993. The Spring 1994 deadline is October 1, 1993.

Complex Systems at the Earth's Surface. Opportunities exist for graduate research into the fundamental nature of landforms and of the processes which create them at the Scripps Institution of Oceanography, University of California, San Diego.

A combination of computer simulation, theory, and field observations are used to address general questions regarding self-organization, pattern formation and nonlinear dynamics, as well as specific mechanical processes operating on coastal and arid landforms. Current applications include beach cusps, ripples, dunes, alluvial fans, patterned ground, landslides, and sediment transport. Facilities include Silicon Graphics workstations, the Mojave Desert, and a research beach. Quantitative background in physics or related field is preferred.

For more information regarding this program and application to Scripps/UCSD, please send a resume, undergraduate transcripts, names, addresses and phone numbers of 3 references, and a statement of interest to Prof. Brad Werner, Complex Systems Laboratory, Center for Coastal Studies 0209, Scripps Institution of Oceanography, La Jolla, California 92093-0209. (619) 534-0583. UCSD is an EO/AA employer.

Student Travel Grants. The GSA Foundation will award matching grants to each of the six GSA Sections to assist students wishing to travel to GSA Section and Annual meetings. For applications contact individual Section secretaries. For Section information contact GSA (1-800-472-1988).

Wright State University — Geophysics Fellowships. The Department of Geological Sciences at Wright State University offers applied geophysics fellowships in the Master of Science program. The Department is well equipped for a wide range of geophysical research. Fellowships begin Fall, 1993. Tuition will be waived for successful applicants and additional summer research assistance is available. The fellowships and other geophysical research are funded by British Petroleum, Amoco, Arco, Conoco, Marathon, Mobil, and Unocal. Completed applications should be submitted to Wright State University, Department of Geological Sciences, Dayton, Ohio 45435, by March 1, 1993. Contact Dr. Ben Richard or Dr. Paul Wolfe at (513) 873-3455 for additional information.

Opportunity for Ph.D. Research — Stable Isotope Geochemistry and Petrology, Lehigh University. Funding is available at Lehigh University (beginning in the fall, 1993) to support the research of a Ph.D. student in the area of stable isotope geochemistry and petrology. This student would pursue 1) improvements in analytical techniques for routine nitrogen-isotope measurements of silicate samples and/or 2) novel applications of nitrogen isotopes in field-based petrologic studies. The ultimate goal of this research is to evaluate the potential of the nitrogen isotope system for contributing unique information regarding metamorphic fluid-rock interactions, magma sources and degassing, and large-scale volatile transfer. Ongoing field-based studies include investigations of fluid processes in subduction zones and mantle volatile budgets.

If interested, please contact Gray E. Bebout, Department of Earth and Environmental Sciences, Williams Hall 31, Lehigh University, Bethlehem, PA 18015-3188 (office 215-758-5831; internet: geb0@lehigh.edu) for further information and application materials. Applicants must have a B.S./B.A. or M.S. in the earth sciences. Lehigh University is an equal opportunity/affirmative action employer.

NASA Planetary Biology Internships. The Marine Biological Laboratory, Woods Hole, Massachusetts, invites applications from graduate students and seniors accepted to graduate programs for awards of \$2200 plus travel to participate in research at 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: 1 March 1993. For information/applications, contact: Lorraine Olendzenski, Planetary Biology Internship, Department of Biology, University of Massachusetts, Amherst, MA 01003. email: PBI@botany.umass.edu. An Equal Opportunity/Affirmative Action Institution.

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1993 John C. Frye Environmental Geology Award

In cooperation with the American Association of 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. The award is a \$500 cash prize from the endowment income of the GSA Foundation's John C. Frye Memorial Fund.

The 1993 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in Boston. Members of the selection committee are Chairman Frank E. Kottowski, New Mexico Bureau of Mines and Mineral Resources; John P. Kempton, Illinois Geological Survey; and Diane L. Conrad, Vermont Division of Geology and Mineral Resources.

Criteria for Nomination

Nominations can be made by anyone, based on the following criteria:

- (1) paper must be selected from GSA or state geological survey publications,
- (2) paper must be selected from those published during the preceding three full calendar years, (3) nomination must include a paragraph stating the pertinence of the paper, (4) **nominations must be sent to Executive Director, GSA, P.O. Box 9140, Boulder, CO 80301. Deadline: March 31, 1993.**

Basis for Selection

Each nominated paper will be judged on the uniqueness or significance as a model of its type of work and report and its overall worthiness for the award. In addition, nominated papers must establish an environmental problem or need, provide substantive information on the basic geology or geologic process pertinent to the problem, relate the geology to the problem or need, suggest solutions or provide appropriate land use recommendations based on the geology, present the information in a manner that is understandable and directly usable by geologists, and address the environmental need or resolve the problem. It is preferred that the paper be directly applicable by informed laypersons (e.g., planners, engineers).

1992 Recipients Announced

Recipients of the 1992 award presented at the GSA Annual Meeting in Cincinnati are Edwin J. Hartke and Henry H. Gray, Indiana Geological Survey, for their report "Geology for environmental planning in Monroe County, Indiana," Special Report 47 (1989), Indiana Geological Survey.

AGI Call for Nominations for 1993 Awards (Deadline: March 31, 1993)

Each year AGI makes nominations on behalf of its member societies for the four national awards that are briefly described below. GSA members have been invited to participate by recommending possible candidates.

Those who wish to make nominations are urged to do so by sending BACKGROUND INFORMATION or RESUMES of their candidates BY MARCH 31, 1993, to the AGI Nominating Committee, 4220 King St., Alexandria, VA 22302-1507; (703) 379-2480; fax 703-379-7563. A roster of nominations will be prepared for final selections by the Member Society Council at its meeting in June 1993.

William T. Pecora Award

The Pecora Award, sponsored jointly by NASA and the Department of the Interior, is presented annually in recognition of outstanding contributions of individuals or groups toward the understanding of Earth by means of remote sensing.

The award recognizes contributions of those in the scientific and technical community as well as those involved in the practical application of remote sensing. Consideration will be given to sustained or single contributions of major importance to the art or science of the understanding of Earth through observations made from space.

Additional information may be obtained from the William T. Pecora Award Committee, Office of Personnel, Dept. of the Interior, MS-5203, MIB, Washington, DC 20240, Attention: Ann Meroney, (202) 208-5284.

National Medal of Science

The medal is awarded by the President to individuals "deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical, engineering, or social and behavioral sciences."

There are now many younger American scientists and engineers who may be reaching a point where their contributions are worthy of recognition. The committee is giving increasing attention to these individuals as well as to those outstanding women and minority scientists who deserve recognition.

Additional information may be obtained by contacting the Secretariat Office, President's Committee on the National Medal of Science, NSF, 1800 G Street, NW, Washington, DC 20550, Attention: Susan E. Fannoney, (202) 357-7512.

Vannevar Bush Award

The Vannevar Bush Award is presented from time to time to a person who, through public service activities in science and technology, has made an outstanding contribution toward the welfare of mankind and the nation.

The award is given to a senior statesman of science and technology and complements the NSF's Alan T. Waterman Award, which is given to a promising young scientist. The two awards are designed to encourage individuals to seek the highest levels of achievement in science, engineering, and service to humanity.

The nomination should be accompanied by a complete biography and a brief citation summarizing the nominee's scientific or technological contributions to our national welfare in promotion of the progress of science.

Additional information may be obtained from the Vannevar Bush Award Committee, National Science Board, 1800 G Street, NW, Washington, DC 20550, Attention: Susan E. Fannoney, (202) 357-7512.

Alan T. Waterman Award

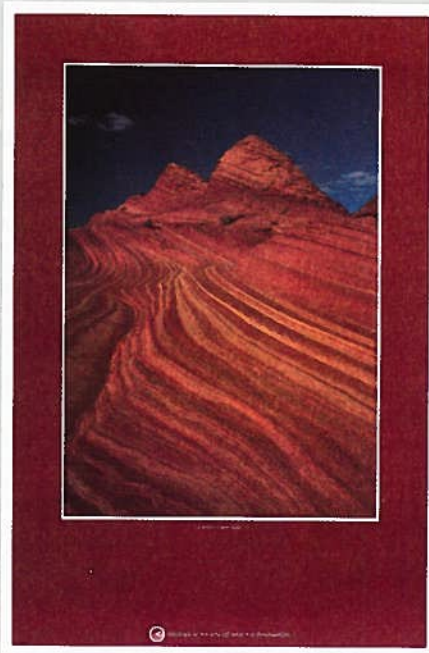
The Waterman Award is presented annually by the NSF and National Science Board to an outstanding young researcher in any field of science or engineering supported by NSF.

Candidates must be U.S. citizens or permanent residents and must be 35 years of age or younger, OR not more than five years beyond receipt of the Ph.D. degree by December 31 of the year in which nominated.

Candidates should have completed sufficient scientific or engineering research to have demonstrated, through personal accomplishments, outstanding capability and exceptional promise for significant future achievement.

Additional information may be obtained by contacting the Executive Secretary, Alan T. Waterman Award Committee, NSF, 1800 G Street, NW, Washington, DC 20550, Attention: Susan E. Fannoney, (202) 357-7512.

Remember: BACKGROUND INFORMATION or RESUMES of nominated candidates should be sent BY MARCH 31, 1993, to the AGI NOMINATING COMMITTEE, 4220 KING ST., ALEXANDRIA, VA 22302-1507, (703) 379-2480, fax 703-379-7563. ■



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