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INSIDE

Stressed Rock Strains Groundwater at Yucca Mountain, Nevada

David A. Ferrill, James Winterle, Gordon Wittmeyer, Darrell Sims, Shannon Colton, Amit Armstrong, *Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, 6220 Culebra Rd., San Antonio, TX 78238-5166*

Alan P. Morris, *Division of Earth and Physical Sciences, University of Texas, San Antonio, TX 78249*

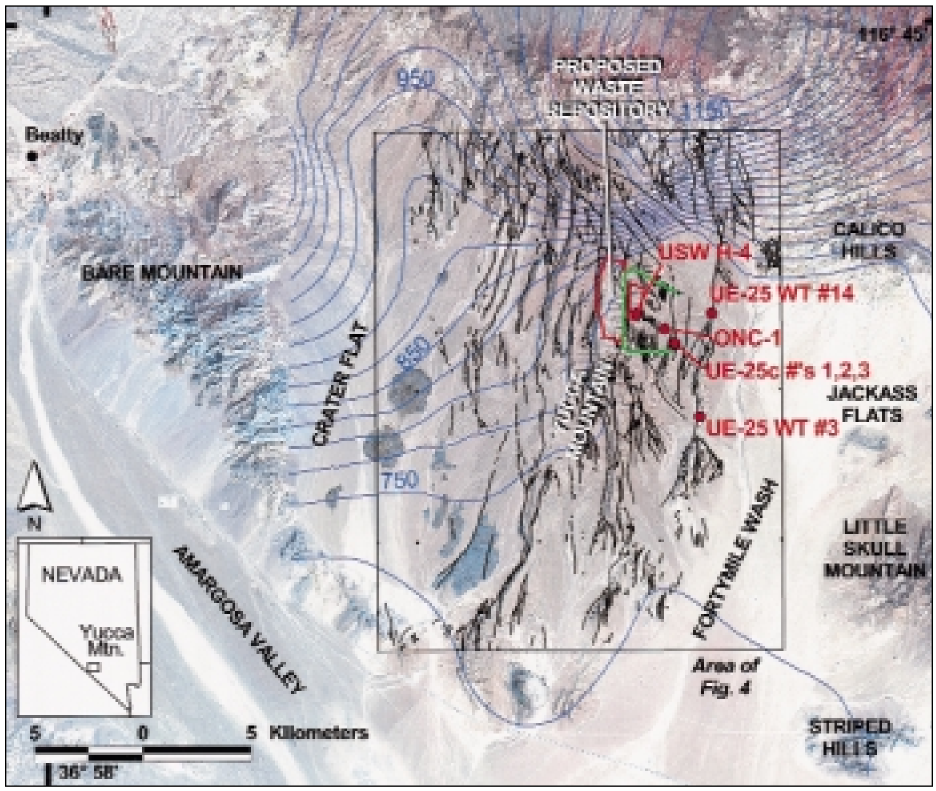

Figure 1. Thematic Mapper scene with potential repository location, wells (red dots), faults (irregular black lines), and water-table contours (blue lines). Water-table contours are from Czarnecki et al. (1997). Green line shows path of Exploratory Studies Facility.

ABSTRACT

Groundwater flow at Yucca Mountain, Nevada, must be understood to determine transport and dilution of contaminants released from the proposed high-level waste repository. The nature of such flow in a complexly faulted and fractured tuff aquifer is not easily characterized. Conceptual models of regional groundwater flow often assume isotropic transmissivity, resulting in flow being interpreted as parallel to the gradient of the potentiometric surface. However, fractured aquifers are typically anisotropic, their transmissivity controlled by the conductive properties of faults and fractures, which are partially controlled by the in situ stress field. Faults at Yucca Mountain predominantly strike approximately north (azimuth ~005). Slip and dilation tendency analysis of the region indicates that those faults and fractures ideally oriented for slip in the current stress field strike north-northeast (azimuth ~025–030) and dip moderately to steeply, whereas those ideally oriented for dilation strike north-northeast (azimuth ~025–030) and are vertical. Faults with favorable orientations for slip or dilation present potential fluid flow pathways. These observations imply anisotropic transmissivity at Yucca Mountain with an azimuthal direction of maximum transmissivity between 005 (based on dominant fault trend) and 030 (based on slip- and dilation-tendency constraints). Reinterpretation of data from a long-term aquifer pumping test on the eastern flank of Yucca Mountain indicates anisotropic transmissivity with a maximum principal transmissivity direction of approximately 030. This is consistent with anisotropic transmissivity controlled by faults and fractures active in the present-day in situ stress field.

INTRODUCTION

Yucca Mountain, a faulted east-dipping cuesta of Miocene tuffs in southwestern Nevada, is being evaluated as the potential site for the nation's first permanent repository for high-level radioactive waste (Fig. 1). The U.S. Department of Energy has prepared a viability assessment, which provides a characterization of the proposed repository, including descriptions of geologic setting, design, and long-term (10 000 year) performance (U.S. Department of Energy, 1998a, 1998b). The Department of Energy is expected to submit a license application in 2002. If the site is licensed by the U.S. Nuclear Regulatory Commission, high-level waste could be emplaced as early as 2010. Original consideration of Yucca Mountain as the candidate repository site was due in part to the >500-m-thick unsaturated zone beneath the mountain and the dry climate. These environmental characteristics were expected to inhibit release and transport of contaminants to the accessible environment via groundwater flow.

Permeability in the Miocene welded tuffs and the underlying Paleozoic and Precambrian carbonate and clastic strata at Yucca Mountain and surrounding area is primarily controlled by faults and fractures (Waddell, 1982; Winograd and Thordarson, 1975; Fridrich et al., 1994). On the basis of alignment of springs (e.g., Ash

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IN THIS ISSUE

In Memoriam

Alan S. Horowitz
Bloomington, Illinois

W. Bradley Meyers
Denver, Colorado

Frank F. Simons
Lakewood, Colorado
January 6, 1995

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Meadows fault—Winograd and Thordarson, 1975; Dudley and Larson, 1976), and elevated groundwater temperatures along faults (e.g., Midway Valley and Solitario Canyon faults—Sass et al., 1995), studies have concluded that faults control groundwater flow locally and are paths for upward flow in the saturated zone at Yucca Mountain (Fridrich et al., 1994; Bredehoeft, 1997). Anomalous concentrations of ^{36}Cl recently identified in samples from the Exploratory Studies Facility, a 7.8-km-long, 7.6-m-diameter tunnel beneath Yucca Mountain (Fig. 1), have been interpreted as indicating rapid downward transport of meteoric water along faults and fractures in the unsaturated zone (Levy et al., 1997; Fabryka-Martin et al., 1998). The production of ^{36}Cl is largely related to atmospheric nuclear testing in the Pacific Ocean in the 1950s.

Anisotropic permeability in fractured aquifers arises from the abundance and distribution of faults and fractures and permeability of associated damage zones (e.g., breccia) (Fig. 2). Although it is known that faulted and fractured aquifers commonly have anisotropic transmissivity (National Research Council, 1996), maps depicting regional-scale groundwater flow usually assume flow parallel to the gradi-

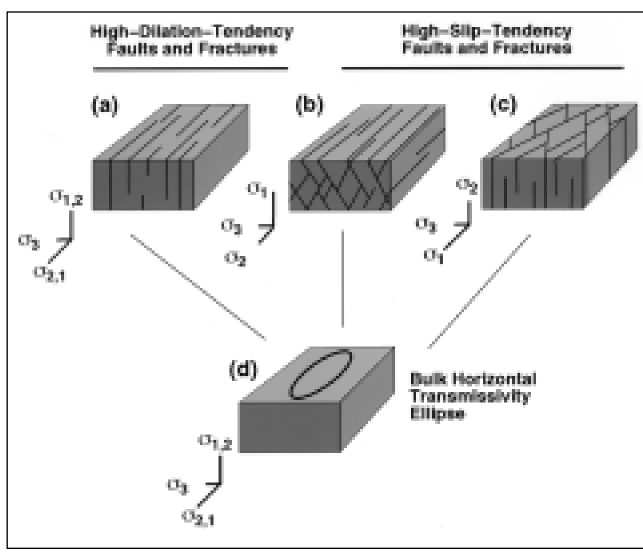

Figure 2. Conceptual illustration of effects of faults with high slip tendency or high dilation tendency on development of anisotropic transmissivity in areas, like the Yucca Mountain (Nevada) region, where the minimum principal compressive stress (σ_3) is horizontal.

PENROSE CONFERENCE

Volcanic Rifted Margins

March 27–31, 2000

Conveners:
Ian Davison and Martin Menzies, Department of Geology, Royal Holloway University;
Joel Baker, Danish Lithosphere Centre

Please note change of venue:
Royal Holloway University of London,
Egham Surrey, UK

Conference Purpose and Objectives

Many rifted volcanic margins (<200 m.y. old) are in close proximity to mantle plumes, but the causal relationship between plumes and rifting remains highly controversial. Do plumes drive continental breakup, or are they channeled into areas of thinned lithosphere? In addition, the relative timing of surface uplift, extension, and magmatism has been predicted by theoretical plume models, but their validity hinges on actual field examples. The North Atlantic and southern Red Sea margins appear to have evolved in a similar way, with minimal uplift and much of the flood magmatism pre-dating break-up. Why does this differ from theoretical models? This conference will bring together scientists working on theoretical, field, and geophysical aspects of rifts, in a stimulating environment.

Field- and laboratory-based scientists with diverse areas of expertise, including landscape evolution and geomorphology, the chronology and geochemistry of continental volcanism, lithospheric extension, mantle and crustal geophysics, thermochronology, and theoretical modeling of rift settings, will be invited to the conference. The main topics will include: extent and amount of uplift and subsidence; relative timing of geological processes on volcanic rifted margins; absolute dating techniques for extension, magmatism, and exhumation; use of volcanic products to understand rift geodynamics; style of, and mechanisms for, lithospheric thinning; syn- and postrift exhumation, sediment budgets and basin formation; thermal history of volcanic rifted margins using dating and modeling techniques.

Field Trips

A premeeting six-day trip to the Deccan Traps will cost an estimated $1000, and a postmeeting five-day trip to the Isle of Mull, Scotland, will cost an estimated $650.

Registration

Limited funding will be available to help cover conference expenses for academics from developing countries, young scientists, and graduate students. Early applications are recommended if you are seeking funding. The conference is limited to 80 participants; selection will include a broad range of disciplines. Costs are currently estimated at $400 for the conference. Interested parties should contact Julie Brown (brown@gl.rhbnc.ac.uk); identify the e-mail as "Penrose Conference." Registration deadline is August 31, 1999. Please include in your e-mail a brief statement of your field of interest, relevance of your research work to the conference theme, proposed title of a poster presentation, a title of topic for discussion (maximum 10 minutes, with a maximum of five overhead projections or slides). Let us know whether you would be interested in participating in the field trips. Invitations will be based on your e-mailed application. Participants will be notified on September 14, 1999, by e-mail.

For more information, contact Ian Davison, Royal Holloway, University of London, Egham, Surrey TW20 OEX UK, phone 44-1784-443615, fax 44-1784- 471780, davison@gl.rhbnc.ac.uk. ■

Sue Beggs Retires

After almost 20 years as the Meetings Manager for GSA, Sue Beggs retired in January 1999. She spearheaded the planning and staging of GSA annual meetings ranging from 4,000 to 7,500 attendees.

Beggs is now a meeting planning consultant in Boulder, Colorado. Kathy Ohmie Lynch, who has been with GSA for 25 years, has assumed the directorship of the GSA Meetings Department.

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ent of the potentiometric surface. This is true only if the transmissive properties of the aquifer are isotropic, or if the major or minor semi-axis of the transmissivity tensor is everywhere parallel to the potentiometric gradient.

Recent studies, including one example from Yucca Mountain, have shown that faults favorably oriented for slip in the ambient stress field tend to be the most active groundwater flow pathways (Barton et al., 1995; Finkbeiner et al., 1997). This observation has been explained by increased small-scale fracturing and faulting in the vicinity of faults on the verge of shear failure (Barton et al., 1995). The ability to recognize such faults allows us to identify the loci of increased fracturing.

A secondary but measurable influence on permeability is the effect of contemporary stress on reducing apertures of existing faults and fractures (Carlsson and Olsson, 1979; Barton et al., 1995; Finkbeiner et al., 1997). Faults and fractures perpendicular to the maximum principal stress are preferentially closed, thereby reducing permeability perpendicular to the maximum principal stress. Permeability perpendicular to the minimum principal compressive stress direction is relatively enhanced because lower resolved normal stress results in less fracture aperture reduction (e.g., Carlsson and Olsson, 1979).

Here, we examine how regional stress combined with existing faults and fracture systems at Yucca Mountain influences permeability and groundwater flow in the saturated zone beneath Yucca Mountain. We then test the model using data from a long-term aquifer pumping test at Yucca Mountain, and consider possible implications for the proposed high-level waste repository at Yucca Mountain.

SLIP TENDENCY AND DILATION TENDENCY

Our approach to stress analysis involves calculating resolved stresses on fault and fracture surfaces to analyze like-

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lihood for slip or dilation in crustal stress fields. The resulting slip and/or dilation tendency data are displayed by color coding three-dimensional models (Fig. 3) or trace maps of the fault and fracture array (Fig. 4).

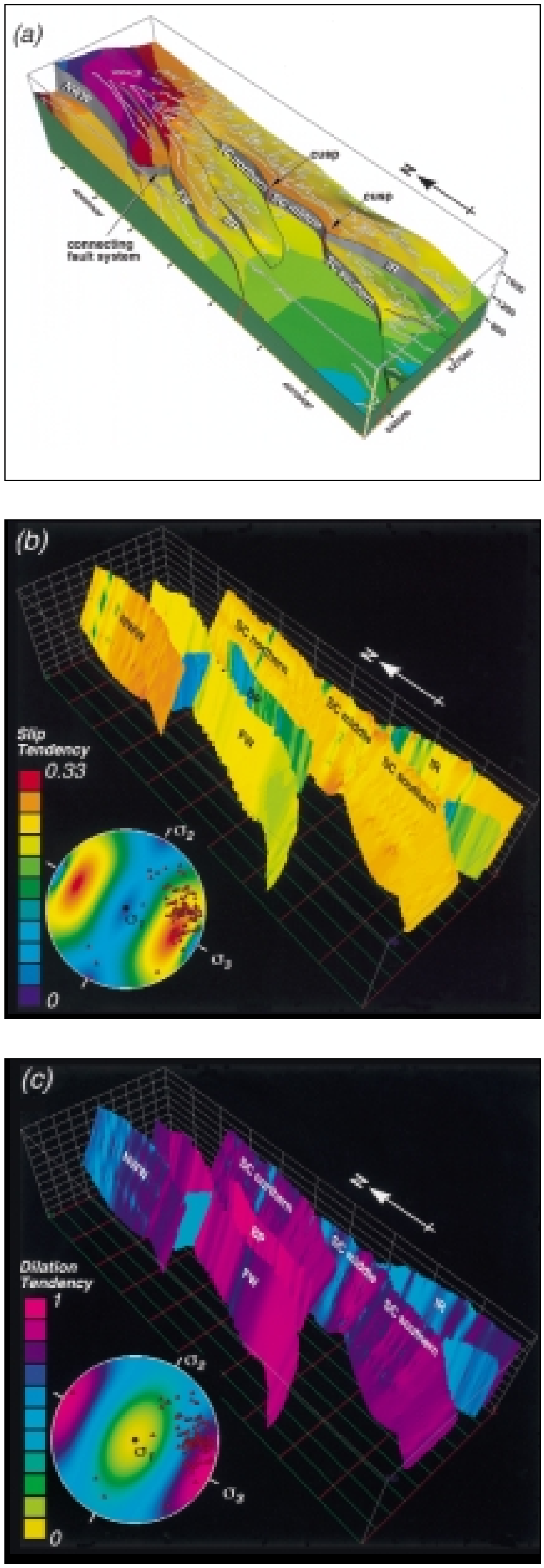

Figure 3. (a) Three-dimensional structure contour map of layer (top of upper lythophysal zone of the crystal-poor member) within the Tiva Canyon Tuff in the western Yucca Mountain, Nevada, area. Irregular white lines represent data points from the three-dimensional outcrop trace of the mapped horizon (from Day et al., 1998a, 1998b). Gray indicates fault gaps for Northern Windy Wash (NWW), Fatigue Wash (FW), Boomerang Point (BP), Solitario Canyon (SC, subdivided into northern, middle, and southern sections), and Iron Ridge (IR) faults. Coordinates are UTM zone 11, elevations are in meters above sea level, and vertical exaggeration is 2.5×. See Figure 4 for location.

(b) Three-dimensional model of western Yucca Mountain fault system with fault surfaces colored according to slip tendency. The slip tendency plot (equal-angle stereographic projection colored according to slip tendency as defined in text) shows poles to planes (measurements from Simonds et al., 1995 and Day et al., 1998a) of the Windy Wash, Fatigue Wash, Boomerang Point, Solitario Canyon, and Iron Ridge faults. The area is the same as in part a; no vertical exaggeration.

(c) Three-dimensional dilation tendency model of western Yucca Mountain fault system. The dilation tendency plot (equal-angle stereographic projection colored according to dilation tendency as defined in text) shows poles to planes of the Windy Wash, Fatigue Wash, Boomerang Point, Solitario Canyon, and Iron Ridge faults. The area is the same as in part a; no vertical exaggeration.

Slip Tendency

Slip tendency analyses are applicable to planar discontinuities like faults, extension fractures, or layering (Morris et al., 1996; Ferrill et al., 1998). For faults and fractures, slip is likely to occur on a surface when the resolved shear stress, τ, on that surface equals or exceeds the frictional resistance to sliding. Frictional resistance is proportional to normal stress, σ_n, acting across that surface (Jaeger and Cook, 1979). The slip tendency, T_s, of a surface is the ratio of shear stress to normal stress acting on that surface (Morris et al., 1996):

$$T_s = \tau / \sigma_n$$

As such, T_s depends solely on the stress field (stress tensor) and surface orientation. Whether or not a surface slips depends upon its cohesive strength, if any, and the coefficient of static friction, μ. The coefficient of static friction, μ, is the value of T_s that causes slip on a cohesionless surface and is often referred to as the fault "strength" in earthquake focal mechanism analysis (e.g., Harmsen, 1994). Under most crustal conditions, faults with $T_s \geq 0.6$ are ideally oriented for slip (Byerlee, 1978). Analysis of slip tendency provides a way to assess which faults are near the ideal orientation for slip and are the most likely to be associated with zones of increased fracture density and enhanced fracture permeability.

Dilation Tendency

Dilation of fractures is largely controlled by the resolved normal stress, which is a function of lithostatic and tectonic stresses and fluid pressure. The normal stress that a fracture feels depends on the magnitude and direction of the principal stresses relative to the fracture plane. The ability of a fracture to dilate and transmit fluid is directly related to its aperture, which in turn is a function of the effective normal stress acting upon it. The magnitude of the normal stress can be computed for surfaces of all orientations within a known or hypothesized stress field. This normal stress can be normalized by comparison with differential stress. The resulting dilation tendency (T_d) for a surface is then defined as

$$T_d = (\sigma_1 - \sigma_n) / (\sigma_1 - \sigma_3)$$

where σ_1 is the maximum principal compressive stress, and σ_3 is the minimum principal compressive stress.

BULK TRANSMISSIVITY ANISOTROPY

A population of steep, aligned, relatively permeable faults and fractures cutting a less permeable rock mass will tend to orient the maximum directional transmissivity parallel to the structural grain. In the case of unequal horizontal stresses acting on a population of steep faults and fractures, those with strikes *parallel* to the maximum horizontal compressive stress tend to open. Those with strikes *perpendicular* to the maximum horizontal stress tend to close. Similarly, some faults in an anisotropic stress field will be more ideally oriented for slip and others for locking. Thus, even if fault and fracture orientation distribution is isotropic, transmissivity in the maximum horizontal stress

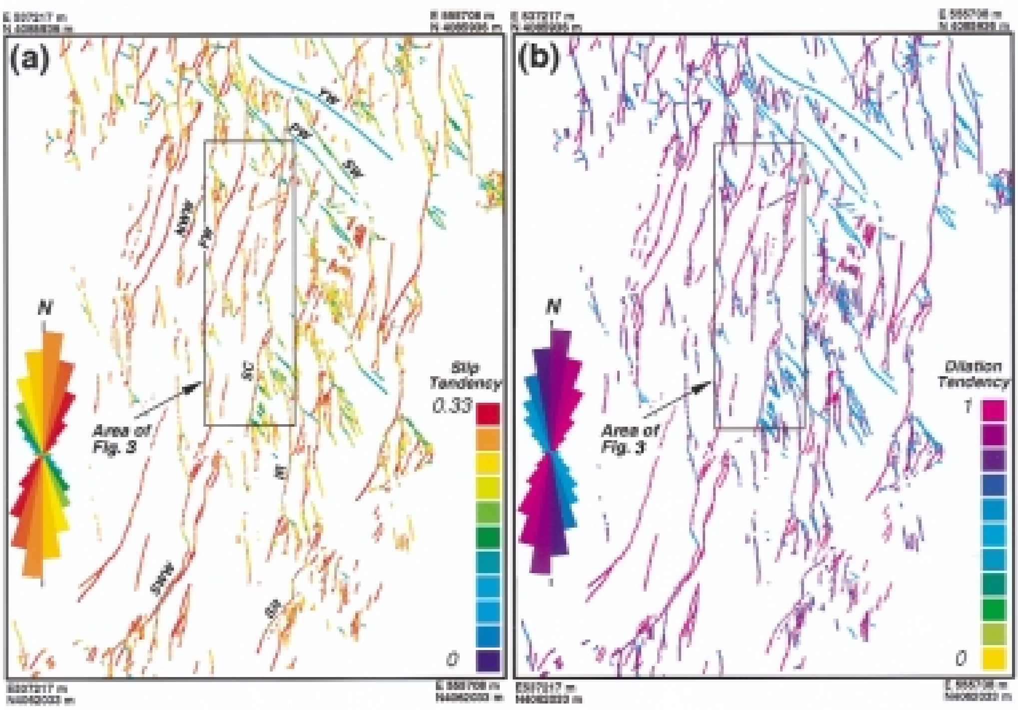

Figure 4. (a) Slip tendency map of Yucca Mountain faults mapped by Simonds et al. (1995). The rose diagram shows cumulative fault length in 10° strike azimuth bins. The map and rose diagram are colored according to slip tendency as shown by the slip-tendency plot and the color bar in Figure 3b. The area is as shown in Figure 1. Named faults discussed in the text are labeled on the map: NWW—Northern Windy Wash, SWW—Southern Windy Wash, FW—Fatigue Wash, SC—Solitario Canyon, IR—Iron Ridge, SR—Stagecoach Road, PW—Pagany Wash, SW—Sever Wash, and YW—Yucca Wash. (b) Dilation tendency map of Yucca Mountain faults. The map and rose diagram are colored according to dilation tendency as shown by the dilation-tendency plot and color bar in Figure 3c. The area is as shown in Figure 1.

direction can be enhanced, producing transmissivity anisotropy.

Because fault and fracture populations commonly exhibit preferred orientations and in situ horizontal stresses are commonly unequal, both are likely to occur together in nature and lead to anisotropic transmissivity. For example, in cases where σ_3 is horizontal, vertical faults and fractures perpendicular to σ_3 have the highest dilation tendency and are likely to be more conductive than those in other orientations (Fig. 2a). Faults and shear fractures are sensitive to the σ_1 direction and commonly form two conjugate sets intersecting at an acute angle (~60) centered on σ_1 (Fig. 2, b and c). In normal fault regimes where σ_1 is vertical, two sets of opposite-dipping conjugate normal faults commonly develop (Fig. 2b). In strike-slip fault regimes where σ_1 is horizontal, two sets of vertical conjugate strike-slip faults commonly develop (Fig. 2c). In areas where σ_3 is horizontal, fault and fracture preferred orientations, and slip tendency and dilation tendency all promote development of a net bulk transmissivity anisotropy with a maximum horizontal transmissivity perpendicular to σ_3 (Fig. 2d). The interaction of aquifer transmissivity with faults and fractures can be field tested by aquifer pumping tests. As done below, the results can be used to determine the full transmissivity tensor and to compare the orientation of the principal components of this tensor with the maximum and minimum in situ horizontal stress orientations and the distribution of faults and fractures.

PREDICTION OF ANISOTROPIC TRANSMISSIVITY AT YUCCA MOUNTAIN

The pattern of faults and fractures in the Yucca Mountain region (Fig. 1) resulted from deformation in a regional stress field that evolved from east-west extension before 10 Ma to west-northwest–east-southeast extension after 10 Ma (Zoback et al., 1981), and from thermoelastic contraction during cooling of the ash-flow tuffs (Sweetkind and Williams-Stroud, 1996). The result is a dominant population of north-south to northeast-southwest–trending normal faults, a subordinate population of northwest-southeast–trending strike-slip faults, and a group of minor connecting faults and curved fault tips (Day et al., 1998b; Ferrill et al., 1999). Fault growth by connection of overlapping fault segments produced irregular fault traces with cusps at fault intersections (Fig. 3a). Although faults at Yucca Mountain are related to several deformational episodes, some faults are unlikely to slip because of unfavorable orientations relative to the contemporary stress state.

Yucca Mountain lies within the western Basin and Range in a region characterized by both normal and strike-slip earthquakes. The regional occurrence of both normal and strike-slip earthquakes indicates that the maximum (σ_1) and intermediate (σ_2) principal compressive stresses have similar magnitudes (Zoback, 1992; Zoback et al., 1992). The least principal compressive stress (σ_3) is approximately horizontal and trends west-northwest–east-southeast. Therefore, σ_3 is the "odd axis" (Krantz, 1988) and has the most direct control on the pattern of fault slip tendency. Stock et al. (1985) estimated the following effective principal stresses at Yucca Mountain (corrected for fluid pressure) at a depth of 1 km: σ_1 = vertical = 21 MPa, σ_2 = N25°–30°E = 17 MPa, and σ_3 = N60°–65°W = 11 MPa for the region.

Slip-Tendency Analysis of Yucca Mountain Faults

Slip-tendency analysis of Yucca Mountain faults was performed using the relative stress values of Stock et al. (1985) given above, a three-dimensional fault model for western Yucca Mountain (Fig. 3b), and the faults mapped by Simonds et al. (1995; Fig. 4a). Faults that strike parallel to the north-northeast–trending maximum horizontal stress (025–030; 028 in Figs. 3 and 4) and dip 55° have the maximum slip tendencies. Slip tendencies are also near maximum (>0.3) for faults that are moderately to steeply dipping (40°–65°), and north-south to northeast-southwest (000–055) striking. Faults at 1 km depth have moderate slip tendencies relative to typical failure conditions. In contrast, at depths of earthquake rupture initiation (e.g., 5–15 km), stresses resolved on similarly oriented faults produce near-failure slip tendencies (Morris et al., 1996). As described by Harmsen (1994), the pattern of slipped faults in the Little Skull Mountain (Fig. 1) earthquake sequence is dominated by dip-slip on southeast-dipping normal faults and right-lateral strike-slip on vertical north-south trending

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faults. This is the pattern predicted by slip tendency analysis of the Yucca Mountain stress field and supports simultaneous activity of strike-slip and normal faults in this area (Morris et al., 1996).

Examination of the faults mapped by Simonds et al. (1995) reveals that nearly all faults with known or suspected late Quaternary displacement are in orientations of high slip tendency (Fig. 4a). Some noteworthy examples are the Northern and Southern Windy Wash, Fatigue Wash, Solitario Canyon, Iron Ridge, and Stagecoach Road faults (Fig. 4a). In contrast, the northwest-southeast–trending Pagany Wash, Sever Wash, and Yucca Wash faults are in low slip-tendency orientations (Fig. 4a) and lack evidence of late Quaternary slip (Simonds et al., 1995).

Dilation-Tendency Analysis of Yucca Mountain Faults

Dilation-tendency analysis of faults and associated fractures at Yucca Mountain (e.g., Figs. 3c and 4b) was performed assuming the same relative stresses and mapped faults used for slip-tendency analysis. The results show that vertical faults and fractures that strike parallel to the maximum horizontal stress (025–030; 028 in Figs. 3 and 4) have the maximum dilation tendencies. Faults trending 028 ± 35° and dipping 65° to 90° have dilation tendencies of 0.8 or greater in the present stress field (Fig. 3c). Dilation-tendency analysis of faults at Yucca Mountain illustrates an abundance of steeply dipping north-northeast–trending faults that have high dilation tendency.

Implications for Anisotropic Transmissivity at Yucca Mountain

Faults with favorable orientations for slip or dilation present potential flow pathways. Although we explicitly consider only large map-scale faults, the processes that alter permeability of large faults and fracture systems also apply to abundant smaller scale fractures and faults like those seen in outcrops, boreholes, and the Exploratory Studies Facility (cf. Sweetkind and Williams-Stroud, 1996), resulting in an effective hydraulic continuum. The dominant trend of faults at Yucca Mountain is approximately north-south (005; see rose diagrams in Fig. 4). The strike, maximum slip tendencies, and maximum dilation tendencies of the fault population indicate the possibility of anisotropic transmissivity, with the direction of maximum transmissivity in the azimuth range between 005 (based on dominant fault trend) and 030 (based on slip- and dilation-tendency constraints).

TABLE 1. **DIRECTIONAL HYDRAULIC DIFFUSIVITIES ESTIMATED FOR OBSERVATION WELLS FROM LONG-TERM PUMPING TEST AT C-WELLS**

Well I.D.	Direction azimuth (θ)	Distance from pumped well (m)	Bulk aquifer transmissivity (m^2/d)	Square root of directional hydraulic diffusivity [$\sqrt{D(\theta)}$; $m/d^{1/2}$]
USW H-4	310	2245	670	560
ONC-1	327	843	1340	416
UE-25 WT #3	161	3526	1230	506
UE-25 WT #14	050	2249	1370	980

ESTIMATION OF ANISOTROPIC TRANSMISSIVITY AT YUCCA MOUNTAIN

A long-term aquifer pumping test was conducted at the C-well complex on the eastern flank of Yucca Mountain from May 1996 to March 1997 (Geldon et al., 1997). The C-well complex consists of three wells (UE-25c #1, UE-25c #2, and UE-25c #3) that are separated by distances of 30–77 m and form a right triangle. During this aquifer test, well UE-25c #3 was pumped at a rate of 9.5 L/s. Water levels in four observation wells (USW H-4, ONC-1, UE-25 WT #3, and UE-25 WT #14; Fig. 1), located at distances of 0.84–3.5 km, were monitored at 15 min intervals.

We estimated horizontal anisotropy of aquifer transmissivity on the basis of data from the four distant observation wells, using the method of Papadopulos (1965) for homogenous, anisotropic aquifers of infinite areal extent. Data from two other wells (UE-25c #1 and UE-25c #2) were not used because of complications related to their proximity to the pumped well. The technique requires the following data from at least three observation wells: (1) the directional azimuth (θ) to the monitored well from the pumped well; (2) bulk aquifer transmissivity (a scalar quantity equal to the geometric mean of the minimum and maximum directional transmissivities); and (3) the directional hydraulic diffusivity (a vector quantity). Directional hydraulic diffusivity [$D(\theta)$] is defined as the directional transmissivity [$T(\theta)$; a vector quantity] divided by the dimensionless bulk aquifer storage coefficient (S). Although we are primarily interested in $T(\theta)$, neither it nor S can be estimated separately from $D(\theta)$ until both the ratio of maximum to minimum $D(\theta)$ and the direction of maximum $D(\theta)$ are known. These are determined by fitting an ellipse to a polar plot of the square root of $D(\theta)$.

Our analysis differs in two ways from the interpretation of Geldon et al. (1997). First, we performed a two-step correction that accounts for the influence on water levels exerted by both direct borehole coupling to atmospheric pressure changes and the delayed atmospheric pressure signal that arrives through the overlying geologic formation. Second, we assume that S is constant throughout the aquifer, and thus differences in $D(\theta)$ between observation wells are attributed to $T(\theta)$. The bulk aquifer transmissivity estimates obtained from our analysis (Table 1) are broadly consistent with, but less variable than those in Geldon et al. (1997).

We began our analysis of aquifer anisotropy by testing the assumption of a homogenous aquifer system. In a purely homogenous aquifer, the bulk transmissivity estimates obtained from each observation well should be the same. With the exception of well USW H-4, aquifer transmissivity estimates are quite similar (Table 1). Because the transmissivity estimate for well USW H-4 could be affected by a fault system between it and the pumped well, this well was excluded from the analysis of horizontal anisotropy. A polar plot of the square root of $D(\theta)$ for the remaining three wells shows that an exact-fitting ellipse could not be obtained from the data, consistent with the fact that not every set of three points defines an ellipse (Fig. 5).

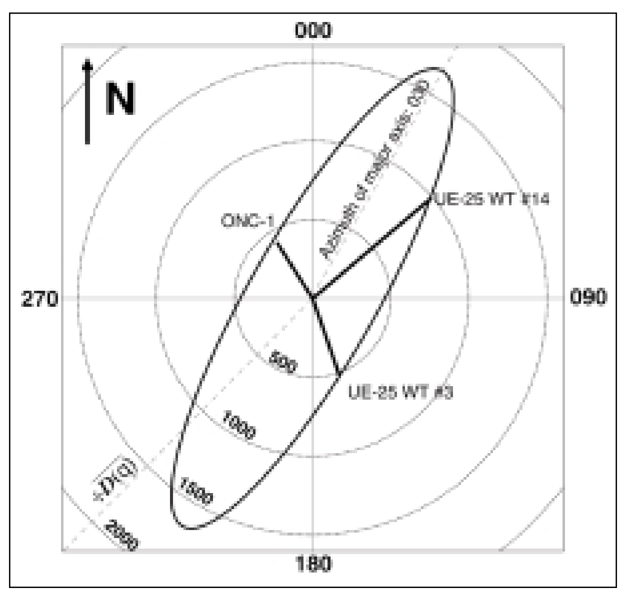

Figure 5. An ellipse with major semi-axis oriented 030 provides a close match to directional hydraulic diffusivities and indicates anisotropic transmissivity that is consistent with predictions based on fault and fracture orientations and effects of regional stress. Concentric contours are in m/d$^{1/2}$.

Although the ellipse in Figure 5 is not an exact fit, it closely matches the observation well data with major semi-axis oriented 030. Because of uncertainty associated with aquifer pumping tests, and the limitation of having only the minimum number of data points to constrain an ellipse, the ratio of minimum to maximum directional transmissivity is poorly constrained. With this in mind, we estimate from Figure 5 a maximum $T(\theta)$ of 5400 m^2/d (azimuth 030), a minimum $T(\theta)$ of 315 m^2/d (azimuth 120), and a bulk S value of 0.002. This analysis indicates a northeast trend in the direction of maximum $T(\theta)$ consistent with the north-northeast (025–030) trend inferred from the slip and dilation tendency.

IMPLICATIONS FOR PROPOSED YUCCA MOUNTAIN REPOSITORY SITE

Current groundwater flow models at Yucca Mountain (e.g., Czarnecki et al., 1997, Department of Energy, 1998a, 1998b) do not incorporate anisotropy of transmissivity. A flow pattern parallel to the hydraulic gradient, as expected in an isotropic aquifer (Freeze and Cherry, 1979), would result in relatively short southeast-directed travel distances in the unconfined welded-tuff aquifer before the flow enters alluvial deposits. In contrast, by taking into account the orientation of maximum horizontal transmissivity and the inferred presence of fault- and fracture-controlled flow conduits, we propose a model in which more southward-directed flow paths would increase travel distances in the tuff aquifer and reduce the amount of flow in alluvium between Yucca Mountain and the receptor location. Such a difference in direction is important, because relative flow velocities should be faster in the lower porosity tuff aquifer, and sorption of radionuclides should be less in the tuff, owing to its lower surface area of sorbing mineral grains (e.g., clays, iron oxides, and calcite).

CONCLUSIONS

In the contemporary stress state at 1 km depth at Yucca Mountain, slip and dilation tendency analyses indicate the following: faults that strike north-north-east (000–055) and dip 40°–65° have high slip tendencies, the maximum being for faults that strike north-northeast (025–030) and dip 53°; and faults that strike north-northeast (350–065) and dip 65°–90° have high dilation tendencies, the maximum being for vertical faults that strike north-northeast (025–030).

The dominant north-south (~005) trend of faults at Yucca Mountain, coupled with slip-tendency and dilation-tendency considerations suggest anisotropic transmissivity, with maximum transmissivity in the azimuth range between 005 and 030.

About People

GSA Member Stephen W. Forster, Federal Highway Administration, Centreville, Virginia, received the 1998 Prevost Hubbard Award from American Society of Testing and Materials Committee D-4 on Road and Paving Materials.

Fellow Lee C. Gerhard, state geologist and director of the Kansas Geological Survey, has been made an honorary member of the Kansas Geological Society.

Fellow Syed E. Hasan, University of Missouri—Kansas City, has received the Claire P. Holdredge Award from the Association of Engineering Geologists.

Fellow Holly Stein, Colorado State University, Fort Collins, has been awarded a Fulbright Research Fellowship to the Norwegian University of Science and Technology.

The Woods Hole Oceanographic Institution has awarded the Henry Bryant Bigelow Chair to Fellow Brian E. Tucholke.

Member Owen L. White, Toronto, Ontario, has received the Hans Cloos Medal from the Canadian National Group of the International Association for Engineering Geology and the Environment.

The anisotropic transmissivity estimated at Yucca Mountain has a maximum principal direction of approximately 030, consistent with the hypothesis that anisotropy is controlled by faults and fractures in the present-day in situ stress field.

Note: For more information on the Yucca Mountain site, see www.ymp.gov/va.htm.

ACKNOWLEDGMENTS

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REFERENCES CITED

Barton, C. A., Zoback, M. D., and Moos, D., 1995, Fluid flow along potentially active faults in crystalline rock: Geology, v. 23, p. 683–686.

Bredehoeft, J. D., 1997, Fault permeability near Yucca Mountain: Water Resources Research, v. 33, p. 2459–2463.

Byerlee, J. D., 1978, Friction of rocks: Pure and Applied Geophysics, v. 116, p. 615–626.

Carlsson, A., and Olsson, T., 1979, Hydraulic conductivity and its stress dependence: Proceedings, Paris, Workshop on Low-Flow, Low-Permeability Measurements in Largely Impermeable Rocks, p. 249–259.

Czarnecki, J. B., Faunt, C. C., Gable, C. W., and Zyvoloski, G. A., 1997, Hydrogeology and preliminary calibration of a preliminary three-dimensional finite-element ground-water flow model of the site saturated zone, Yucca Mountain, Nevada: U.S. Geological Survey, Yucca Mountain Project Milestone Report SP23NM3.

Day, W. C., Potter, C. J., Sweetkind, D., Dickerson, R. P., and San Juan, C. A., 1998a, Bedrock geologic map of the Central Block area, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I-2601, scale 1:6000.

Day, W. C., Dickerson, R. P., Potter, C. J., Sweetkind, D. S., San Juan, C. A., Drake, R. M. II, and Fridrich, C. J., 1998b, Geologic map of the Yucca Mountain area, Nye County, Nevada: U.S. Geological Survey Geological Investigations Series I-2627, scale 1:24,000.

Dudley, W. W., and Larson, J. D., 1976, Effect of irrigation pumping on the desert pupfish habitat in Ash Meadows, Nye County, Nevada: Geological Survey Professional Paper 927.

Fabryka-Martin, J. T., Wolfsberg, A. V., Levy, S. S., Campbell, K., Tseng, P., Roach, J. L., and Wolfsberg, L. E., 1998, Evaluation of flow and transport models of Yucca Mountain, based on chlorine-36 studies for FY98: Los Alamos National Laboratory, Yucca Mountain Project Milestone Report SP33DDM4.

Ferrill, D. A., Morris, A. P., Jones, S. M., and Stamatakos, J. A., 1998, Extensional layer-parallel shear and normal faulting: Journal of Structural Geology, v. 20, p. 355–362.

Ferrill, D. A., Stamatakos, J. A., and Sims, D., 1999, Normal fault corrugation: Implications for growth and seismicity of active normal faults: Journal of Structural Geology (in press).

Finkbeiner, T., Barton, C. A., and Zoback, M. D., 1997, Relationships among in-situ stress, fractures and faults, and fluid flow: Monterey Formation, Santa Maria Basin, California: American Association of Petroleum Geologists Bulletin, v. 81, p. 1975–1999.

Freeze, R. A., and Cherry, J. A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 604 p.

Fridrich, C. J., Dudley, W. W., Jr., and Stuckless, J. S., 1994, Hydrogeologic analysis of the saturated-zone ground-water system, under Yucca Mountain, Nevada: Journal of Hydrology, v. 154, p. 133–168.

Geldon, A. L., Umari, A. M. A., Fahy, M. F., Earle, J. D., Gemmel, J. M., and Darnell, J., 1997, Results of hydraulic and conservative tracer tests in Miocene tuffaceous rocks at the C-Hole Complex, 1995 to 1997, Yucca Mountain, Nevada: U.S. Geological Survey Yucca Mountain Milestone Report SP23PM3.

Harmsen, S. C., 1994, The Little Skull Mountain earthquake of 29 June 1992: Aftershock focal mechanisms

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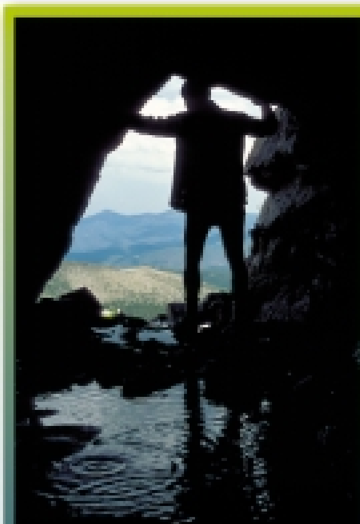

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and tectonic stress field implications: Seismological Society of America Bulletin, v. 84, p. 1484–1505.

Jaeger, J. C., and Cook, N. G. W., 1979, Fundamentals of rock mechanics (third edition): London, Chapman and Hall, 593 p.

Krantz, R. W., 1988, Multiple fault sets and three-dimensional strain: Theory and application: Journal of Structural Geology, v. 10, p. 225–237.

Levy, S. S., Sweetkind, D. S., Fabryka-Martin, J. T., Dixon, P. R., Roach, J. L., Wolfsberg, L. E., Elmore, D., and Sharma, P., 1997, Investigations of structural controls and mineralogic associations of Chlorine-36 fast pathways in the ESF: Los Alamos National Laboratory, Yucca Mountain Project Milestone Report SP2301M4.

Morris, A. P., Ferrill, D. A., and Henderson, D. B., 1996, Slip-tendency analysis and fault reactivation: Geology, v. 24, p. 275–278.

National Research Council, 1996, Rock fractures and fluid flow: Washington, D.C., National Academy Press, 551 p.

Papadopulos, I. S., 1965, Nonsteady flow to a well in an infinite anisotropic aquifer: International Symposium of Scientific Hydrology, Proceedings, Dubrovnik Symposium on the Hydrology of Fractured Rocks, p. 21–31.

Sass, J. H., Dudley, W. W., Jr., and Lachenbruch, A. H., 1995, Regional thermal setting, *in* Oliver, H. W., et al., eds., Major results of geophysical investigations at Yucca Mountain and vicinity, southern Nevada: U.S. Geological Survey Open-File Report 95-74, 23 p.

Simonds, W. F., Whitney, J. W., Fox, K., Ramelli, A., Yount, J. C., Carr, M. D., Menges, C. D., Dickerson, R., and Scott, R. B., 1995, Map of fault activity of the Yucca Mountain area, Nye County, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I-2520, scale 1:24,000.

Stock, J. M., Healy, J. H., Hickman, S. H., and Zoback, M. D., 1985, Hydraulic fracturing stress measurements at Yucca Mountain, Nevada, and relationship to regional stress field: Journal of Geophysical Research, v. 90, p. 8691–8706.

Sweetkind, D. S., and Williams-Stroud, S. C., 1996, Characteristics of fractures at Yucca Mountain, Nevada: Synthesis report: Denver, Colorado, U.S. Geological Survey Administrative Report.

U.S. Department of Energy, 1998a, Viability assessment of a repository at Yucca Mountain: Introduction and site characteristics, December 1998. Volume 1: Las Vegas, Nevada, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, DOE/RW-0508.

U.S. Department of Energy, 1998b, Viability assessment of a repository at Yucca Mountain: Total system performance assessment, December 1998. Volume 3: Las Vegas, Nevada, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, DOE/RW-0508.

Waddell, R. K., 1982, Two-dimensional, steady-state model of ground-water flow, Nevada Test Site and vicinity, Nevada-California: U.S. Geological Survey Water Resources Investigations Report 82-4085.

Winograd, I. J., and Thordarson, W., 1975, Hydrogeologic and hydrochemical framework, south-central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C.

Zoback, M. L., 1992, First- and second-order patterns of stress in the lithosphere: The world stress map project: Journal of Geophysical Research, v. 97(B8), p. 11,703–11,728.

Zoback, M. L., Anderson, R. E., and Thompson, G. A., 1981, Cenozoic evolution of the state of stress and style of tectonism of the Basin and Range Province of the western United States: Royal Society of London Philosophical Transactions, sec. A, v. 300, p. 407–434.

Zoback, M. L., and 36 project participants, 1992, World stress map—Maximum horizontal stress orientations: Journal of Geophysical Research, v. 87(B8).

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GSA International Internet Symposium: An Experiment in Scientific Communication

Todd Halihan, Department of Geological Sciences, University of Texas, Austin, TX 78712-1101
Craig Simmons, School of Earth Sciences, Flinders University, GPO Box 2100, Adelaide, South Australia 5001, Australia
John Sharp, Jr., Matthew Uliana, Tom Fenstemaker, Department of Geological Sciences, University of Texas, Austin, TX 78712-1101

The time and the cost involved in international travel often make it difficult for scientists to travel to conferences overseas, collaborate with colleagues abroad, or simply discuss scientific problems of mutual interest. For instance, North America and Australia both have extensive arid and semiarid zones in which groundwater is a key natural resource. At the 1998 GSA meeting in Toronto, GSA's Hydrogeology Division, in conjunction with The University of Texas at Austin and Flinders University of South Australia undertook an experiment in modern scientific communication by holding GSA's first International Internet symposium. The event marked the first time that GSA has linked up to a country outside of the United States for one of its symposia. Approximately 100 scientists in Toronto, Canada, and Adelaide, Australia, attended the International Internet symposium, "Understanding Groundwater in Arid and Semiarid Environments in North America and Australia."

The symposium provided scientists on two continents an opportunity to exchange thoughts and experiences on hydrogeology in these areas. Three speakers from North America and three from Australia presented videotaped talks, followed by live discussion, over the Internet using Microsoft NetMeeting. The symposium had some successful aspects, but also some limitations, as described here.

BACKGROUND

Apart from everyday electronic mail, use of the Internet in the geological sciences is often limited to class notes, syllabi, and the like. This passive approach has missed out on the developing capabilities of the Internet for scientific communication. In today's "global village," it is becoming increasingly important to keep well informed and up to date about the activities of the international scientific community. Despite easy access to e-mail, telephones and fax machines, useful research collaborations across town or on the other side of the planet are still commonly limited by communication barriers.

Today, personal computers and networks are faster than ever, and a new type of software has become available for communication across the Internet. Among these programs is Microsoft NetMeeting, which was used for the symposium because the software is free, easily downloadable from the Web, and simple to use. The software allows two computers at remote locations across the globe to speak via the Internet and to share voice, video, and software applications. The software makes it possible to discuss research with colleagues, edit papers or presentations, listen to talks, or even look at a laboratory experiment on rock samples being carried out in real time in another country. Problems with network speed and reliability mean that the software cannot replace telephone, e-mail, or video conferencing. However, in our opinion, it provides an excellent new method of communicating that complements the more traditional methods.

INFRASTRUCTURE

The major problem we encountered in conducting the symposium was the lack of compatible infrastructure and technical support. To our knowledge, such a symposium had never been attempted before, and there were many questions to be answered, such as: Why not just use video teleconferencing to hold the symposium? What happens if the technology fails on the day? Video teleconferencing is very expensive, especially when a pre-established video conferencing room is not already available. We received quotes in the $10,000 range for a two-hour dedicated line between the convention center in Toronto and Flinders University in Adelaide. Additionally, when the conference is over, videoconferencing is unavailable to the majority of geoscientists. NetMeeting, however, is different in this regard. All that is needed is a PC, a microphone, and a connection to the Internet.

Because we were using the Internet, and projecting the computer and videos for a larger audience, there were difficulties finding equipment. Additionally, we needed to establish network connections in both locations; fortunately, for everyday use, network connections and PCs are already hooked up. The main requirement for effective meetings using the Internet is a good microphone. The typical omnidirectional microphone that comes with many PCs is insufficient. The alternative is a clip or a unidirectional shotgun microphone, which are much better.

One of the glitches in the symposium was that we had to replace the VCR projector in Toronto 10 minutes before the symposium was scheduled to commence. This caused a system crash, and it took almost 25 minutes to get back on line, setting us slightly off schedule. However, the use of prerecorded video presentations not only allowed us to organize the symposium on a shoestring budget but also assured available presentations in case of network failure.

In our experience, personal use of NetMeeting in research collaboration is a significantly easier process than using it in a large meeting, such as the symposium at GSA. We have been successfully using NetMeeting in our research collaboration between the University of Texas at Austin and Flinders University of South Australia for over a year, testimony to its immediate suitability for that purpose. The only hurdle that may never be overcome is that Earth is round, which means finding a suitable time that both collaborators are awake, working, and ready to talk!

Finally, although flexible delivery, remote distance education, and alternative teaching methods are touted at many universities, the procedures to make a scien-

Symposium *continued on p. 10*

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Symposium *continued from p. 9*

tific video presentation and conduct such a symposium are not always clear or simple. For our symposium, the invited speakers solved these difficulties locally—usually with great effort. Video quality was problematic, owing to the use of standard video cameras instead of broadcast quality cameras and to video translation between the NTSC (United States) and PAL (Australia) formats. Further losses in video quality occurred during projection onto large screens. It may be that this technique is more useful for small group communications, but is not yet appropriate for large meetings.

PSYCHOLOGICAL BARRIERS

Potentially the most interesting aspect of the symposium was an unexpected psychological barrier. We found that it was not easy getting people to converse using the technology. At some points, there were problems with audio quality and understanding the questions and discussion. In this respect, this technique is probably not unlike the early days of leaving messages on answering machines or when e-mail and the Internet were just emerging as new technologies. These are all now a part of our everyday lifestyles. The symposium attendees were interested in observing, but they were tentative about talking to an unseen foreign scientist. The Internet technique could not be compared with, e.g., video conferencing, because the standard video camera that can be used on an everyday PC, fine for single users talking across the Internet, would not have been satisfactory for the symposium. The costs involved in using high-quality camera and visual facilities were prohibitive.

An organizational point of interest was that the strict GSA presentation schedule caused some problems because it was difficult to cut off discussion when it was happening. The conveners could not simply tell the audience that the authors would be available for informal discussions during the coffee break. This is especially difficult when an international discussion had just heated up and become interesting.

GEOSCIENCE COMMUNITY

We were impressed at the skill and energy of the geoscience community involved with this experiment. The invited speakers (Graham Allison, of Allison Partners, former head of CSIRO Land and Water, Australia; Fred Phillips and colleagues from New Mexico Tech; Richard Evans of Sinclair Knight Merz, Australia; Elizabeth Jacobson and colleagues from the Desert Research Institute; Craig Simmons of Flinders University of South Australia; and Matt Uliana and Jack Sharp of the University of Texas at Austin) presented a range of videos on their research on groundwater in arid and semiarid areas. The authors were given complete artistic license over the way that they prepared their videos. The diversity in the styles of video presentation was intriguing. Most speakers had never before made a scientific video. Speakers commented on the difficulty in making a good scientific video presentation and how it required a different level of thought and preparation compared with giving a live presentation at a conference.

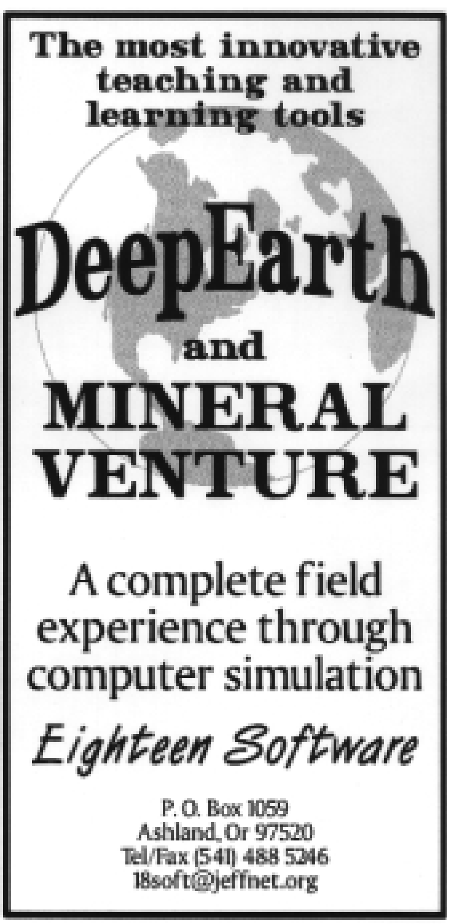
The audiences provided a lot of support for the symposium. On the Australian side at Flinders University, faculty from nearly every science and engineering department were present to see how these new techniques might be incorporated into their research and teaching. Academic staff and graduate and undergraduate students were also quick to pick up GSA membership application forms. In Toronto, brave souls stayed until late in the evening to learn about arid-zone hydrology. Additionally, international scientists from Europe, Africa, South America, North America, and Australia expressed interest in the symposium at our symposium Web site (http://www.geo.utexas.edu/halihan/s27.htm).

CONCLUSIONS AND RECOMMENDATIONS

The symposium demonstrated that today's Internet technology could provide a venue for long-distance scientific communication. Furthermore, we presented some of the best arid-zone hydrology research now being conducted on two continents. The demonstrated interest level supports our belief that the scientific community only stands to benefit from the use of this emerging technology. It is ideal for scientists wishing to collaborate between states and countries. We have found that half-hour conversations about research using NetMeeting are much more effective than months of e-mails because, unlike e-mail, this communication method is spontaneous and immediate.

Some may think, however, that the use of this technology for an international symposium was an overly ambitious idea given the current problems with network and computer reliability that we all seem to face on an almost daily basis. They may be correct, but we favor Einstein's quote, "Anyone who has never made a mistake has never tried anything new." For symposiums and presentations, the technology is not yet as strong as video conferencing, but it is more portable and cost effective. This technology is not a substitute for attending a conference, but it is useful for holding symposia to discuss a particular field area or topic among assembled field assistants, students, and scientists who might otherwise never be able to attend a GSA (or similar) meeting in another country.

We think that the 1998 GSA International Internet symposium was successful as an experiment in an area that will become commonplace in teaching and research in the future. New information technology developments will provide networking methods better than those we employed. Such Internet conferencing will become more widespread in research, in teaching, and at professional meetings. ■



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SAGE REMARKS

Promoting Geoscience Education

Michael J. Smith and Laurie Martin-Vermilyea,
Education Department, American Geological Institute

This has been a very exciting and action-packed year for the Education Department of the American Geological Institute (AGI), and we are delighted to update GSA members about our recent activity. In this report we describe rapid developments within our earth science curriculum projects, AGI's continued support of geoscience scholarships for underrepresented minorities, and a variety of outreach activities directed at promoting earth science awareness and understanding from K–16 and beyond.

EarthComm: Earth System Science in the Commuiity

Many of you have heard of EarthComm, AGI's high school earth science curriculum project, supported through the National Science Foundation and the AGI Foundation. EarthComm was funded to target the grades 9–12 earth science and inquiry standards of the National Science Eduation Standards (NSES). Over the years, many extremely talented individuals have contributed to EarthComm. It has been a labor of love for everyone who has had a hand in shaping it, and the project remains the product of everyone who has contributed.

EarthComm had a highly productive year in 1998. Project staff outlined a design and plan for curriculum development in February, and by late April we had developed template chapter materials and contracted 24 writers in six writing teams across the country to develop the curriculum. Teams of high school teachers and university earth scientists collaborated throughout the summer to produce the first full draft of EarthComm by the first of August. Early in 1998 we established that EarthComm would be shaped to the greatest extent possible by practicing teachers, 37 of whom took part in reviewing the first draft in August and September. By March we had selected the best inquiry-based investigations (over 120 were written) for inclusion in five units and fourteen chapters:

Natural Hazards—Volcanoes and your Community, Earthquakes and Your Community, Plate Tectonics and Your Community

Environments—Geomorphology of Your Community, Surface Processes in Your Community, Land Use Planning in Your Community

Fluid Spheres—Atmosphere Above Your Community, Cryosphere and Your Community, Oceans and Your Community

Earth Resources—Mineral Resources of Your Community, Energy Resources and Your Community, Water Resources in Your Community

Earth System Evolution—Changing Environments in Your Community, Changing Life in Your Community

Every investigation in EarthComm centers on a chapter challenge. The challenge motivates students to use a variety of methods and resources while inquiring about a problem or a focal issue in their community, region, or state, including hands-on data collection and interpretation, video, CD-ROM and Internet-based applications, and media and text-based research. Students are prompted to think about how their developing awareness of issues and science concepts helps them to better understand their community and its connections to the Earth system. We have much work ahead as we refine EarthComm into a version for national field testing in the 1999–2000 school year, but we are excited about the prospects of bringing a product to market that has been shaped by so many talented individuals. For more information, please visit our Web site at http://www.agiweb.org/earthcomm.

Investigating Earth Systems

Investigating Earth Systems (IES) is AGI's inquiry-based earth science curriculum for middle school. Developed within the past two years through funding from the National Science Foundation (NSF) and the Chevron Corporation, IES evolved from the original conception of an upper elementary earth science sourcebook into a nine-module series that targets the grades 5–8 earth science and inquiry standards of the NSES. According to the NSES, middle-grade curriculum should help students apply their observational skills and awareness of natural phenomena to develop an understanding of Earth as a set of closely coupled systems. IES is designed to help students investigate the geosphere, hydrosphere, atmosphere, and biosphere, and establish the inquiry abilities necessary to engage in deeper inquiry into energy systems, geochemical cycles, and the evolution of the Earth system at the high school level.

The scientific and pedagogic design of IES is driven by the NSES and derived from current science education research. Each module is based on a scientific inquiry approach to learning and is focused on student questions and investigations. Collaborative learning strategies are the centerpiece of IES, which promotes student success at making progress in inquiry abilities and earth science understanding and making cross-disciplinary and cross-curricular connections. All IES titles begin with the word "Investigating," and include the following titles: Soil, Minerals, Oceans, Landforms, Water Resources, Climate and Weather, Dynamic Earth, Energy Resources, and Life through Time. IES focuses upon the following big ideas: Earth is a set of closely coupled systems; the geology of Earth is dynamic and ever-changing; the geology of Earth has evolved slowly over a very long time, 4.5 billion years since its birth; Earth's processes are powered by two sources: the Sun and Earth's own inner heat; the geological evolution of Earth has left a record of its history that geoscientists interpret; we rely on Earth's resources, both mined and grown.

More than 45 teachers in 15 states tested IES between December 1997 and April 1999. This spring, pilot versions of all nine modules (with teacher guides) will be revised in preparation for a national field-test program. AGI is currently in the final stages of selecting a publisher. Further information is available on the IES Web site at http://www.agiweb.org/earthsystems/.

Undergraduate and Graduate Education

AGI has a long history of running minority participation programs. The first program began more than 25 years ago. The goal of these programs has always been to increase the representation of ethnic minority students in the geosciences. For the past 25 years, one way in which AGI has addressed this goal is through scholarships. More recently, AGI has sponsored a mentoring program to enhance the experience of these scholars during their academic careers.

In 1998, AGI resubmitted a proposal for continued funding support for the Minority Geoscience Scholarship (MGS) Program. The NSF agreed to fund the program to award $155,000 in under-

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SAGE Remarks *continued from p. 11*

graduate scholarships over a two-year period. In 1998–1999, the MGS program awarded $94,000 to 39 undergraduate scholars (supported by NSF) and 17 graduate students (supported with funds provided by AGI corporate partners, member societies, and individuals).

As part of ongoing dialogue with the NSF, AGI is preparing a proposal to conduct a workshop on underrepresentation in the geosciences. The workshop has four goals. First, we must identify the barriers to minority participation in the geosciences. We expect both to draw upon the knowledge gained from forums and workshops previously held by the geoscience community and to develop new insights from discussions among the workshop participants. Second, we must explore how other science communities have addressed similar barriers. By inviting representatives from other science disciplines, we hope to learn from the experience of others. Third, we must determine if research shows that particular strategies for addressing these barriers are successful. If research in this area is sparse, we might consider developing a partnership with an education research professional to evaluate minority participation programs. Fourth, we must develop a tentative plan to bring down barriers to minority participation in the geosciences. Individuals interested in learning more about or contributing to this conference should contact Laurie Martin-Vermilyea at lmv@agiweb.org.

Collaboration and Outreach

In December 1998, the education departments and executive directors of all AGI member societies participated in a forum on K–12 earth science education. The forum gave participants an opportunity to share ideas and brainstorm about mutual concerns and goals. Participants agreed to a second meeting at AGI on May 22, 1999. We welcome your involvement and participation in the forum. A key item for discussion in May will be GSA's proposed action plan for the implementation of high school earth and space standards.

AGI also made a focused effort to work closely with the leadership and membership of the National Earth Science Teachers Association. NESTA has long supported AGI education initiatives, and we want to ensure that AGI provides opportunities that help the NESTA organization to grow and flourish. Through regular meetings, we have outlined ways that AGI and NESTA can collaborate during the coming year, including revising Earth Science Investigations into a joint AGI-NESTA publication and inviting NESTA members to take an active role in AGI curriculum development and teacher enhancement projects.

This year, *Geotimes* established a monthly column, "Core Studies," dedicated to exploring issues and developments in K–16 earth science education. Topics addressed to date have included the content and method of earth science education, the NESTA organization, AAAS Project 2061 middle school earth science curriculum evaluation, and the issue of content coverage in traditional middle school textbooks. Topical guest columns are welcome and should be directed to Mike Smith at msmith@agiweb.org.

AGI is stepping up efforts for National Earth Science Week, to be held October 10–16, 1999. A Web site at http://www.earthsciweek.org/ provides information about a variety of ways that all members of the geoscience community can become actively involved in promoting the geosciences in public settings. We also continue to promote an Environmental Awareness series and develop and disseminate related posters and bookmarks through a variety of scientific and science education publications. Look for an article about our most recent poster "Metals Empower Us" in the April issue of *Science Scope,* NSTA's middle school teacher journal. ■

1999 GSA SECTION MEETING

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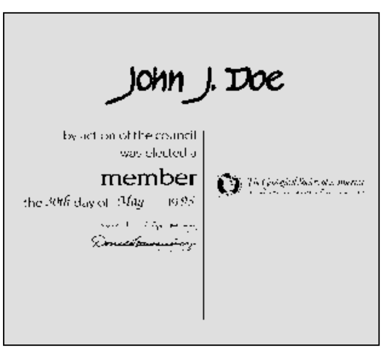

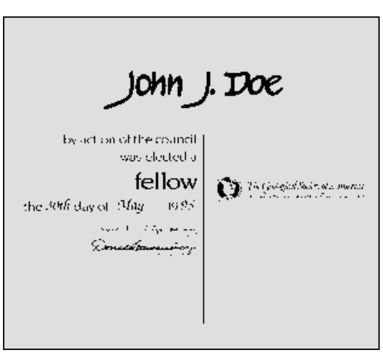

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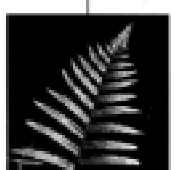

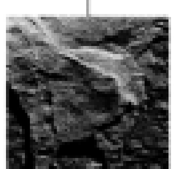

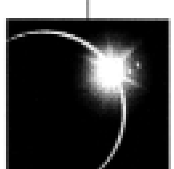

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Washington Report provides the GSA membership with a window on the activities of the federal agencies, Congress and the legislative process, and international interactions that could impact the geoscience community. These reports present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

A Speech and a Legacy

In one way or the other, almost all of us have come to see nature as a precious, but fragile, gift, and an important part of the fabric of our lives. Probably every one of us could cite one particular example where that came home to us as never before. I remember once in 1971, when I was driving to California to visit Hillary—we had just started seeing each other—and I stopped at the Grand Canyon. And I crawled out on a ledge, about an hour-and-a-half or two before sunset, and I just sat there for two hours, and I watched the sun set on Grand Canyon—if you've never done it, you ought to do it.

And because of the way the rocks are layered over millions of years, it's like a kaleidoscope. And the colors change over and over and over again, layer by layer by layer as the sun goes down. It is a stunning, stunning thing to see the interplay of light and stone, and realize how it happened over the ages. I never got over it. I think about it all the time, now, nearly 30 years later.

That kind of moment can't be captured in the words I have shared with you, or even photographed, because the important thing is the interaction of human nature with nature. But we've all felt it. And we all know that part of our essential humanity is paying respect to what God gave us, and what will be here a long time after we're gone.

—President Bill Clinton, March 4, 1999

I've been waiting for several months for the right opportunity to write about the Administration's Lands Legacy Initiative, announced in January. President Clinton's speech, presented at the celebration of the 150th anniversary of the Department of the Interior (DOI) prompted me to do so. Many of the President's comments focused on the diverse stewardship activities of the DOI. He stated that perhaps more than any other department of the federal government, the DOI embodies the history of the United States, from manifest destiny and the great expansion West to fertile fields rising from arid deserts, to people rising from the depths of the Great Depression, to a nation marshaling the resources to win two world wars, to scientific discovery and relentless explorations, to a story of our country's struggle to recognize the dignity and independence and sovereignty of Native Americans.

Clinton commented that in 1849, when the DOI was launched with a headquarters staff of 10 and a budget of $14,200, it lacked a unifying purpose. By comparison, he said, "everything this department does today is guided by the unifying purpose of stewardship." Clinton told the 800 assembled in the DOI auditorium, "As wise and dedicated stewards, you act in the recognition that all of us are but brief visitors on this small planet. You understand that everything we want for our children depends on protecting the forests, the streams, the deserts that were here so very long before we came along. Today, the 'Department of Everything Else,' as it was once called, is and forever will be the 'Department of Stewardship.'"

Stating that "we have much, much more to do," the President said, "First, we must preserve more precious lands...." He stated that he would "soon send the Congress a plan to bestow the highest level of wilderness protection on more than 5 million acres of back country lands within Yellowstone, Glacier, and other national parks. In these vast regions, the roar of bulldozers and chainsaws never again will drown out the call of the wild. I'm also proposing an unprecedented $1 billion Lands Legacy Initiative.... It is no longer enough for our nation to preserve its grandest natural wonders. As communities grow and expand, it has become every bit as important to preserve the small, but sacred, green and open space closer to home. So my Lands Legacy Initiative will also help communities protect meadows and seashores, where children play; streams where sportsmen and women can fish; farmlands that produce the fresh harvest we often take for granted.... I promise to work with Congress to create for the very first time a guaranteed fund for protecting and restoring priceless land all across America."

The Lands Legacy Initiative is the largest one-year investment ever in the protection of America's land resources. This FY 2000 budget proposal represents a 125% increase over FY 1999 funding. The President will ask Congress to provide $1 billion to expand federal protection of critical lands across America, help states and communities preserve local green spaces, and strengthen protections for America's oceans and coasts. This initiative includes $900 million from the Land and Water Conservation Fund (LWCF), marking the first time any Administration has requested funding from the fund to the limit allowable by law. The LWCF draws revenues from federal offshore oil sales. To continue these efforts in the new century, the President has committed to work with Congress to create a permanent funding stream beginning in FY 2001.

The Land Legacy's primary themes are these:

Federal Acquisitions. The initiative increases federal land acquisition funding through the LWCF by 26% to a total of $413 million ($295 million for DOI, and $118 million for USDA). In recent years, the Administration has used LWCF funds to protect Yellowstone National Park from mining, to save ancient redwoods in California's Headwaters Forest, to preserve Civil War battlefields, to complete the Appalachian Trail, and to acquire more than 100 natural and historic sites across the country. Priorities for FY 2000 include acquisition of over 450,000 acres in California's Mojave Desert around Mojave and Joshua Tree National Parks, acquiring 100,00 acres of additional land within national forests and wildlife refuges in Maine, Vermont, New Hampshire, and New York, acquiring lands critical to ongoing federal and state restoration efforts of Florida's Everglades, protecting the Lewis and Clark Trail, the explorers' historic route along the Missouri River, and acquiring lands within Gettysburg, Antietam, and other Civil War battlefields.

Protecting Our Parks. The President is asking Congress to grant permanent wilderness protection to more than 5 million acres within Arches, Big Bend, Bryce Canyon, Canyonlands, Capitol Reef, Crater Lake, Glacier, Grand Teton, Great Smoky Mountains, Rocky Mountain, Yellowstone, and Zion National Parks; Cedar Breaks, Colorado, and Dinosaur National Monuments; Assateague Island National Seashore–Chincoteague National Wildlife Refuge; and Cumberland Gap National Historic Park. Granting these areas the highest level of federal protection available would, in the words of the Wilderness Act of 1964, recognize them as areas "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."

Helping States and Communities Preserve Green Spaces. The Lands Legacy includes $150 million for Land Acquisition Grants for matching grants to state, local, and tribal governments and nonprofit land trusts, for acquisition of land and easements for urban parks, greenways, outdoor recreation, wildlife habitat, and coastal wetlands. The DOI program retools the LWCF state grants program for "smart growth" and preservation of open space. Grants will be awarded on a competitive basis, with priority going to projects consistent with statewide "smart growth" plans. The initiative also proposes a new $50 million for Open Space Planning Grants, a program of matching grants to states to develop open space preservation and "smart growth" strategies. States would use a variety of data and tools to identify priority areas for urban development, farmland, and conservation. The program, administered by DOI, would award grants competitively, with priority going to proposals that tie state plans to regional strategies for managing the economy, job growth, and infrastructure development.

Cooperative Endangered Species Conservation Fund. The initiative proposes $80 million, a $66 million increase, for state and local land acquisition to protect threatened and endangered species. By supporting Habitat Conservation Plans and other flexible tools under the Endangered Species Act, the Fund promotes collaborative strategies that sustain both wildlife and economic development. The program is administered by the U.S. Fish and Wildlife Service.

Forest Legacy Program. To protect private forest land that provides critical wildlife habitat and is threatened by development, the initiative proposes $50 million, a more than sixfold increase, for matching grants to states for the purchase of permanent conservation easements. Use of protected lands for forestry and compatible activities is permitted. The program is administered by the U.S. Forest Service (USFS), and the proposed funding would protect roughly 135,000 acres.

Urban and Community Forestry. The initiative proposes $40 million, a 29 % increase, for matching grants to states and communities to establish, maintain, and expand urban and community forests and related green spaces. The program, administered by USFS, operates in partnership with 8,000 volunteer organizations in more than 10,000 communities. The proposed funding would support 75,000 projects in those communities.

Farmland Protection Program. To protect farmland and sustain rural economies, the Lands Legacy would provide $50 million in matching grants to states, communities, tribes, and land trusts for the purchase of permanent conservation easements on farmland threatened by development. The program, administered by USDA's Natural Resources Conservation Service (NRCS) was created by the 1996 Farm Bill. Through mid-1998, $35 million in federal funding had leveraged an estimated $230 million in easements, protecting about 127,000 acres.

Smart Growth Partnership. The initiative proposes a new revolving loan program to support acquisition of land and easements in rural areas. The partnership, administered by USDA, would make loans to intermediate borrowers (state, local, and tribal governments, and nonprofit corporations), which in turn would loan funds to rural businesses, land trusts, and other nonprofit organizations. Proposed funding of $10 million would support $50 million in loans. Priorities are supporting "smart growth" strategies and helping owners of underproducing forest land, at risk of sale, to improve forest productivity.

Urban Parks and Recreation Recovery. The initiative proposes $4 million in matching grants and technical assistance for the restoration of parks in economically distressed urban communities. The program, administered by the National Park Service, awarded more than 1200 grants from 1978 to 1995 but has remained unfunded since 1995.

Protecting Our Oceans and Coasts. The Lands Legacy proposes $29 million, a 107 % increase, to strengthen protections at 12 national marine sanctuaries off California, Florida, Georgia, Hawaii, Louisiana, Massachusetts, North Carolina, Texas, Washington, and American Samoa. It also begins plans for several future marine sanctuaries. The funding will allow NOAA to accelerate the adoption and implementation of management plans for existing sanctuaries and expand outreach activities with coastal communities.

Coastal Zone Management Act Program. To help promote "smart growth" strategies along America's coasts, the initiative proposes $90 million, a 55% increase, to help states implement Critical Coastal Area Management and Restoration Plans. The matching grants can be used to acquire lands or to undertake other efforts to protect wildlife habitat, protect life and property from coastal hazards, and revitalize ports and urban waterfronts.

National Estuarine Research Reserves System. The initiative proposes $19 million, a 375% increase, to expand a network of critical estuaries representing all the biological regions along America's coasts. NOAA provides guidance and matching funds to states to acquire land, protect resources, and conduct research and education. Twenty-two reserves in 19 states and territories manage about 500,000 acres. The proposed funding would double the protected acreage.

Coral Reef Restoration. The Lands Legacy proposes $10.3 million, a $10 million increase, to protect fragile coral reefs from pollution and other human impacts. NOAA, in conjunction with DOI, would restore injured reefs in Puerto Rico, Florida, Hawaii, and U.S. territories, and develop a coral nursery to grow donor material for restoration projects.

Coastal Dredge Area Restoration. The initiative proposes $10 million for NOAA to work with the U.S. Army Corps of Engineers to use material dredged from ports and shipping channels to restore coastal habitats. Dredging is critical to keep shipping lanes open and deepen channels to accommodate larger ships. Reusing dredge spoils benefits the environment and reduces disposal costs.

Fisheries Habitat Restoration. To restore declining fisheries, the initiative proposes $25 million for NOAA's National Marine Fisheries Service to acquire and protect critical habitat. Efforts would focus on the northeast and middle Atlantic coast, the Gulf Coast, the West Coast, Alaska, and other regions that participate in the National Estuary Program or have multiple threatened or endangered species.

According to the Administration, the Lands Legacy Initiative continues the Clinton-Gore efforts to save America's "natural treasures." If funded at the requested level, DOI will administer $579 million, USDA will administer $268 million, and NOAA will administer $183 million. A parallel $1 billion Livability Agenda was announced by Vice President Gore on January 11. ■

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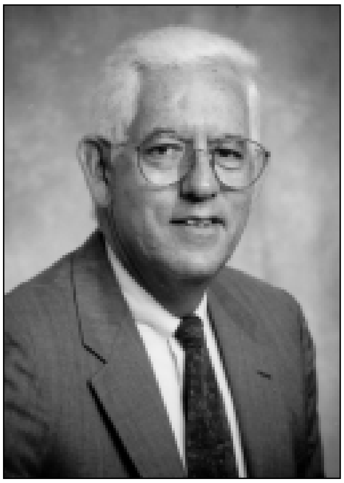
GSAF UPDATE

Julie A. Wetterholt, Acting Director of Development, GSA Foundation

Robert D. Hatcher, Jr., Appointed to Board of Trustees



Bob Hatcher will apply his considerable knowledge about GSA as the newest member of the Foundation's Board of Trustees. Hatcher will serve a five-year term, filling the vacancy left on the board from the June 1998 death of Philip Oxley.

Hatcher, one of the first recipients of GSA's Distinguished Service Award (1988), comes to the Foundation with 25 years of service to GSA. He was a Penrose Conference convener in 1974, 1976, and 1980; served on numerous GSA committees; was both an Associate Editor and Editor of the *GSA Bulletin*; served as a GSA Councilor from 1980 to 1982; and was GSA vice-president in 1992 and president in 1993. Most recently, Hatcher has worked with the GSA Foundation closely on the Second Century campaign, serving as the Southeastern Section Chair.

Hatcher's distinguished career in geology began with degrees from Vanderbilt University and the University of Tennessee (Ph.D.). He has taught and published at Vanderbilt, University of Tennessee, Clemson University, Florida State University, and University of South Carolina. He is currently professor of geology and distinguished scientist at the University of Tennessee's Oak Ridge National Laboratory. He has also served as a consultant with various corporations and has done extensive geologic mapping in North and South Carolina, Georgia, Louisiana, and Tennessee.

Hatcher's knowledge of the geological arena as well as his extensive institutional memory of GSA will bring an important perspective to the board's discussions.

Morris W. Leighton, Chair of the Board of Trustees, commented, "I'm delighted that Bob Hatcher has agreed to join the GSA Foundation's Board of Trustees. He has an outstanding record as a scientist, a teacher, and a leader in our profession. Adding a person of his stature bodes well for the Foundation and its efforts to help support vital GSA programs and activities."

New trustees are selected and appointed by the board from a list of candidates approved by the GSA Council. Trustee terms of office are five years, and individuals can serve a maximum of two consecutive five-year terms. ■

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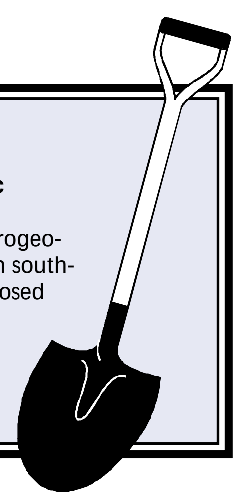

LETTER

Stanley and Hardie (*GSA Today,* v. 9, February 1999) have hypothesized a relationship between skeletal mineralogy and Mg/Ca seawater ratios through the Phanerozoic, but they have overlooked the relationship between protistan skeletal mineralogy, seawater chemistry, and other factors. They (p. 5) state that "there is no overall temporal relationship between their [foraminifera] predominant mineralogy and the Mg/Ca ratio of seawater." Nevertheless, most calcareous suborders of foraminifera that evolved in late Paleozoic "aragonite seas" are characterized by tests of high-Mg calcite or aragonite. The suborder Fusulinina, which is characterized by low-Mg tests, originated in the low-Mg calcite seas of the early Paleozoic.

Like fusulinids, calcareous nannofossils (coccolithophorids) also consist of low-Mg calcite. Nannofossil oozes were prominent in early Paleogene time; but, according to Stanley and Hardie's Figure 2, Mg/Ca ratios in the early Paleogene exceeded those of most of the Cretaceous, when nannofossil oozes were also widespread. Changes in rates and types of ooze deposition may well be related to factors such as nutrient availability and water mass stratification. For example, the apparent decline in coccolithophorid productivity in the Neogene (Stanley and Hardie, 1999) occurred as diatoms, which prefer nutrient-rich conditions, became prominent components of marine plankton. Nutrient availability has also been implicated in the decline and extinction of other taxa, including fusulinids (Martin, 1995, 1996).

References Cited

Martin, R. E., 1995, Cyclic and secular variation in microfossil biomineralization: Clues to the biogeochemical evolution of Phanerozoic oceans: Global and Planetary Change, v. 11, p. 1–23.

Martin, R. E., 1996, Secular increase in nutrient levels through the Phanerozoic: Implications for productivity, biomass, and diversity of the marine biosphere. Palaios, v. 11, p. 209–219.

Stanley, S. M., and Hardie, L. A., 1999, Hypercalcification: Paleontology links plate tectonics and geochemistry to sedimentology: GSA Today, v. 9, no. 2, p. 1–7.

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GSA DIVISIONS—DO YOU BELONG?

Gail Ashley, *GSA President, president@geosociety.org*
Mary Lou Zoback, *GSA Vice-President, zoback@andreas.wr.usgs.gov*

While GSA and science as a whole is acknowledging the need for an integrative, interdisciplinary attack on important scientific problems, we all recognize that effective interdisciplinary science requires strong disciplinary science. GSA's twelve divisions provide a home for like-minded scientists within the Society as a whole, as well as a focus for cross-disciplinary discussion and interaction. In particular, the divisions help develop the scientific program for the annual meetings, provide opportunities for students to participate in the meetings, and help fund student research.

One of the six goals of the new strategic plan adopted by Council in October 1998 is to strengthen relations among GSA divisions and sections, associated societies, and Council. Over the next three years, two candidates will be nominated for the Council ballot from each of the three components; sections (1999), divisions (2000), and associated societies (2001). So, it is particularly important to start a dialogue within all groups now.

This year, each of the 12 divisions will provide information in *GSA Today* about the services they offer students and members. If aligning with a discipline-based group appeals to you, we encourage you to join and bring your ideas to this broader forum within the Society.

The divisions were initially formed by members to ensure topical diversity at annual meetings. The current structure of Divisions should be considered dynamic, rather than fixed. Are there other disciplinary or topical areas (such as environmental geology, paleontology, or marine geology) not covered by the current divisions that could help GSA increase its intellectual diversity and its potential to address current and future earth science and societal challenges? We would like to hear from you.

Coal Geology Division

Cortland F. Eble, *Division Chair, eble@kgs.mm.uky.edu*

The origins of the Coal Geology Division date back to 1945, when the Society of Economic Geologists (SEG) formed a special subcommittee specifically to study coal. This group, known as the SEG Coal Subcommittee, immediately became quite active, sponsoring its first formal meeting on coal research in 1948 at a GSA meeting in New York. The subcommittee was promoted to committee status by SEG in 1950, and its successor, the GSA Coal Geology Group (later Division), was established in late 1955. There has been a formal program every year since 1948.

Today, the Coal Geology Division is represented by a diverse group of earth scientists who encompass the fields of petrology, sedimentology and stratigraphy, structural geology, hydrogeology, geochemistry, paleontology, and environmental geology, as all have applications to coal research. For example, people who study the sedimentology and stratigraphy of coal-bearing areas help predict where mineable coal bodies are likely to occur. More recently, considerable attention has been focused on the environmental impacts of coal utilization, both nationally with the Clean Air Act amendments, and internationally with proposed limits on "greenhouse gas" emissions.

The Coal Geology Division sponsors two awards. In 1971, the Coal Geology Division established the Gilbert H. Cady Award to recognize individuals who have made outstanding and meritorious contributions to the field of coal geology. The award honors the famous American coal geologist and founding member of the division. The division also sponsors an annual student award, the Antoinette L. Medlin Award, to help fund coal-related research.

The Coal Geology Division has a distinguished past and a promising future. Please consider attending the division-sponsored activities at the 1999 annual meeting in Denver. A pre-meeting field trip is being planned as well. By all means, check out the Web site, www.mysite.com/coalgeology, which can be accessed directly or from the GSA home page.

Hydrogeology Division

Mary Jo Baedecker, *Division Chair, mjbaedec@usgs.gov*

The Hydrogeology Division is 40 years old this year, and with 1,340 current members, it is one of the three largest divisions in GSA. The Division emphasizes the role of geology in the hydrologic sciences and the importance of hydrogeology, that branch of the geological sciences that is concerned with the character, source, occurrence, movement, availability, and use of water, to society. Over the past 30 years, hydrogeologists have recognized the importance of geochemical and biological processes to understanding complex problems, and the division offers a forum for interdisciplinary science related to water resource issues.

The division actively promotes activities that benefit students by sponsoring the Birdsall-Dreiss Lectureship, student research grants, and a strong technical program at the GSA Annual Meeting. Students, professionals, and emeritus scientists particularly enjoy the division's annual meeting student reception, where books, software, and historical mugs are distributed to hydrogeology students through a free raffle.

The Birdsall-Dreiss Lecture is presented by a leading hydrologist at 30–40 academic and research institutions each year. This year's lecturer is Stuart Rojstaczer from Duke University (see the Web site for more information—http://www.uakron.edu/geology/gsahydro). The Hydrogeology Division presents the O. E. Meinzer Award annually to the author(s) of a published paper or body of papers of distinction that advanced the science of hydrogeology. It has representatives to GSA sections and encourages participation in section meetings. You are invited to visit the Web site and to join the division (yearly dues for GSA members are $8 for professionals and $3 for students).

Planetary Geology Division

Ralph P. Harvey, *Division Second Vice-Chair, rph@po.cwru.edu*

Geology is more than just "earth science" to the members of the Planetary Geology Division of GSA. The division's goal is to stimulate communication, facilitate learning, and promote student research across the range of planetary geology topics, to recognize outstanding contributions to the field, and to advise and assist the members of GSA in matters pertaining to planetary geology. To meet these goals, a series of yearly activities includes:

- The Stephen T. Dwornik Awards, given annually to the best student presentations (both oral and poster) at the Lunar and Planetary Science Meeting by a U.S. citizen;
- The G. K. Gilbert Award, given annually to an individual who made exceptional contributions to the solution of fundamental problems in planetary geology;
- Providing support for student research related to craters, cratering, and related phenomena through the Shoemaker Memorial Fund for Crater Studies;
- Workshops at GSA Annual Meetings for K–12 educators, bringing current planetary topics to those who can best energize the youngest generation of planetary explorers;

1999–2000 Section Officers and Past Chairs

Cordilleran Section

Margaret E. Rusmore	Chair
To be elected	Vice-Chair
Bruce A. Blackerby	Secretary
Gregory A. Davis	Past Chair

Rocky Mountain Section

Donald W. Hyndman	Chair
Ian M. Lange	Vice-Chair
Kenneth E. Kolm	Secretary
Scott S. Hughes	Past Chair
Glenn D. Thackray	Past Vice-Chair

North-Central Section

Robert D. Hall	Chair
Joseph F. Pachut, Jr.	Vice-Chair
Robert F. Diffendal, Jr.	Secretary
Dennis Kolata	Past Chair
Ardith K. Hansel	Past Vice-Chair

South-Central Section

Calvin Barnes	Chair
Doy L. Zachry, Jr.	Vice-Chair
Rena M. Bonem	Secretary-Treasurer
M. Charles Gilbert	Past Chair

Northeastern Section

Robert D. Jacobi	Chair
Walter A. Anderson	Vice-Chair
Kenneth N. Weaver	Secretary-Treasurer
Allan Ludman	Past Chair

Southeastern Section

Gail S. Russell	Chair
Larry D. Woodfork	Vice-Chair
Harold H. Stowell	Secretary-Treasurer
R. Heather Macdonald	Past Chair
Samuel E. Swanson	Past Vice-Chair

- Theme sessions and symposia on planetary topics, including the upcoming 1999 Pardee Keynote Symposium "Impact Events; Environmental Consequences and Their Influence on the Origin and Evolution of Life" at the GSA Annual Meeting;
- Promoting field trips to sites of interest in planetary geology, such as the "K-T Boundary in the Raton Basin, New Mexico and Colorado" trip at the 1999 GSA Annual Meeting;
- Distribution of recent, relevant planetary educational materials, as well as other planetary goodies, at the division booth in the exhibit hall of the GSA Annual Meeting.

Sedimentary Geology Division

***Mark J. Johnsson,** Division Chair, rph@po.cwru.edu*

The Sedimentary Geology Division exists to bring together GSA members interested in the broad field of sedimentary geology. It does this through sponsorship of events at the GSA Annual Meeting, as well as by building a sense of community through a gathering at the meeting, a newsletter, and a Web site. Students come into this community through workshops subsidies and field trips and through the annual Student Research Award.

Several interesting changes mark this year. The division has adopted a system whereby the secretary-treasurer and the second vice-chair are elected by the membership, and the second vice-chair ascends through succeeding years to first-vice chair, chair, then past chair—a system that should foster more institutional memory than in the past. At the 1999 Annual Meeting in Denver, the division will return to holding its very informal business meeting and get-together over wine and cheese on an afternoon early in the meeting. For the first time, a raffle of donated items (books, maps, software, etc.) will be included. The division has established an award for career achievement in the field of sedimentary geology, named in honor of Laurence L. Sloss.

Sedimentary geology has always been an integral part of GSA. As the field changes and grows, the Sedimentary Geology Division will strive to support the efforts of all its members—especially students. ■

MOVING?

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Call For GSA Committee Service—2000

The GSA Committee on Committees wants your help. The committee is looking for potential candidates to serve on committees of the Society or as GSA representatives to other organizations. You can help by volunteering yourself or suggesting the names of others you think should be considered for any of the openings and submitting your nomination on the form on page 23. Younger members are especially encouraged to become involved in Society activities.

Listed are the number of vacancies along with a brief summary of what each committee does and what qualifications are desirable. If you volunteer or make recommendations, please give serious consideration to the special qualifications for serving on a particular committee. *Please be sure that your candidates are Members or Fellows of the Society and that they meet fully the requested qualifications.*

Volunteering or Making a Recommendation

All nominations received at headquarters by Friday, July 9, 1999, on the official one-page form will be forwarded to the Committee on Committees. *Council requires that the form be complete.* Information requested on the form will assist the committee members with their recommendations for the 1999 committee vacancies. Please use one form per candidate (additional forms may be copied). The committee will present at least two nominations for each open position to the Council at its October 26, 1999, meeting in Denver, Colorado. Appointees will then be contacted and asked to serve, thus completing the process of bringing new expertise into Society affairs.

Committee on Committees

The 1999 committee consists of the following people: Chair J. Leslie Smith, **Department of Geological Sciences, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada, (604) 822-4100**; Joann M. Stock, Division of Geological and Planetary Science, 252-21, California Institute of Technology, Pasadena, CA 91125, (626) 395-6938; Jacob B. Lowenstern, U.S. Geological Survey, Mail Stop 910, 345 Middlefield Road, Menlo Park, CA 94025-3591, (650) 329-5238; Terry L. Pavlis, Department of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148, (504) 280-6797; Deborah R. Harden, 708 Garland Drive, Palo Alto, CA 94303, (408) 924-5021; and David E. Fastovsky, Department of Geology, University of Rhode Island, Kingston, RI 02881-0807, (401) 874-2185.

Committee Vacancies

Annual Program (0 vacancies)
Develops a plan for increasing the quality of the annual meeting in terms of service, education, and outreach. Evaluates the technical and scientific programs of the annual meeting.

Committee members should have previous program experience or experience at organizing an annual meeting, or be actively involved in applying geology knowledge to benefit society and awareness of critical issues.

Continuing Education (1 vacancy)
Directs, advises, and monitors the Society's continuing education program, reviews and approves proposals, recommends and implements guideline changes, and monitors the scientific quality of courses offered.

Committee members should be familiar with continuing education programs or have adult education teaching experience.

Day Medal (1 vacancy)
Selects candidates for the Arthur L. Day Medal.

Committee members should have knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems."

Education (1 vacancy)
Stimulates interest in the importance and acquisition of basic knowledge in the earth sciences at all levels of education.

Committee members work with other interested scientific organizations and science teachers' groups to develop precollege earth-science education objectives and initiatives. The committee also promotes the importance of earth-science education to the general public.

Geology and Public Policy (2 vacancies)
Translates knowledge of the earth sciences into forms most useful for public discussion and decision making.

Committee members should have experience in public-policy issues involving the science of geology. They should also be able to develop, disseminate, and translate information from the geologic sciences into useful forms for the general public and for the Society membership; they should be familiar with appropriate techniques for the dissemination of information.

Honorary Fellows (1 vacancy)
Selects candidates for Honorary Fellows, usually non–North Americans.

Committee members should have knowledge of geologists throughout the world who have distinguished themselves through their contributions to the science.

Membership (2 vacancies)
Evaluates membership benefits and develops recommendations that address the changing needs of the membership and attracts new members.

Committee members must be able to attend one meeting a year. Previous experience in benefit, recruitment, and retention programs is desired.

Minorities and Women in the Geosciences (1 vacancy)
Stimulates recruitment and promotes positive career development of minorities and women in the geoscience professions.

Committee members should be familiar with minority and female education and employment issues and have expertise and leadership experience in such areas as human resources and education. Membership shall include representation of minorities and women and representatives from government, industry, and academia.

Nominations (3 vacancies; one to be a member from Canada or Mexico)
Recommends to the Council nominees for the positions of GSA officers and councilors.

Committee members should be familiar with a broad range of well-known and highly respected geological scientists.

Penrose Conferences (1 vacancy)
Reviews and approves Penrose Conference proposals, recommends and implements guidelines for the success of the conferences.

Committee members must either be past conveners or have attended two or more Penrose Conferences.

Committee Vacancies *continued on p. 21*

Committee Vacancies
continued from p. 20

Penrose Medal (2 vacancies)
Selects candidates for the Penrose Medal.

Committee members should be familiar with outstanding achievements in the geological community that are worthy of consideration for the honor. Emphasis is placed on "eminent research in pure geology, which marks a major advance in the science of geology."

Research Grants (3 vacancies)
Evaluates research grant applications and selects grant recipients.

Committee members must be able to attend the spring meeting and should have experience in directing research projects and in evaluating research grant applications.

Young Scientist Award (Donath Medal) (2 vacancies)
Selects candidates for the Donath Medal.

Committee to have members covering a broad range of disciplines, i.e., geophysics, economic geology, stratigraphy. Committee members should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research which marks a major advance in the earth sciences."

entative to the North American Commission on Stratigraphic Nomenclature (2 vacancies)
Must be familiar with and have expertise in stratigraphic nomenclature. ■

A GSA Committee May Need You

Steve Stow, *Chair, 1997 Committee on Committees*

Perhaps you feel that if you nominate someone for a GSA committee, your nomination goes into a black hole, or is lost among hundreds of other nominations submitted when the Society annually calls for members to serve on committees, as it does in this issue of *GSA Today.* And if you were to volunteer for a committee assignment, your offer wouldn't be taken seriously, would it?

The reality is that there is no black hole, and every nomination for committee service is considered carefully.

The reality is also that since 1990, the number of volunteers for committee service has dropped from 50 per year to an average of 30 and that the number of members nominated for appointment has varied annually from a low of 16 in 1996 to a high of 75 in 1993; the average is 39 per year. Since 1992, the number of appointees to GSA committees has been highly variable, from zero to more than 20.

For many reasons, it is not possible—or even advisable—to use only names of volunteers and nominees in making committee assignments. Many factors, including experience, geoscience discipline, geography, prior GSA experience, and minority representation, go into the selection process. The Committee on Committees draws on names of individuals considered but not selected by the previous committee, as well as its own personal knowledge of qualified candidates, in getting a slate that is truly representative of the GSA membership and qualified to perform the functions of the varied committees. It is a full day's job (after a lot of preliminary work) to arrive at the final list of candidates to be presented to the GSA Council for approval, an indication of how carefully each volunteer and each nominee are considered.

If your name, volunteered or nominated, comes before the 1999 Committee on Committees and is not selected, don't lose hope—try again next year. The simple fact that someone wants to devote some of his or her time to helping GSA, or the fact that one member feels strongly about nominating another, goes a long way in elevating that person's chance of being selected.

Graduate Students Encouraged to Volunteer!

Graduate students are now eligible to serve on GSA Committees as full members. All graduate students are encouraged to volunteer or nominate others for committee service.

1999 Committees and Representatives

Executive Committee
Gail M. Ashley—President and Chair; Mary Lou Zoback—Vice-President; Victor R. Baker—Past President; David E. Dunn—Treasurer; Dorothy L. Stout—Council Member-at-Large

Annual Program Committee
Sharon Mosher—Chair, 1996–1998; Rob Van Der Voo, 1999–2001; Larry Middleton, 1999–2001; Jonathan G. Price, 1997–1999; Denis M. Shaw, 1997–1999; G. Lang Farmer, 1998–2000; Robert Karlin, 1999–2001; *Ex officio:* Kathy Lynch—Meetings Manager; Donald M. Davidson, Jr.—Executive Director; John D. Humphrey

Audit Committee
Joaquin Ruiz—Chair, 1999; Allison R. Palmer, 1999; David B. MacKenzie, 1997–1999; Melvin J. Hill, 1998–2000; Joaquin S. Ruiz, 1998–2000; *Ex officio:* David E. Dunn—Treasurer

Committee on the Budget
David E. Dunn—Chair and Treasurer, Samuel S. Adams, 1996–2000; Arden L. Albee, 1998–2002; *Ex officio:* Donald M. Davidson, Jr.—Executive Director; Dennis G. Kyhos—Chief Financial Officer

Committee on Committees
J. Leslie Smith—Chair; Joann M. Stock; Jacob B. Lowenstern; Terry L. Pavlis; Deborah R. Harden; David E. Fastovsky

Committee on Continuing Education
Odin D. Christensen—Chair, 1997–1999; Grant R. Woodwell, 1997–1999; Charles G. Groat 1998–2000; David S. McCormick, 1998–2000; James E. Barrick, 1999–2001; Anthony W. Walton, 1999–2001

Committee on the Arthur L. Day Medal Award
B. Clark Burchfiel—Chair, 1999; Kip V. Hodges, 1997–1999; E. Calvin Alexander, Jr., 1998–2000; Jon P. Davidson, 1998–2000; Julie D. Morris, 1998–2000; D. Michael Gurnis, 1999–2001; Ken Kodama, 1999–2001

Committee on Education
R. Heather MacDonald—Chair, 1997–1999; Madge Evans, 1997–1999; Maureen Allen, 1998–2000; Steven C. Good, 1999–2001; Katie KellerLynn, 1999–2001; Brian Poelker, 1999–2000; Section representatives: Elizabeth Ambos (Cordilleran); not yet chosen (Rocky Mountain); Sherman P. Lundy (North-Central); Frances (Betsy) E. Julian (South-Central); Rachel Burks (Northeastern); John Callahan (Southeastern); *Ex officio:* Mary Lou Zoback—Vice-President; Conferee: Edward E. Geary—Director of Educational Programs

Committee on External Awards
Douglas W. Burbank—Chair; B. Clark Burchfiel—; Division Representatives: Cassandra R. Coombs (Planetary Geology); George M. Hornberger (Hydrogeology); Mark Cloos (Structural Geology and Tectonics); Susan Mahlburg Kay (International Geology); Rolfe D. Mandel (Archaeological Geology); Christopher Fedo (Sedimentary Geology)

Committee on Geology and Public Policy
Peter F. Folger—Chair, 1999–2001; Lee C. Gerhard, 1997—1999; James M. Robertson, 1997–1999; James E. Evans, 1998–2000; Virgil A. Frizzell, Jr., 1998–2000; Sally J. Sutton, 1998–2000; Paul Geoffrey Feiss, 1999–2001; Rachel Burks, 1999–2001; Patricia H. Kelley, 1999–2001; Past Congressional Science Fellows: Jill S. Schneiderman, 1996–1998; Peter F. Folger, 1997–1999; Tamara J. Nameroff,

1999 Committees *continued on p. 22*

1999 Committees *continued from p. 21*

1998–2000; *Ex officio* (Section representatives): Susan Halsey (Northeastern); Thomas J. Evans (North-Central); Jerome V. DeGraff (Cordilleran);

Not yet chosen (Rocky Mountain); John D. Kiefer (Southeastern); not yet chosen (South–Central); Conferee—ad hoc Committee on Critical Issues: Allison R. Palmer; *Ex officio:* Monica Gowan—Past Chair; Cathleen L. May—Director, IEE; Council/Committee Liaison: Victor R. Baker—Past President

Committee on Honorary Fellows
Parke D. Snavely III—Chair, 1997–1999; Brian J. Skinner, 1997–1999; Michael A. Dungan, 1998–2000; Donald R. Lowe, 1998–2000; Hans J. Hofmann, 1999–2001; Gabor Tari, 1999–2001; *Ex officio:* Ian W. D. Dalziel—International Secretariat

Committee on Investments
Carel Otte—Chair, 1996–1999; R. Thayer Tutt, Jr., 1996–1999; Melvin J. Hill, 1998–2000; Michael Wahl, 1999–2002; George H. Davis, 1999–2001; *Ex officio:* David E. Dunn—Treasurer; Brian J. Skinner—GSA Foundation designee

Committee on Membership
William D. Carlson—Chair, 1997–1999; George H. Davis, 1997–1999; Reinhard A. Wobus, 1997–1999; Bruce A. Bouley, 1998–2000; Kenneth L. Pierce, 1998–2000; Andrew Gombos,1999–2001

Committee on Minorities and Women in the Geosciences
Mary E. Dowse—Chair, 1998–2000; Rosaly Lopes-Gautier, 1997–1999; Joseph C. Cepeda, 1998–2000; Jim B. Finley, 1998–2000; Lisa A. Rossbacher, 1998–2000; Arthur G. Goldstein, 1999–2001; Frank R. Hall, 1999–2001; Lois J. Wardell, 1999–2001; Lisa D. White, 1999–2001; Conferees: Rhea L. Graham—Council/Committee Liaison; Edward E. Geary—Director of Educational Programs

Committee on Nominations
Lisa Pratt—Chair, 1997–1999; John W. Hess, Jr., 1998–1999; Derald G. Smith, 1998–1999; James N. Connelly, 1999–2000; Marcus Milling, 1999–2000

Committee on Penrose Conferences
Thomas W. Gardner—Chair, 1999; Joann M. Stock, 1997–1999; Thomas W. Gardner, 1998–2000; Naomi M. Oreskes, 1998–2000; Fred M. Phillips, 1998–2000; Paul L. Koch, 1999–2001

Committee on the Penrose Medal Award
Douglas W Burbank—Chair, 1999; Phillip C. England, 1997–1999; John E. Suppe, 1997–1999; Russell S. Harmon, 1998–2000; Leonard F. Konikow, 1998–2000; Mary J. Kraus, 1998–2000; Earle F. McBride, 1999–2001; Richard K. Bambach, 1999–2001

Committee on Publications
B. Clark Burchfiel—Chair, 1999; Allison R. Palmer, 1998–2000; Kevin T. Biddle—Member-at-large, 1997–1999; Abhijit Basu, Editor, Books; John W. Geissman, Editor, *Bulletin;* Lee R. Kump, Editor, *Geology;* John M. Sharp, Jr., Co-Editor, *Environmental and Engineering Geoscience;* Peg Lehr, Conferee, Director of Publications; Connie J. Manson, GIS Representative

The GSA Council acknowledges the many member-volunteers who, over the years, have stimulated growth and change through their involvement in the affairs of the Society.

Each year GSA asks for volunteers to serve on committees, and many highly qualified candidates express their willingness to serve. Not everyone can be appointed to the limited number of vacancies; however, members are reminded that there are also opportunities to serve in the activities and initiatives of the sections and divisions. Annually, the Council asks sections and divisions to convey the names of potential candidates for committee service to the Committee on Committees.

Committee on Research Grants
Paul M. Myrow—Chair, 1999; James N. Connelly, 1997–1999; Duncan M. FitzGerald, 1997–1999; James G. Schmitt, 1999; Thomas L. Patton, 1997–1999; Allen F. Glazner, 1998–2000; Brian G. Katz, 1998–2000; Jim E. O'Connor, 1998–2000; National Science Foundation Conferee: Russell C. Kelz

Treatise on Invertebrate Paleontology Advisory Committee
John Pojeta, Jr.—Chair, 1997–2000; William I. Ausich, 1997–2000; Richard Arnold Davis, 1997–2000; Donald M. Davidson, Jr., Executive Director

Committee on the Young Scientist Award (Donath Medal)
J. Leslie Smith—Chair, 1997–1999; Randall R. Parrish, 1997–1999; Robert C. Thunell, 1997–1999; Judith L. Hannah, 1998–2000; W. Berry Lyons, 1998–2000; Ian Hutcheon, 1999–2001; Joaquin Ruiz, 1999–2001

Ad Hoc Committee on Critical Issues
Alison R. (Pete) Palmer—Chair; Mary Barber; Kenneth L. Conca; George W. Fisher; William S. Fyfe; R. Gordon Gastil; Carroll Ann Hodges; Susan W. Kieffer; Emlyn Koster; Richard B. Norgaard; Allison R. (Pete) Palmer; Daniel Sarewitz; Jill S. Schneiderman; A. Wesley Ward, Jr.

GSA Member of the American Geological Institute (AGI) Member Society Council
Mary Lou Zoback, 1999-2001

GSA Member of the AGI Education Advisory Committee
Edward E. Geary—GSA Director of Educational Programs

GSA MEMBER OF THE AGI GOVERNMENT AFFAIRS PROGRAM ADVISORY COMMITTEE
Virgil A. Frizzell, Jr., 1998–2000

GSA Representatives to the American Association for the Advancement of Science (AAAS)
Section E—Geology and Geography: Maryellen Cameron, February 19, 1997–February 22, 2000; Section—Atmospheric and Hydrospheric Sciences: John G. Weihaupt, July 1, 1988–February 22, 2000

GSA Representatives to the AAAS Consortium of Affiliates for International Programs (CAIP)
Ian W. D. Dalziel—International Secretary; Donald M. Davidson, Jr.—GSA Staff Liaison

GSA Representatives to the North American Commission on Stratigraphic Nomenclature (NACSN)
David T. King, Jr., 1997–2000; Ardith K. Hansel—Representative Elect, 1998–2001

GSA Representative to the *Treatise* Editorial Advisory and Technical Advisory Boards of the Paleontological Institute
John Pojeta, Jr.—Chair, *Treatise on Invertebrate Paleontology* Advisory Committee

GSA Representatives to the Joint ASCE–GSA–AEG Committee on Engineering Geology (American Society of Civil Engineers, Association of Engineering Geologists)
Donald C. Helm, 1997–1999; Bruce R. Rogers, 1997–1999

GSA Representative to the U.S. National Committee on Scientific Hydrology
David A. Stephenson, 1990–; John M. Sharp, Jr., (alternate)

GSA and AASG Selection Committee for the John C. Frye Memorial Award in Environmental Geology (Association of American State Geologists)
Frank E. Kottlowski—Chair, AASG representative; Richard C. Berg, GSA representative, 1998–2000; Larry D. Fellows, AASG representative ■

NOMINATION FOR GSA COMMITTEES FOR 2000

(One form per candidate, please. Additional forms may be copied.)

(Please print)

Name of candidate ____________________

Address ____________________

____

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COMMITTEE(S) BEING ☐ VOLUNTEERED or ☐ NOMINATED FOR (please check):

Committee(s):

Comment on special qualifications:

☐ GSA Fellow Section affiliation:

☐ GSA Member Division affiliation(s):

Brief summary of education:

Brief summary of work experience (include scientific discipline, principal employer—e.g., mining industry, academic, USGS, etc.):

If you are VOLUNTEERING to serve GSA, please give the names of 2 references (please print):

Name: ____________________

Phone: ( ) ____________________

Name: ____________________

Phone: ( ) ____________________

If you are NOMINATING SOMEONE other than yourself to serve GSA, please give your name, address, and phone number (please print):

Name: ____________________

Address: ____________________

____

Phone: ( ) ____________________

DEADLINE: Please return this form to GSA Headquarters, Attn: Becky Bordner, P.O. Box 9140, Boulder, CO 80301-9140, by Friday, July 9, 1999. *Form must be complete to be considered.*

New Headquarters Department Focuses on Development

A Professional Development Department has been formed at GSA headquarters to coordinate the wide variety of education and career-enhancement opportunities available from the Society. Creation of this department allows new and existing programs to be brought together in order to effectively provide a suite of related services to the membership.

Programs and activities available through Professional Development include: Research Grants, Field Trips, Short Courses, Penrose Conferences, Field Forums, GeoVentures, Career and Employment Services, and the activities of GSA Sections, Divisions, and Associated Societies. Terry Moreland, who is also GSA's Director of Member Services, heads the department. Staff members include Leah Carter, Pat Chenworth, Edna Collis, and Nancy Williams. To contact the Professional Development group, please call GSA headquarters, or e-mail profdev@geosociety.org.

BOOK REVIEWS

Geomorphology: A Canadian Perspective. *By A. S. Trenhaile. Oxford University Press, Toronto, 1998, Can $37.95.*

Over the past several decades, geomorphology has grown remarkably. It has also evolved from a largely descriptive discipline, commonly a secondary element in traditional geography programs, into a more quantitative and autonomous natural science with links to many other disciplines, including geology, oceanography, climatology, hydrology, and soil science. Understanding the processes that shape Earth's surface is central to an education in earth science, and enrollments in university geomorphology courses have shot up as the science has matured.

Numerous books in geomorphology and related fields have appeared in recent years, the most recent being *Geomorphology: A Canadian Perspective,* by Alan S. Trenhaile, professor of geography at the University of Windsor (Ontario). This text builds on its predecessor, *The Geomorphology of Canada* (Oxford University Press, 1990), but differs from it in being more comprehensive. What sets this book apart from other geomorphology texts is its strong emphasis on Canadian themes and examples.

The book comprises an introduction, 13 thematic chapters, a glossary, a list of symbols, a bibliography, and an index. The Introduction is a mini-primer in earth science and is perhaps the weakest part of the book, covering too much ground in too little space (21 pages). The Introduction is followed by a chapter on the physical background of Canada and by 11 chapters on various geomorphic processes and landforms (weathering, slope forms and processes, glaciers, glacial sediments and landforms, glaciation of Canada, periglaciation, fluvial processes, fluvial landforms, coastal processes, coastal landforms, and karst). Fundamental processes and resulting landforms are emphasized in each of these chapters. Trenhaile skillfully avoids dry recitations of stratigraphic terminology and sequences of events of only local or regional interest. The last chapter deals with humans as geomorphological agents and the role of geomorphology in environmental planning. This chapter, like the Introduction, is too short to do justice to the topic.

The book is well organized, clearly written, and nicely illustrated. It contains few typographical or factual errors. Although there are no photographs, the text is complemented by 174 line drawings. Trenhaile appears to have made a conscious decision to write a book that students could afford. He has succeeded in packing an amazing amount of information into a 340-page paperback. The downside of such a short, affordable book is that topics cannot be discussed in depth—each of the chapters could easily be expanded into a separate book (most have). Some topics, however, especially those that the author knows best (glaciation, coastal processes, and landforms), are given more thorough treatment than others. The book is largely descriptive, but quantitative aspects of mass movement, glacier and stream flow, and coastal and aeolian processes are briefly mentioned—again a more in-depth discussion is precluded by lack of space.

A few quibbles: The reference list is selective. I would have preferred more thorough referencing even if it meant eliminating the glossary, which is also selective. A map showing key geographical place names (perhaps on the inside back cover, which is blank) would help non-Canadian readers orient themselves. Finally, the short summaries at the ends of chapters are not very informative; they either should be deleted or improved in the next edition.

Book Reviews *continued on p. 26*

Field Forums: A New Opportunity for Research Scientists

Field Forums, a new GSA program starting in 2000, offers the opportunity for exchange of current knowledge and exciting ideas well expressed by the geology of a specific area. Field Forums are designed after Penrose Conferences, with a combination of invited and interested attendees, but completely in a field setting. The format is similar to GSA Annual Meeting field trips, but run independently from that or any other meeting. The intent is to stimulate and enhance individual and collaborative research and to accelerate the advance of the science by interactions in the field. Field Forums are designed to encourage open and frank discussion of ideas in an informal field atmosphere. In this new Field Forum program, geologists can lead organized field trips to any area, unrestricted by the time or location of the annual or section meetings. We anticipate a greater diversity of both field trips and attendees.

Field Forums will have a specific thematic focus, similar to Penrose Conferences, but may be more geographically oriented. Content will be guided by a small group of leaders with logistical responsibility.

Organizers will invite a few key participants, such as other people who have worked in the area or on similar problems, to ensure the success of the Field Forum. The rest of the participants will be selected by the organizers from applications received in response to an announcement of the forum in *GSA Today* and other scientific publications. Student participation (20%) will be encouraged through discounted rates.

Field Forums will be five or more days and the size of the group between 20 and 40 people. The length and size are flexible, however, depending on the logistics. The only in-house conferencing will occur in the evenings and will be a very minor component of the forum.

Field Forums may be international in scope and are not restricted to a single location.

Potential Field Forums

Potential field forums include Penrose Conference topics that would be much more effective in a field setting or field trips that capture the essence of new, exciting discoveries or a controversial topic. The first Field Forums for 2000 will be announced this summer.

Specific Requirements

Leaders: Field trip leaders should have technical competence and be knowledgeable about current activities in the field area

Field Forums *continued on p. 25*

2000 Annual Meeting Reno, Nevada

November 13–16
Reno-Sparks Convention Center

General Chair

Richard A. Schweickert, University of Nevada
richschw@mines.unr.edu

Technical Program Chair

Robert Karlin, University of Nevada
karlin@mines.unr.edu

Due Date for Pardee Keynote Symposia and Topical Proposals:

January 10, 2000

For More Information:

Call the GSA Meetings Department: (303) 447-2020 or 1-800-472-1988
Fax: 303-447-0648
E-mail: meetings@geosociety.org
Web site: www.geosociety.org

Call for Field Trip Proposals

We are interested in proposals for single-day and multi-day field trips beginning or ending in Reno, and dealing with all aspects of the geosciences.

Please contact the Field Trip Co-Chairs:

Mary Lahren
University of Nevada, Department of Geological Sciences, Mackay School of Mines, MS 172, Reno, NV 89557-1038, (775) 784-6610, fax 775-784-1833, lahren@mines.unr.edu

Paula Noble
University of Nevada, Department of Geological Sciences, Mackay School of Mines, MS 172, Reno, NV 89557-1038, (775) 784-6610, fax 775-784-1833, noblepj@unr.edu

Steve Peters
University of Nevada, Department of Geological Sciences, Mackay School of Mines, MS 172, Reno, NV 89557-1038, (775) 784-6610, fax 775-784-1833, speters@usgs.unr.edu

Future GSA Meetings

2001 Boston, Massachusetts, November 5–8
2002 Denver, Colorado, October 27–30
2003 Seattle, Washington, November 2–5

Field Forums *continued from p. 24*

to be visited. Responsibility for organizing a Field Forum should be shared by at least two leaders, one of whom has actively worked in the area. At least one leader should be a member of GSA. In addition to scientific expertise, the leaders must have experience leading field trips in general and with the logistics involved in leading a trip to this specific area. Both organizational and interpersonal skills are required to deal positively and effectively with potential logistical problems and the many personality types of the participants. Leaders need to be able to run a field trip where open discussion of different ideas and interpretations is fostered.

Guidebook: A guidebook will be written for each trip and is the sole responsibility of the leaders. No formal publication is expected, but the leaders may submit a proposal to include the guidebook in GSA's field guide series.

Costs: The field trip must be self-supporting. The leaders have complete responsibility for the planning, logistics, and finances. GSA provides the following benefits: insurance, publicity, registration, accounting, and surveying of registrants. GSA will provide administrative support through the early stages of the procedures.

Location of Trips: No restrictions about holding forums anywhere in the world are made, although logistics, costs, and other problems dictate caution in organizing forums outside North America. Such forums may add an important dimension to the Field Forum program.

Participation: Participants have the ethical obligation of not using, in any way, any original information that may be revealed in discussion by other participants.

Review: Proposals for 2000 will be reviewed by the Annual Program Committee, which will provide quality control and guidance to prospective leaders.

Sponsors: The Geological Society of America is the principal sponsor of the Field Forums; however, other societies, organizations, and institutions are welcome as cosponsors and may share in the costs.

Professional Rates: Companies are encouraged to pay a special rate for participation of employees to help cover partial costs of student participation.

Donors: Foundations and private industry may be solicited for donations to partially cover field costs, particularly for expensive trips, with prior approval of the Executive Director of GSA.

To submit a proposal or for more information, contact ecollis@geosociety.org. To discuss potential Field Forums, contact Sharon Mosher, chair of the Annual Program Committee (mosher@mail.utexas.edu). ■

Call for Short Course Proposals

Due December 1, 1999

The GSA Committee on Continuing Education invites those interested in proposing a GSA-sponsored or cosponsored short course to contact GSA headquarters for proposal guidelines. Short courses may be conducted in conjunction with all GSA annual or section meetings. We are particularly interested in receiving proposals for the 2000 Annual Meeting in Reno or the 2001 Annual Meeting in Boston.

Proposals must be received by December 1, 1999. Selection of courses for 2000 will be made by February 1, 2000. For those planning ahead, we will also consider courses for 2001 at that time.

For proposal guidelines or information, contact: Edna Collis, Professional Development Coordinator, GSA headquarters, 1-800-472-1988, ext. 134, ecollis@geosociety.org.

These criticisms, however, are minor. Thumbs up to *Geomorphology: A Canadian Perspective*. It provides an excellent introduction to geomorphological processes and landforms. I recommend this book to geologists and geographers who wish to know more about the geomorphology of the world's second largest country, the landscape of which has been profoundly shaped by glaciation, periglaciation, and other geomorphic processes. The book will be particularly valuable to Canadian university students. At approximately US $25, it's a bargain.

John J. Clague
Simon Fraser University
Burnaby, BC V5A 1S6, Canada
and Geological Survey of Canada
jclague@sfu.ca

Integrated Earth and Environmental Evolution of the Southwestern United States: The Clarence A. Hall, Jr. Volume. *By W. G. Ernst and C. A. Nelson, Geological Society of America, Boulder, Colorado, 1998, paperbound, 502 p., $89.95.*

There are basically two kinds of papers in this volume: (1) tectonic reconstruction papers (10), providing insightful interpretation of the tectonic development of regions, or the tectonic evolution of processes within prescribed time windows; and (2) focused descriptive papers (13), providing comprehensive data and elaborated interpretations for specific subregional geological systems with the aim of addressing particular debated issues. The tectonic reconstruction papers will be of interest to a broad readership in tectonics; the focused descriptive papers will be of particular interest to geoscientists working on particular problems. The 23 contributions are organized loosely within a four-part framework: Crustal Evolution, Great Basin, Sierra Nevada, and Western and Baja California. The organizational framework does not really work; however, the papers themselves, no matter how arranged, *do* work.

Tectonic Reconstruction Papers: W. B. Hamilton presents a rare account of the details of Archean history. E. M. Moores speculatively challenges our comfortable views on the Mesozoic evolution of the North American Cordillera. B. P. Wernicke and J. K. Snow lay a foundation for the stepwise kinematic evolution of the Basin and Range. C. H. Stevens and others provide a comprehensive look at continental-margin evolution along the western edge of North America. S. Hetzner and others disclose patterns and gradients of temperature, precipitation, evaporation, and topography in relation to ecology and vegetation, from the Sierras to the Colorado Plateau. M. Ducea and J. B. Saleeby make a strong case for delamination of the lithosphere beneath the Sierra Nevada. R. V. Ingersoll places the Proterozoic to Holocene tectonic evolution of the Cordilleran in an actualistic context, illustrating plate tectonic sections crossing from the central California coast to Utah. G. J. Axen and J. M. Fletcher provide a critical review of the late Miocene to Pleistocene extensional history of the northern Gulf of California. T. Atwater and J. Stock provide "the last word" on formation of the slab window and the evolution of the spreading geometry of the post-Farallon microplates. The tight reconstructions place important constraints on the "time-space budget of deformation" within western North America. A. E. Fritsche presents palinspastic reconstructions of southwestern California that make me glad I'm working on the Colorado Plateau.

Focused Descriptive Papers: A. Yin and R. V. Ingersoll clarify the interrelationships of basins to pop-ups in the Southern Rockies, and elaborate the regional stress implications. D. I. Axelrod estimates paleoelevations from Tertiary floras for the Sierra Nevada–Great Basin–Rocky Mountains region. J. E. Warme and H-C. Kuehner conclude that the Devonian Alamo Breccia of southern Nevada represents catastrophic detachment and flow of platform carbonates. S. S. Morgan and R. D. Law do nitty-gritty tectonite analysis on two sets of folds and cleavage in the White-Inyo Range. K. B. Krauskopf revisits *Ten Plutons* in a *Retrospective View.* C. A. Nelson examines the Beer Creek–Cottonwood igneous contact in the White Mountains, California. J. F. Mount and K. J. Berg provide detailed paleoreconstructions of the Lower Cambrian evolution of sequences of siliciclastic and carbonate rocks. B. C. Burchfiel, C. S. Cameron, and L. H. Royden take us through the Keystone thrust family, unit by unit, fault by fault, movement by movement. D. S. Coleman and A. F. Glazner provide an essential reference on the geochemical and isotopic characteristics of plutons of the high peaks of the Sierras, including the Tuolumne intrusive suite. D. J. Wood and J. Saleeby present a tour de force in documenting collapse-generated detachment relationships in the southern Sierras. K. M. Knesel and J. P. Davidson discuss the origin of large-volume silicic magma systems related to Long Valley caldera. D. P. Mayo, J. L. Anderson, and J. L. Wooden evaluate source and source level of Jurassic plutons in southern California. D. E. Miller and W. G. Ernst look carefully at the Western Triassic and Paleozoic belt of the Klamaths and conclude that it represents a single metamorphosed thrust sheet, exposed at various levels.

Editors Ernst and Nelson and the contributing authors achieved their objective. They have a book that celebrates the quality and range of the intellectual contributions of Clarence Hall. This book will become known as "The Clarence Hall Volume"; nobody will remember "integrated earth and environmental evolution of the southwestern United States." This is how it should be. Oh, yes, the cover for the second printing should show Clarence Hall, in action.

George Davis
University of Arizona
Tucson, AZ 85721-0077
George.davis@geo.arizona.edu
Note: Available through the GSA Bookstore

Ecoregions: The Ecosystem Geography of the Oceans and Continents. *By Robert G. Bailey. Springer-Verlag, New York, 1998, 176 p., $79.95.*

The intent of this book is to apply principles of climate and geography to describe and characterize Earth's major ecoregions or ecological zones—continental and oceanic—and to provide descriptions, illustrations, and examples that will assist the user in interpreting ecoregion maps. Following an introductory chapter, there are two chapters on the ocean and then five chapters on different continental ecoregions (e.g., polar, humid temperate, dry, humid tropical, and mountain ecoregions).

This very generalized, simplified, and descriptive treatment of these global regions has some shortcomings, including misspelling, incorrect use of terminology, and general lack of proofreading. Many of the references cited are 25 to over 50 years old; the text doesn't present much new information, but renames and redescribes regions that were designated some decades ago (many of these regions, denoted Pa, A, Pt, for example, are simply renamed from 1954 and 1963 references). The names of oceanic ecoregions bear no resemblance to terminology used by present oceanographers. For example, the Eastern Boundary Current areas are called "Equatorward Trades Division." Two of the examples of such regions are spelled incorrectly as "Canaries" and "Humbolt" currents. The explanation of the upwelling process, which characterizes these regions, is also incomplete. Regions of Western Boundary Current are designated as the "Jet Stream Division." The well-known gyres that dominate wind patterns over certain regions of the oceans are called "oceanic whirls." Hydrographic regions are called "hydrologic" regions. "Sea elephant" is used instead of "elephant seal."

Book Reviews *continued on p. 28*

May *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 111, Number 5, May 1999

GEOLOGY

VOLUME 27
NO. 5
P. 385–480
MAY 1999

Many of the explanations are very simplified; some of these were not proofread—for example (p. 21), "small, sometime microscopic plant animal and plant organisms know as plankton."

Bailey appears to be far more comfortable describing the continental ecoregions—general characteristics, flora and fauna, climate, etc. On the positive side, many of the illustrations are in color, and although on a global scale, do help to illuminate the generalized global distribution of various parameters that determine ecoregions. Some of the color figures are simply hand-colored historic postcards of various geographic regions of Earth from the "author's collection." The book ends weakly in a one-half page chapter titled "Summary and Conclusion." This is a very generalized reference that doesn't contribute significantly to the existing information base or our understanding of these global regions.

Gary B. Griggs
University of California
Santa Cruz, CA 95064

People and the Earth: Basic Issues in the Sustainability of Resources and the Environment. *By John J. W. Rogers and P. Geoffrey Feiss. Cambridge University Press, Cambridge, UK, 1998, 338 p., $80 (hardbound), $32 (paperbound).*

People and the Earth is not a conventional Geo-1 text newly packaged in a veneer of add-on environmental and/or Earth systems science. Rather, it is a novel, from-the-ground-up approach to the overwhelming socioeconomic, political, scientific, and technological problems that face humanity as we approach the 21st century. Divided logically into eight chapters plus a wrap-up—(1) People and Land, (2) Food, (3) Natural Hazards, (4) Water, (5) Energy, (6) Mineral Resources, (7) Waste and Pollution, and (8) Global Change—it treats the terrestrial environment as a series of interlocking, intergradational problems. Topics progress smoothly from exponential population growth, to agricultural productivity and the Green Revolution, to geologic hazards, sea-level rise, and tropical storms, then to the fundamental growth-limiting resources of water, energy, and mineral deposits, and finally to the effluents and impacts of civilization. The fundamentals of environmental science—including the relevant chemistry, physics, biology, and geology—are introduced only as needed, and their applications are clear, persuasive, and direct. Because of this integrated approach, science and engineering principles are elucidated with regard to a range of interrelated environmental problems, and the transition to past and present policies and future options invariably ends with questions directed at the reader. Thus, the student is armed with the knowledge to understand and deal with the vexing anthropogenic impacts challenging the global biosphere. I think it's a marvelous way of involving the reader in the environmental questions facing us all.

However, by far the most engaging sections of *People and the Earth,* at least in my view, are the numerous sidebar boxes. While slightly tangential in a few instances (e.g., Jason and the golden fleece, p. 216), all are illuminating, and most are cogent examples of the principles being discussed in the surrounding text. The treated subjects vary enormously, from mad-cow disease (p. 56), to the Aswan High Dam (p. 142), petroleum for the Axis war machine during WWII (p. 186–187), and the year without a summer (p. 300). The style of both text and sidebar boxes is informal, engaging, and often humorous. As a beginning text in environmental or Earth systems science, it hits the mark squarely and effectively.

What didn't I like about this book? The figures, including halftones, although simple and clear enough, are somewhat lackluster. Perhaps I'm just too accustomed to the *National Geographic* color pictorial approach to elementary textbooks, as produced by commercial publishers. The manuscript was finished in mid-1995 and published three years later, presumably because Cambridge University Press was meticulous in its production of the book. In any case, a few discussions, such as that concerning the Three Gorges Dam Project (p. 176–177) are a bit dated. The authors recognize this and are trying to overcome this problem by operating a Web site with new boxes and a few other comments; the address is www.wm.edu/FAS/faculty/People_and_Earth. There are inevitable typos, such as the one stating that the Japanese attack on Pearl Harbor took place in 1942 (p. 186–187), but these are trivial and surely will be corrected in subsequent editions.

This is an excellent template for the new geology, also known as Earth systems science or environmental studies. *People and the Earth* is written at the introductory level and contains a seamless melding of policy implications as well as the requisite physical and biological science principles. I learned a lot reading it. I feel that this text contains the kinds of concepts that society must assimilate if the next century is to witness a better-managed planet than in the past.

W. G. Ernst
Stanford University
Stanford, CA 94305-2115

A Color Atlas of Carbonate Sediments and Rocks Under the Microscope. *By A. E. Adams and W. S. MacKenzie. John Wiley & Sons, New York, 1998, 180 p., $49.95 (paperbound).*

This slim volume focuses on showing color photographs with relatively limited text. Aimed mainly at a very advanced undergraduate or graduate student audience, the book covers the identification of carbonate grains, interpretation of diagenetic fabrics, description of porosity types, and carbonate classification. It generally succeeds at these objectives. It provides clear, logically organized, reasonably representative photographs of carbonate thin sections, including many that have been selectively stained. The identifications are accurate, and the text provides a rational framework for identifying and interpreting both grains and rock fabrics. This, coupled with the reasonable price for a color book, makes it one of the best currently available student texts in this field.

It has some significant weaknesses, however. The table of contents is sparse, with only seven topical entries. This forces the user to consult an index, which is also fairly limited at just over three pages. There are no diagrams in the book to help explain the structure of grains or the relationship of particular section cuts to the whole grain or organism. Samples are mostly from Europe, and many important carbonate rock formers from other parts of the world are given little or no coverage. The numbers of pictures of different organism groups also are oddly unbalanced; there are six views of echinoid spines (all in the same orientations) and only eight views of all the arthropods combined. Likewise, bivalves and brachiopods have 22 pages of coverage, whereas all other organisms combined have only twice that number. But the largest drawback seems to me to lie in the figure captions, which give no information on the subject of the picture. Only locality, age, staining, and magnification are provided. The user must then search through the text to find where the picture is discussed in order to discover what it shows. For students trying to learn petrography, this will be a frustrating experience. Why not include at least a two- or three-word description (e.g. "brachiopod spine" or "inoceramid bivalve") to inform the neophyte?

These drawbacks notwithstanding, this book provides a useful, well-written overview of a complex subject. It will find a home in many carbonate petrography or advanced sedimentology classes, although it is too limited in size, scope, and organization to serve well as a professional reference work.

Peter A. Scholle
Southern Methodist University
Dallas, TX 75275-0395 USA
pscholle@post.cis.smu.edu

Ancient Invertebrates and Their Living Relatives. *By Harold L. Levin. Prentice-Hall, Inc., Upper Saddle River, New Jersey, 1999, $61.*

For a medium-length book, this text provides good coverage of invertebrate fossil groups, and it does a fair but brief and dated job with evolution, the value of fossils, and the origin and diversity of life. The problem is that this book is filled with errors, most of them in the numerous illustrations and their captions. There are over a dozen prominent spelling errors, many of which we already see far too often in student writing ("Permain" and "Crustecea" being my personal unfavorites). More important, the reader who examines only the figures (and more of our students do this than we would like to admit) will learn that the chronostratigraphic equivalent of an epoch is a stage, that rugose corals were common in the Mesozoic and Cenozoic, that conodonts survived until the end of the Cretaceous, that terebratulid brachiopods and ctenostome bryozoans appeared first in the Silurian, and that there were no asterozoan echinoderms in the Triassic. Most of these mistakes are contradicted in the text, but the damage is nevertheless severe. Today there are numerous competing textbooks for invertebrate paleontology courses, none with as many problems as this book. The author clearly loves the subject, and he worked hard to produce readable, concise prose in a useful format. He was poorly served, though, by shoddy editing and incompetent proofreading. We can only hope that this is not the future of textbook publishing, with machines and bored technicians replacing the artisans we have long admired. We can demand higher quality for our students, especially considering how much they are asked to pay for these books. It is a pity that there is simply no reason to use this paleontology textbook in any course, and numerous reasons to avoid it entirely.

Mark A. Wilson
College of Wooster
Wooster, OH 44691
mwilson@acs.wooster.edu

The Antarctic Region: Geological Evolution and Processes. *Edited by C. A. Ricci. Terra Antartica Publications, Siena, Italy, 1997, 1,206 p., L150 000 (approximately US $90).*

Geologically, the Antarctic plate is the least known of all the plates. Understanding its geologic history is the key to many important problems in Earth history such as the amalgamation of Gondwana in the late Proterozoic–early Paleozoic, the breakup of Pangea in the Mesozoic, and the development of the Antarctic ice sheet. Although less than 5% of the continent is accessible to bedrock study, a coherent geologic history is gradually being assembled. These efforts are truly an international effort and therefore information is scattered throughout national and international literature. This is the seventh in a series of proceedings volumes associated with the International Symposia on Antarctic Earth Sciences (ISAES), which

Book Reviews *continued on p. 30*

NEWS FROM THE GSA

BOOKSTORE

WATCH THIS COLUMN FOR NEWS ABOUT GSA PUBLICATIONS

THE MID-ATLANTIC PIEDMONT: TECTONIC MISSING LINK OF THE APPALACHIANS
edited by David W. Valentino and Alexander E. Gates, 1999
Many topical special volumes on northern and southern Appalachian tectonics have been published. As critical advances in plate tectonics were applied to the rest of the Appalachians however, the Mid-Atlantic Piedmont was commonly neglected or included as an afterthought, making this part of the orogen a "missing link." Valentino and Gates have assembled a collection of papers that tie the central Appalachian Piedmont to the northern and southern regions by filling this void. Major themes include the impact of late Paleozoic dextral transpressive tectonism, the continuation of the Piedmont under the Atlantic coastal plain and new results in the tectonothermal history of the Piedmont.
SPE330, 148 p., ISBN 0-8137-2330-2, $60.00, Member price $48.00

GEOLOGIC EVOLUTION OF THE BARBERTON GREENSTONE BELT, SOUTH AFRICA
edited by Donald R. Lowe and Gary R. Byerly, 1999
The Barberton Greenstone Belt contains the oldest well-preserved volcanic and sedimentary rocks known on Earth and provides a unique window on surface environments, biological evolution, and crustal development 3,550 to 3,200 m.y. ago. This volume presents a systematic account of the geology of the Barberton Belt and its implications for interpreting surface conditions and processes on early Earth. The subjects include stratigraphy, structural divisions, sedimentary geology, and biological materials of the entire belt; mafic and ultramafic volcanic rocks and their petrogenesis; the sedimentology and volcanology of ultramafic volcaniclastic units; the depositional and tectonic setting of the oldest known foreland basin sediments of the overlying Fig Tree Group; and the petrology and tectonic implications of the upper syntectonic quartzose clastic sediments of the Moodies Group. An interpretative summary of the overall evolution of the Barberton Belt concludes the book.
SPE329, 324 p., softcover, indexed, ISBN 0-8137-2329-9, $60.00; Member price $48.00

HIMALAYA AND TIBET: MOUNTAIN ROOTS TO MOUNTAIN TOPS
edited by Allison Macfarlane, Rasoul Sorkhabi, Jay Quade, 1999
More than 30 international authors contributed to the first Himalaya-Karakoram-Tibet (HKT) Workshop held in America. The 11th HKT Workshop, in April 1996 in Flagstaff, Arizona, was a logical outcome of an increasing involvement of North American geologists in the studies of the Himalaya and Tibet over the past two decades. One of the prominent features of this 21 chapter volume is the integration of both "hard-rock"and "soft-rock" geology, paleotectonic and neotectonic history, and endogenic (tectonic) and exogenic (geomorphic) processes in the Himalaya. Fully refereed, seven articles cover the Tibet, Trans-Himalaya, and Tethys unit. The High Himalayan Crystalline zone is the subject of another eight chapters; the final six chapters cover the Himalayan Foreland and its sediments, structures, and landforms.
SPE328, 336 p., softcover, 1 large plate, indexed, ISBN 0-8137-23280, $70.00, Member price $56.00

LATE CENOZOIC XIANSHUIHE-XIAOJIANG, RED RIVER, AND DALI FAULT SYSTEMS OF SOUTHWESTERN SICHUAN AND CENTRAL YUNNAN, CHINA
by E. Wang, B. C. Burchfiel, L. H. Royden, Chen Liangzhong, Chen Jishen, Li Wenxin, 1998
The Tibetan plateau and its surrounding mountain ranges and basins are a natural laboratory in which to study geological processes ranging from continental collision tectonics to effects of plateau development on climate. Three active fault systems, the Xianshuihe-Xiajiang, Red River, and Dali, offer clues about the extrusion of crustal fragments eastward from the Tibetan plateau, how far back into time the present pattern of deformation can be projected, and the relation between these fault systems and the intracontinental deformation of the India-Eurasia collision zone. The region of these fault systems is an example of rapid changes in partitioning of strain during 5 m.y. in a rotational tectonic regime.
SPE327, 112 p., ISBN 0-8137-2327-2, $41.00, Member price $32.80

MILITARY GEOLOGY IN WAR AND PEACE
edited by J. R. Underwood, Jr. and P. L. Guth, 1998
In addition to the introductory paper this volume includes 24 papers, covering selected aspects of the history of military geology from the early 19th century through the recent Persian Gulf war, military education and operations, terrain analysis, engineering geology in the military, use of military geology in diplomacy and peace keeping, and the future of military geology.
REG013, 256 p., ISBN 0-8137-4113-0, $76.00, Member price $60.80

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The Geological Society of America

CALENDAR

Only new or changed information is published in *GSA Today*. A complete listing can be found in the Calendar section on the Internet: **http://www.geosociety.org.**

1999 Penrose Conferences

June

June 21–27, Terrane Accretion along the Western Cordilleran Margin: Constraints on Timing and Displacement, Winthrop, Washington. Information: J. Brian Mahoney, Dept. of Geology, University of Wisconsin, Eau Claire, WI 54702-4004, (715) 836-4952, fax 715-836-2380, mahonej@uwec.edu.

August

August 17–22, The Marine Eocene-Oligocene Transition, Olympia, Washington. Information: Donald R. Prothero, Dept. of Geology, Occidental College, 1600 Campus Road, Los Angeles, CA 90041, (213) 259-2557, fax 213-259-2704, prothero@oxy.edu.

2000 Penrose Conferences

March

March 27–31, Volcanic Rifted Margins, Royal Holloway University of London, Egham Surrey, UK. Information: Martin Menzies, Dept. of Geology, Royal Holloway, University of London, Egham Hill, Egham, Surrey TW20 OEX, UK, phone 44-1784-443105, fax 44-1784-471780, menzies@gl.rhbnc.ac.uk. See May 1999 *GSA Today* for meeting details.

1999 Meetings

June

June 14–15, 3rd Annual Workshop on Continental Scientific Drilling, Hilo, Hawaii. Information: Theresa Fall, tfall@egi.utah.edu, (801) 585-9687, www.DOSECC.org.

August

August 29–31, Mid-Continent AAPG Convention, Wichita, Kansas. Information: American Association of Petroleum Geologists, P.O. Box 979, Tulsa, OK 74101, www.aapg.org.

September

September 16–18, Gold in Carolina and America, Charlotte, North Carolina. Information: Gold History Corporation, Attn: Bicentennial Symposium, 9621 Reed Mine Rd., Stanfield, NC 28163, (704) 721-4653, fax 704-721-4657, reedmine@ctc.net.

October

October 8–10, 1999 SEPM Great Lakes Section Field Conference, Cincinnati, Ohio. Information: Tom Algeo, Dept. of Geology, University of Cincinnati, Cincinnati, OH 45221-0013, phone (513) 556-4795, fax 513-556-6931, Thomas.Algeo@uc.edu.

October 28–November 6, International Association of Geologists Working Group on Yangtze River, Shanghai, China. Information: Zhongyuan Chen, Conference Secretary, Dept. of Geography, East China Normal University, Shanghai, 200062, China, phone 86-21-62232706, fax: 86-21-62233660 or 62576217, Z.Chen@gislab.ecnu.edu.cn or Geogl@ecnu.edu.cn. *(Abstract deadline: June 31, 1999.)*

November

November 16–17, Wetlands and Remediation: An International Conference, Salt Lake City, Utah. Information: Karl Nehring, Environmental Restoration Dept., Battelle Memorial Institute, phone (614) 424-6510, Nehringk@battelle.org.

December

December 5–9, American Water Resources Association 1999 Annual Conference, Seattle, Washington. Information: American Water Resources Information, Attn: 1999 AWRA Annual Water Resources Conference (Seattle), 950 Herndon Parkway, Suite 300, Herndon, VA 20170-5531, phone (703) 904-1225, fax 703-904-1228, awrahq@aol.com, www.awra.org. *(Abstracts deadline: June 1, 1999.)*

December 6–10, 14th William T. Pecora Memorial Remote Sensing Symposium, Denver, Colorado. Information: ASPRS, 5410 Grosvenor Lane, Suite 210, Bethesda, MD 20814-2160, www.asprs.org.

Send notices of meetings of general interest, in format above, to Editor, *GSA Today,* P.O. Box 9140, Boulder, CO 80301, E-mail: editing@geosociety.org.

BOOK REVIEWS *(continued from p. 29)*

attempt to gather the most recent findings into one place. The seventh symposium was held in Siena, Italy, in September 1995. This volume and its predecessors offer an excellent gateway to the ever-expanding literature on the least known continent and surrounding oceans.

The book is organized into 11 chapters representing the various theme sessions at the meeting. Each chapter is introduced by a separate set of editors, who attempt to tie the various papers together. Topics covered by 162 papers span all areas of earth science. The large format lends itself well to diagrams and maps, some of which are in color. All papers were reviewed and edited, but a few could have used more editorial attention.

More than half the book is represented by the first three chapters discussing the amalgamation of Gondwana, the tectonic evolution of active plate margins, and breakup processes. Several papers are regional studies of magmatic and/or metamorphic histories of various localities in Antarctica. The relative roles of Grenville-age (1200–1000 Ma) and Pan-African (550–500 Ma) events are discussed, and localities in Antarctica are compared to their Gondwana counterparts in southern Africa, India, or Australia. One emphasis is validation of the SWEAT hypothesis, in which western North America and Antarctica were part of the same plate prior to separation in the late Proterozoic. Better dates from isotope geochronology and fossils increasingly identify basement rock sequences in the Transantarctic Mountains as Cambrian rather than late Proterozoic in age, so convincing proof is still lacking. In a paper in the active margins chapter, a Carboniferous to Cretaceous zone of magmatism in Marie Byrd Land (West Antarctica) is compared to the Median Tectonic Zone of New Zealand. Several excellent papers review the Mesozoic-Cenozoic geologic history of the Antarctic Peninsula–Scotia Arc region, which has experienced episodic plutonism since mid-Triassic time. In the breakup chapter, three papers discuss the opening of the Weddell Sea, which is a key to the understanding of the evolution of West Antarctica and the formation of the Southern Ocean. Magnetic, gravity, and paleobathymetry data are used to argue that the Ellsworth Mountains crustal block simply rotated with the Antarctic Peninsula as the Weddell Sea opened during the Mesozoic–Cenozoic.

Other chapters cover the evolution of the Southern Ocean, Cenozoic climate change, the last glacial cycle, fossil biotas, station geophysics, new directions, and maps. One chapter includes an unlikely mix of papers on high-temperature petrology, sedimentology, and glaciology. A few highlights are noted here. The Bransfield Strait, possibly the site of a new ocean basin, is the subject of four papers and related volcanism on Deception Island, three. The morphologies of six volcanoes in the Bransfield Strait, a back-arc basin between the South Shetland Islands and the Antarctic Peninsula that is no older than 4 Ma, show various stages in the evolution of a rift toward sea-floor spreading. Effective arguments and new data support a stable East Antarctic ice sheet, opposing a Pliocene meltdown. Contrary to the predictions of paleoclimate models, several papers note fossil biota that suggest relatively warm climates in the Antarctic polar region before the mid-Cenozoic. Several papers in the chapter on new directions demonstrate that remote sensing is an increasingly important tool in interpreting the geology of a continent mostly covered by ice.

This volume will probably find itself mainly on the bookshelf of Antarctic researchers, but it will be an invaluable resource in libraries for all those interested in earth science in Antarctica and a global view of earth history and processes.

James W. Collinson
Ohio State University
Columbus, OH 43210

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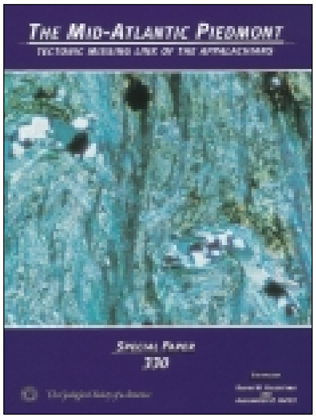

edited by
David W. Valentino and Alexander E. Gates, 1999

Many topical special volumes have been published on northern and southern Appalachian tectonics. As critical advances in plate tectonics were applied to the rest of the Appalachians however, the Mid-Atlantic Piedmont was commonly neglected or included as an afterthought, making this part of the orogen a "missing link." Valentino and Gates have assembled a collection of papers that tie the central Appalachian Piedmont to the northern and southern regions by filling this void. Major themes include the impact of late Paleozoic dextral transgressive tectonism, the continuation of the Piedmont under the Atlantic coastal plain, and new results in the tectonothermal history of the Piedmont.

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