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# GSA TODAY

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# Anatomy of the North Anatolian Fault Zone in the Marmara Sea, Western Turkey: Extensional Basins Above a Continental Transform

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## ABSTRACT

**Although it straddles an area of extreme earthquake risk, the origin of the Marmara Sea transtensional basin has been enigmatic. Recently acquired high-resolution seismic profiles and earthquake hypocenter locations show the crustal architecture to be characterized by a negative flower structure, bounded by two west-trending sidewall faults that are linked to a single vertical to steeply south-dipping master fault that extends to depths of >30 km. The negative flower structure has a complicated architecture consisting of relatively intact detached basinal blocks, separated by southwest-trending ridges which serve as strike-slip transfer zones between the basins. The basins and ridges are rotating counterclockwise, accommodated by the southward retreat of the southern sidewall of the flower structure as crustal material is passed from its eastern to western end along the transtensional strike-slip zone. This new interpretation provides a better context for understanding seismicity in the region and for understanding complexities of fault segmentation in large transtensional basins along continental transforms in zones of tectonic escape.**

## INTRODUCTION

In the January issue of *GSA Today,* Reilinger et al. (2000) explained the inevitability of destructive earthquakes along the North Anatolian transform fault of northern Turkey as a consequence of the westward tectonic escape of the Aegean-Anatolian Plate from a collision zone between the converging African and Eurasian plates (Fig. 1, inset). They pointed to the lack of a detailed map of faults crossing the locally deep (>1200 m) floor of the Marmara Sea (Fig. 2A) as an impediment to establishing the precise mechanics of faulting and earthquake generation. This region is of critical concern because devastating earthquakes over the past 100 years have progressed westward along the plate boundary toward the Marmara Sea region (Reilinger et al., 2000). Because of poor constraints on fault geometry, conflicting tectonic interpretations have been proposed for the deep basins of the Marmara Sea and associated seismicity (Fig. 2C and 2D). Comparisons of existing models show that separate groups of authors have advocated different locations for fundamental

Fault Zone, Turkey *continued on p. 4*

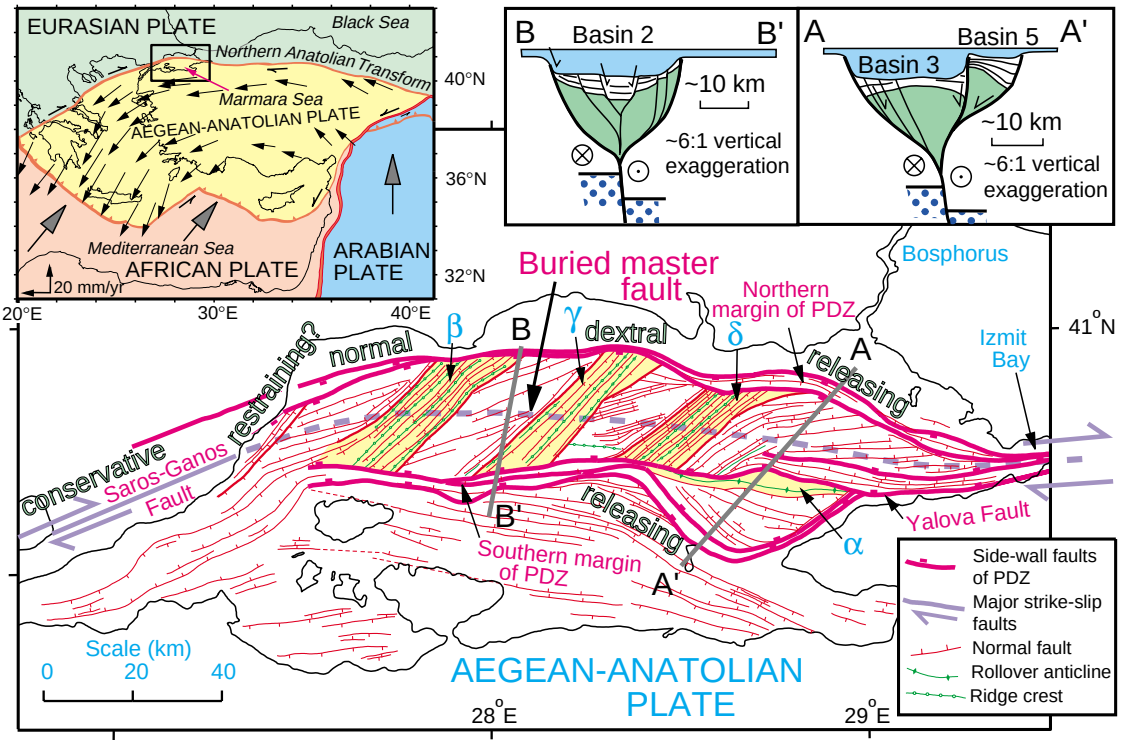


Figure 1. Structural map showing margins of principal deformation zone (PDZ), major strike-slip faults (half arrows), and normal faults with ticks on hanging wall. Areas α, β, γ, and δ are major ridges. Structural features are taken directly from interpreted seismic profiles along closely spaced survey tracks (Fig. 2E), so this figure is just like the field map of a land geologist. The only interpreted features are buried, dashed trace of dextral North Anatolian transform fault (NATF) and inferred zones of compression (restraining bends) and extension (releasing bends). Upper left inset is simplified tectonic map of eastern Mediterranean region, showing sense of plate motion (large gray-headed arrows) and global positioning system (GPS) horizontal velocities of Aegean-Anatolian plate (from Reilinger et al., 2000) relative to a fixed Eurasian plate (thin black arrows scaled in length to GPS velocities in mm/yr). Half arrows indicate transform or strike-slip faults. Cross sections A–A' and B–B' show our perception of architecture of elongate negative flower structure where it has central anticlinal swell and step-out basin perched on edge of principal deformation zone (A–A'; compare Fig. 4A), and where it encloses symmetrical graben (B–B'; compare Fig. 4B). Green substratum in cross sections represents older deposits beneath Pliocene to Quaternary basin fill.

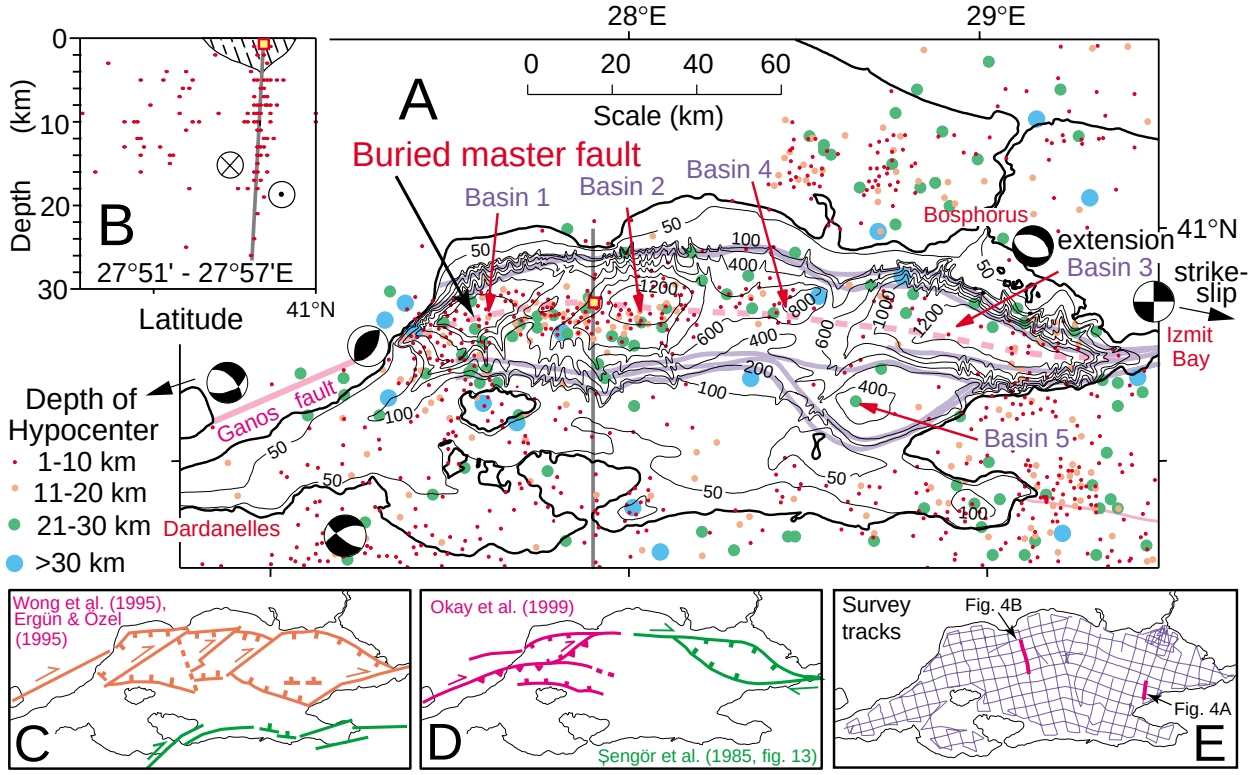


Figure 2. A: Bathymetry simplified from Aksu et al. (1999), depths of hypocenters of selected 1970–1998 earthquakes (Boğaziçi University, Kandilli Geological Observatory; see koeri.boun.edu.tr), margins of principal deformation zone (PDZ, thick purple lines), and position of steeply dipping dextral master fault (thick pink lines) to west of Marmara Sea (= Saros-Ganos fault) and as dashed line where buried beneath elongate negative flower structure along axis of principal deformation zone. Of five principal basins, four straddle principal deformation zone and lie directly above buried North Anatolian transform fault. Soccer-ball–shaped symbols are lower-hemisphere projections of fault-plane solutions for selected large earthquakes (compiled by Kiratze and Papazachos, 1995; Wong et al., 1995; Yalıtırak et al., 1998); quadrants with compressional first motion are black. B: Cross section along north-south line at ~27.6°E in A, showing distribution of earthquake hypocenters in band of latitudinal width 0.06', projected into cross section. Other cross sections are essentially identical and reveal location and dip of buried master fault (= North Anatolian transform fault) beneath principal deformation zone. Patterned region from 0 to 5 km depth is outline of principal deformation zone from seismic displays of Okay et al. (1999). Note lack of correlation between earthquake hypocenters and sidewall faults of principal deformation zone. C and D: Contradictory fault patterns proposed for Marmara Sea by various authors. E: Survey tracks of seismic grid used to construct Figure 1 and locations of seismic profiles of Figure 4.

Fault Zone, Turkey *continued from p. 3*

strike-slip faults, contrasting asymmetries for adjacent strike-slip basins, and different linkages with faults on land. This high level of uncertainty as to the first-order geometry of structures makes it impossible to confidently evaluate the seismicity of the Marmara Sea area.

The Marmara Sea region is also an important place for understanding the nature of transform plate boundaries. The North Anatolian transform fault forms the northern boundary of the Aegean-Anatolian plate and accommodates its westward escape by dextral strike-slip movement (Fig. 1, inset). The Marmara Sea is located on the transform fault, at a place where a notable southwestward swing occurs in the velocity field of the Aegean-Anatolian plate and where a broad zone of faults swings gradually to the southwest to connect the North Anatolian transform fault to the Saros-Ganos fault (Figs. 1 and 2). Global positioning system measurements constrain the horizontal velocity field of the Aegean-Anatolian plate relative to a fixed Eurasia (Reilinger et al., 2000), demonstrating a counterclockwise rotation of the Aegean-Anatolian plate and a progressive southwestward increase in plate velocity in the Aegean region (Fig. 1, inset).

Published tectonic models have failed to properly explain the origin of the Marmara Sea because of poor seismic coverage and insufficient use of available earthquake data. For example, cross-sectional plots of the locations of earthquake hypocenters beneath the deeper areas of the Marmara Sea (Fig. 2B) show that the steep marginal fault scarps enclosing the deep basins are not fundamental crustal-scale faults (i.e., none of these are main strands of the North Anatolian transform fault). Instead, the plate boundary fault lies directly beneath the axis of the Marmara Sea, where it is buried by a structurally complex zone of rhombohedral to elongate basins and ridges. This observation, combined with new maps of bathymetry (Fig. 2A) and fault traces (Fig. 1) that we have prepared from closely spaced seismic profiles (Fig. 2E), allows us to rule out origination of the Marmara Sea as either a pull-apart basin (Fig. 3A) or a transform-parallel strike-slip basin (Fig. 3B), and shows that it is instead a rather unconventional negative flower structure with complex internal geometry (Fig. 3C). Mann (1997) formulated a general model for the formation of large transtensional basins in zones of tectonic escape emphasizing the hybrid nature of such basins in terms of both pull-apart and transform-normal extensional styles. We believe that this notion is directly applicable to the Marmara Sea.

## BATHYMETRY

Bathymetry provides a first-order data set for inferring the positions of surface faults, the geometry of uplift and subsidence, and the interaction of faulting and sedimentation. The Marmara Sea is a 30–35-km-wide and 150-km-long, west-trending depression that consists of steep-flanked basins and ridges (10°–30° slopes) nestled between a 3–5-km-wide shelf dominated by eroded Tertiary bedrock in the north and an ~30-km-wide shelf in the south (Fig. 2A). There are five deep depressions within the central zone of basins and ridges. Westernmost basins 1 and 2

(Tekirdağ and Central Marmara Basins of Wong et al., 1995) are elongate, southwest–trending rhombohedral depressions deeper than 1100–1200 m. Easternmost basin 3 (Çınarcık Basin of Wong et al., 1995), at >1200 m depth, is a west-northwest–trending elongate depression. Basins 4 and 5 are significantly shallower features. Basin 4 (~800 m deep) is perched on the broad southwest-trending ridge separating basins 2 and 3, whereas basin 5 is a shallow (~370 m deep), crescent-shaped depression perched high on the southern slope of basin 3 (Fig. 4A). The three ridges that separate basins 1–4 (β, γ, and δ in Fig. 1) have water depths shallower than 600 m. The flanks of the ridges are generally segmented by steps, creating a rugged and terraced appearance. The west-trending ridge α (Figs. 1 and 4A) separates basins 3 and 5; here, the seafloor rises ~100 m above the floor of basin 5, then quickly descends to basin 3.

## UPPER CRUSTAL FAULT ARCHITECTURE

Faults were imaged seismically on 40 in.$^3$ airgun profiles and precisely transferred to a base map (Fig. 1). The upper crustal architecture in the Marmara Sea is characterized by an intricately linked fault system with two long west-trending boundary faults called sidewall faults. The zone between is referred to as the *principal deformation zone.* The sidewall faults are actually zones of narrowly spaced faults that dip steeply toward the axis of the principal deformation zone. They show close correlation with bathymetry.

The principal deformation zone swings gradually to a west-southwest trend in the western Marmara Sea, the northern sidewall fault linking to the Saros-Ganos fault via a set of faults along the western margin of basin 1 (Fig. 1). The southern sidewall fault appears to link to the west into a relay of southwest-trending faults with normal throw extending to the eastern Dardanelles. To the east, the two sidewall faults converge in western Izmit Bay, linking with the main northern strand of the North Anatolian transform fault. The architecture of the principal deformation zone thus displays an overall elongate tapered shape (Fig. 1). Basin 5 (Figs. 2A and 4A) is considered to be an out-step zone of the southern margin of the principal deformation zone, bounded by an arcuate fault zone that merges with the southern sidewall fault both to the east and west, and likely at depth (Fig. 1, section A–A').

The principal deformation zone consists of a shingled array of four basins and three ridges oblique to the trend of the sidewall faults (Figs. 1 and 2A). Basins 1, 2, and 4 and their bounding ridges β, γ, and δ are arranged in an en echelon pattern, controlled by the southwest trend of the ridges. The western margin of basin 1 is defined by steep southwest-trending faults with considerable normal throw. This fault zone occupies a position similar to that of the marginal faults of the ridges. To the northeast, the fault zone links with the northern sidewall fault; to the southwest, it follows the northern shoreline of the Dardanelles and does not merge with the southern sidewall fault. Furthermore, the zone is not cut by the Ganos fault as was suggested by Okay et al. (1999) (Fig. 2D). The 10–15-km-wide ridges are cut by narrowly spaced, southwest-trending, high-angle faults, many of which extend to the seafloor, creating a rugged topography. The boundaries between the ridges and adjacent basins are prominent fault scarps. The Pliocene to Quaternary basinal strata converge dramatically onto the flanks of the ridges (Fig. 4B). Normal-sense drag on the faults suggests upward propagation of fault tips to the surface (Fig. 4B). The convex-upward internal stratal architecture of ridges β, γ, and δ is attributed to pervasive faulting concentrated in narrow zones, normal throw increasing toward the edges of the basins. The linkage of the faults in the ridges with the sidewall faults is poorly resolved because of the spacing of the seismic grid. However, the ridge-margin faults clearly bend in a clockwise sense toward the sidewall faults, compatible with dextral displacement (Fig. 1).

Crustal blocks containing basins 1, 2, and 4 have well-defined rhombohedral shapes with aspect ratios of ~2.3:1. The internal structure of these blocks is defined by a central graben with south-southwest–trending normal faults that dip both northward and southward (Figs. 3C and 4B). Each basinal depocenter lies oblique (20°–25°) to both the sidewall faults and the ridge-margin faults. The depocenters are truncated by the ridge-margin faults, and their tapered ends are strongly dissected by faults. The setting of basin 3 is fundamentally different in that the depocenter is almost completely enveloped by the sidewall faults of the principal deformation zone. Only at its western edge is this block bounded by the southwest-trending faults of the eastern flank of ridge δ (Fig. 1). Basin 5 is an asymmetric half graben developed above a north-dipping listric normal fault with its associated rollover anticline (Figs. 1, section A–A' and 4A). This fault is interpreted as a footwall splay of the southern sidewall fault.

## PULL-APART, TRANSFORM-NORMAL EXTENSION, OR SOMETHING DIFFERENT?

All previous tectonic models correctly note the fragmentation of the Marmara Sea into small crustal blocks, but adhere to classical models of pull-apart basin formation along releasing bends or stepovers within an east-trending dextral strike-slip system (Fig. 2C and 2D)(Ergün and Özel, 1995; Wong et al., 1995; Okay et al., 1999). Okay et al. (1999) considered basin 1 to be a flat-bottomed, negative flower

Fault Zone, Turkey *continued on p. 6*

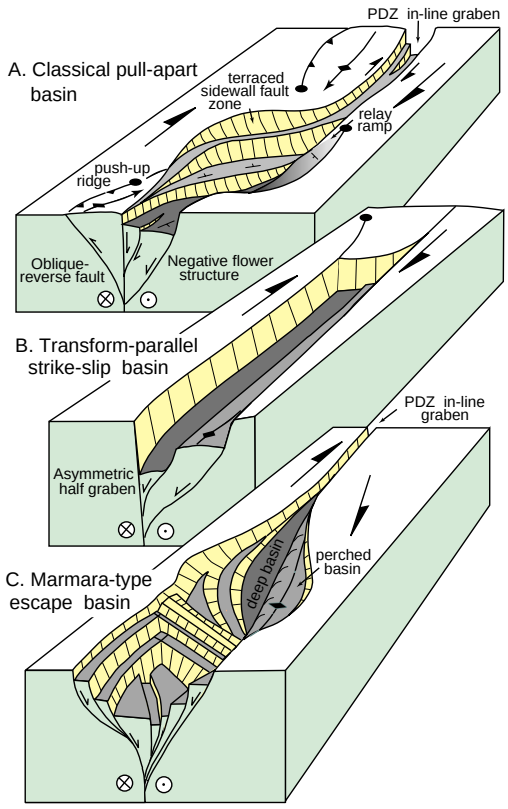


Figure 3. Contrasting geometries of strike-slip basins in dextral system. In all views, yellow surfaces are slopes facing reader. A: Classic pull-apart basin (Dooley and McClay, 1997) with negative flower structure oblique to strike of master fault. B: Transform-parallel strike-slip basin with asymmetrical, elongate half-graben structure (modified from Ben-Avraham and Zoback, 1992). C: Marmara-type escape basin with in-line symmetrical flower structure above single buried master fault.

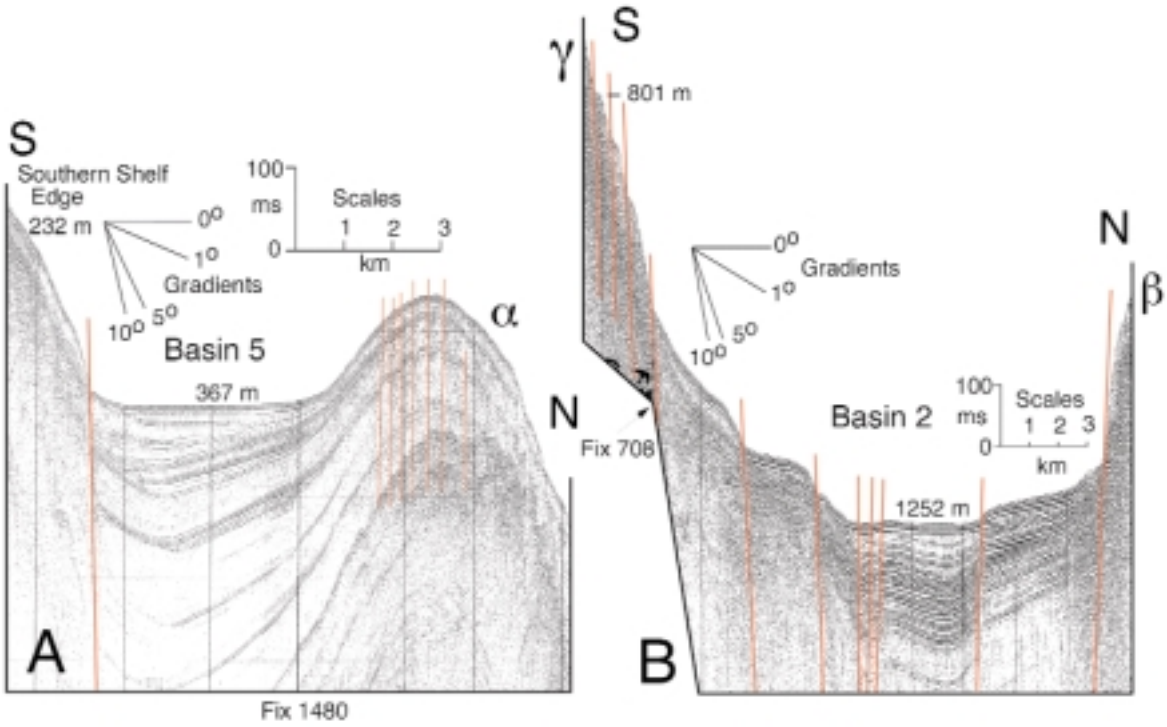


Figure 4. Single-channel seismic reflection profiles across basins 5 (A) and 2 (B) showing syntectonic architecture of basin fill and its relationship to basin boundaries and faults (red lines). See Figure 2E for location.

Fault Zone, Turkey *continued from p. 5*

structure that is detached at the base of the Pliocene to Quaternary sediments and is oriented transverse to the main stem of the North Anatolian transform fault. This requires that the North Anatolian transform fault cross the Marmara Sea, merging with the northern sidewall fault (Fig. 2D) to form a releasing bend as it curves toward the Saros-Ganos fault. Eastward in their model, the North Anatolian transform fault swings along a restraining segment coinciding with the western margin of ridge β, an inferred push-up swell. Wong et al. (1995) and Ergün and Özel (1995) recognized five blocks, consisting of three rhomb-shaped basins and two intervening transpressional push-up structures aligned with a southwest trend oblique to the main dextral North Anatolian transform fault (Fig. 2C). In other models, the northern and southern sidewall faults are considered to be normal fault segments, allowing subsidence of the basins, whereas the ridges form arrays of linking oblique-normal faults accommodating rotation between the blocks (e.g., Şengör et al., 1985, their Fig. 12).

The detailed geometry of the fault network in the principal deformation zone and the location of earthquake hypocenters beneath its axis reveal a negative flower or tulip structure. The tulip structure is the suprastructure of the principal deformation zone, extending only to depths of ~4–5 km (Fig. 1 cross sections and Fig. 2B). It links below ~5 km into a single vertical to steeply south-dipping stem, extending to depths of at least ~30 km (Fig. 2B). The tulip structure delimits an area of major Pliocene to Quaternary subsidence, with an aspect ratio of 5.5:1, that is in line with the buried master fault. The root of the tulip structure is thus a prominent, doubly plunging depression of the tipline of the buried master fault, situated across the central part of the Marmara Sea at a depth of ~4–5 km. Contrary to the earlier models of Okay et al. (1999) and Wong et al. (1995), all faults show considerable normal throw and upward fault-tip propagation, suggesting that the entire negative flower structure is in a state of wholesale crustal extension. We propose that this extension is partitioned between the basins and ridges. The basins represent relatively intact detached blocks, whereas ridges serve as strike-slip transfer zones between the basins linking the prominent sidewall faults.

The occurrence of a highly elongate, in-line negative flower structure above a centrally positioned buried master fault precludes an origin as a classic pull-apart basin. This conclusion is supported by the internal architecture of the flower structure where various fault elements are oriented exactly opposite to the geometry expected for a right-handed, releasing strike-slip system (Fig. 3A and 3C). Whereas the dimensional aspect ratios of ~3:1 for the individual basins are compatible with the ratios observed for classic pull-apart basins (Mann et al., 1983), the overall ratio of ~6:1 for the in-line flower structure as a whole is anomalous. The geometry of an in-line negative flower structure conforms better with models of basin development related to transform-normal extension (Fig. 3B; Ben-Avraham and Zoback, 1992). However, the presence of faults oblique to the sidewall faults is not a feature of such models.

This segment of the North Anatolian transform fault has been in transtension since at least 5 Ma (Armijo et al., 1999), acting as a relatively "soft" transform margin, where deformation is distributed across a linked network of strike-slip and extensional faults. We propose that the east-trending normal faults delineating basin 3 record this extension in the region where the strike-slip system feeds crustal material into the flower structure. Conversely, basins 1, 2, and 4 record the progressive feed-through and counterclockwise rotation of the crustal material that has progressively slipped into the zone of transtension since the Pliocene. The rotation of the crustal blocks is allowed by the southward retreat of the southern sidewall of the flower structure, as exemplified by basin 5, and is accommodated by strike-slip along the faults in the ridges. The ridges and basins act like rotating domino blocks within the envelope of the flower structure above the centrally located master fault. It is noteworthy that microseismicity in the Marmara Sea region is concentrated in swarms, situated along the western and eastern edges of the principal deformation zone (Crampin and Evans, 1986) where the greatest displacement incompatibilities should occur.

It is clear that the highly anomalous, intricate architecture of the Marmara Sea flower structure creates a challenging kinematic problem, particularly as to how transtension is geometrically accommodated along the buried master fault and how seismicity is partitioned between the master fault (seismic slip) and the principal deformation zone (predominantly aseismic slip). Further, the fault patterns that we describe here point to an alternative deformation style and architecture for transtensional basins that is not represented in existing literature (Fig. 3C), and

that may be an important element of shallow-level continental transform systems and microplate sutures.


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# Engaging "My Neighbor" in the Issue of Sustainability

## Part VI: Ecological Footprints and Carrying Capacity: Measuring Our Impact

***A.R. Palmer,*** *Boulder, Colorado*

Every one of us requires a finite area of Earth's surface to support his or her existence. This is our "ecological footprint" (Wackernagel and Rees, 1996). Its principal components are our food footprint, our wood-products footprint, and our degraded-land footprint.

If I eat potatoes, in the course of a year I consume a measurable quantity of potatoes. There is thus an area of potato production somewhere in the world that is dedicated solely to me for my annual consumption of potatoes. Ditto for every other terrestrial food product I consume. That's my food footprint. The size of this footprint is not fixed; I can change it by changing my eating habits—beef carries a bigger footprint than chicken.

My use of printer paper, the packaging of the products I buy, the magazines and newspapers I read, the wood in my furniture and my home, and the firewood I consume if I have a fireplace, constitute my personal wood-products footprint. This puts real demands on an area of the global forest that must be dedicated solely to me. However, this footprint must also include my share of the wood products in the infrastructure that supports me. I can change the overall footprint only a bit with decisions about my personal consumption.

My degraded-land footprint comprises the area under my house and driveway. For others, it may be a part of the shared area under our apartment buildings and adjacent parking lots. We also share a part of the land under our city streets, businesses, and public buildings, and under the industrial infrastructure that supports us, as well as a part of the land beneath our highways, railroads, airports, and garbage dumps. I can't do too much to change this, which is a reflection of our culture.

It is possible to calculate a semi-quantitative estimate of our food, wood-products, and degraded-land footprints and thus a measure of our minimal land-use needs at current levels of consumption. If this level of "need," when projected to the global population, exceeds the available land areas of Earth, we have a problem. On the other side of this coin, if we decide on the desirability of a particular level of consumption, we can get a rough idea of how many of us can be supported at this level by the land resources at our disposal—i.e., the carrying capacity of the land.

In addition to the "accountable" elements of our footprint cited below, there are other less tangible footprint elements represented by our use of fossil energy and water. Approximately 50% of the carbon dioxide we generate burning fossil fuels cannot be accommodated by existing terrestrial or oceanic sinks. If we had to create new forest to serve as a carbon dioxide sink, to keep the human contribution to atmospheric carbon dioxide from increasing, we would need to more than double the world's area of forest—an improbable solution. And warming oceans will hold even less carbon dioxide than they do now. It appears that the human component of carbon dioxide buildup in the atmosphere will remain with us until we stop burning fossil fuels. The footprint effects of water use are more subtle. When the lower reaches of the Yellow and Colorado rivers, for example, run dry because of upstream human water use, this will seriously impact downstream ecosystems in ways that are difficult to measure.

I have calculated the accountable components of the per-capita ecological footprint for the United States (Palmer, 1999). Our food footprint, using figures from the U.S. Department of Agriculture and related sources is about 1.5 acres. In simple terms, this is obtained by determining yields in pounds per acre for each foodstuff. That number is easily converted to acres per pound. Data on our per-capita consumption of each foodstuff in pounds are also available. The per-capita area required for each foodstuff is then calculated by multiplying these two figures. The sum of the resulting areas is our per-capita food footprint. Similarly, our annual U.S. per-capita demand on the world's forests for all wood products is estimated to be 0.04–0.05 acres. This sounds trivial, but that area cannot be reused until it has regrown. On average, this takes about 40 years. Thus, the estimated area of forest that must be dedicated to each one of us to sustain our present level of wood-products consumption—our wood-products footprint—is about 1.6 acres ($40 \times 0.04$ acres). Our U.S. per-capita degraded-land footprint is estimated to be about 0.4 acre. Therefore, the total ecological footprint for the average American is a minimum of about 3.5 acres.

Let's put this into perspective. Earth has about 22 billion acres of ecologically productive land. This comprises about 3.3 billion acres of arable and crop land, 8.4 billion acres of pasture land, and 10.1 billion acres of forest land. Not all of the arable land is of high quality, and improving agricultural productivity by use of fertilizers and insecticides, or shifting to monocultural forestry, affects ecosystems in other, often deleterious, ways. Expansion of land use in any of those categories can only be done at the expense of one of the other categories, and development of the land for human structures of all kinds competes for this same area. Not only that, but we have to share this land with the other organisms on Earth, who might not be able to tolerate our land use "improvement" measures or to survive as a group as environmental fragmentation becomes extensive.

If we maintain our current footprint and the human population of 2050 (estimated at 9 billion) reaches consumption levels similar to ours, which is a practical goal for the developing world, humanity would need 13.5 billion acres of land for food production and 14.4 billion acres for wood products on a steady-state basis to be sustainable, and we would have degraded about 3.6 billion acres for human structures. For humans alone, excluding the needs of other organisms, there is not that much land available!

Furthermore, the food footprint calculations cited above used U.S. yields, which are significantly higher than average global yields. If global yields were used in those calculations, our food footprint would be closer to 3 acres. Earth's carrying capacity for a population with 3-acre food footprints might be no more than about 4 billion people (12 billion acres of arable crop and pasture land divided by 3). Each year, more of our most productive farmland is buried under human structures, and both good and marginal farmland becomes unusable due to poor farming practices, so even the estimate of a sustainable carrying capacity of 4 billion people eating and living as we do may be high.

The simple calculations cited above should raise some warning flags that humanity already has a problem with the demands we make on Earth. And we seem to be continuing our present course unabated. Refinement of footprint and carrying capacity

Stewardship *continued on p. 9*

# Dialogue

**Sara Foland, CEO**

© Paul Abdoo

Sara Foland

"Among these treasures of our land is water—fast becoming our most valuable, most prized, most critical resource."

——Dwight D. Eisenhower

## *Stewardship and Applied Geology*

Last month we began exploring the role of stewardship in the world of applied geology. Joining me is Russ Slayback, chairman of Leggette, Brashears & Graham, a hydrogeologic and environmental engineering consulting firm headquartered in Trumbull, Connecticut. Russ is president of the American Geological Institute and past president of the American Institute of Professional Geologists.

Foland: I worked in the oil and gas industry for 20 years, with a view of stewardship as effective and ethical management of a nonrenewable resource. What does stewardship mean to you?

Slayback: Consulting environmental hydrogeologists are blessed with a wide variety of client problems that impact the public. They range from development of safe water supplies, to design and implementation of dewatering systems for mines or construction, to evaluation and clean-up of man-made contaminants in soil and/or groundwater. In all these endeavors we're concerned that impacts to the surrounding community are properly considered and mitigated where necessary.

Foland: A huge concern for all applied geologists is balancing environmental awareness with resource demand and utilization and the economics of doing business.

Slayback: That's true, and this is an area where our experience differs from that of our academic colleagues. Academics usually look to understand every aspect of a research issue. Applied geologists, on the other hand, usually make considered judgments on how to solve a problem with an economically driven partial data set. Our goal is to provide clients with a quality solution at the lowest possible cost.

Foland: In major corporations, another important issue is the relationship between corporate and personal stewardship values. As each new policy, event, or crisis arises, it's important to reflect and make sure that "values alignment" is intact.

Slayback: In a firm such as ours, there's really no problem between corporate and personal values in the realm of stewardship. Leaders of the firm are the working owners, and we have to live with our advice to clients every day. In this litigious society, a consultant who loses sight of his or her role as steward of a client's interests and those interests in relation to the public will live to regret that sort of professional negligence.

Foland: Having faced the challenge of recruiting young geoscientists for the oil industry, I found the best thing to do was hire the very best geologists, regardless of specialty, and teach them the oil business.

Russ Slayback

Slayback: I agree. As a consultant who commonly hires bachelors or masters students as entry-level field staff, I'm enthused about GSA's Shlemon and Mann mentoring programs, which expose students who are not headed for academic careers to people working in the applied geosciences. I've had the opportunity to lead a Shlemon session, and thought I was providing useful information and guidance to young people who would soon be in the job market.

Foland: Let's talk more about your involvement with GSA. I think some people assume the Society is too academically oriented to be of value to applied geologists, yet you've been a member since 1965.

Slayback: Consultants don't get to do much cutting-edge research; we tend to apply the results of research by others to practical problems in the field. To me, GSA is one of the best sources of research, especially on behavior of subsurface contaminants. GSA is also my link to the broader world of geoscience that's outside my daily work.

Foland: In your view, what can GSA do to better serve applied geologists?

Slayback: I think there are two important areas. The first is making GSA more user-friendly for applied geoscientists, in publishing opportunities, invited papers at meetings, and perhaps special symposia for specific topics, with invited speakers. The second, of course, is marketing. It doesn't help to present more opportunities if the consulting community doesn't know about them. ■

Stewardship *continued from p. 8*

figures should be an ongoing part of the process of evaluating and monitoring the sustainability of the human enterprise.

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For a current discussion of ecological footprints with most of the important literature citations, see the March 2000 issue of *Ecological Economics* (v. 32, no. 3, p. 341–394). ■

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# Research in the Sedimentary Geology of the Coastal Zone and Inner Shelf

*Report of NSF-sponsored workshop, Honolulu, Hawaii, November 9–11, 1999*
*Edited by* ***Chip Fletcher,*** *University of Hawaii*

Figure 1. North Myrtle Beach, South Carolina, is the northern end of a 60-mile-long stretch of heavily developed shoreline characterized by hotels and private homes on narrow sandy barriers backed by tidal marshes and lagoons. Much of the waterfront development was destroyed in 1989 by Hurricane Hugo, but it has since been rebuilt. This illustrates one of the major national and global coastal problems—lack of planning or regulation of shoreline development in high-hazard zones. Photo by D.B. Scott, 1996.

Participants in a recent international conference* agreed that sedimentary coastal environments constitute a critical national and global resource that suffers widespread degradation due to human impacts. Moreover, human population growth and inappropriate development in coastal zones are escalating losses of public assets owing to coastal hazards and placing large numbers of communities at growing risk (Fig. 1).

Consensus was reached at the Honolulu conference on specific scientific priorities, which include correlating local Holocene relative sea-level histories better, identifying mass balance in littoral sediments, extending the instrumental record with sedimentary archives, understanding the biolithology of carbonate reefs on the meter scale, tracking geochemical flux through coastal waters and substrates, and placing more emphasis on why coastal variability exists rather than simply characterizing it. With the understanding that coastal environmental change is a critical national and international research priority, the participants agreed that an international workshop on coastal forecasting should be convened to define a vision for the future of coastal sedimentary research and identify critical areas of enhanced investigation within a research framework.

## Crowded Coasts

The U.S. coastal zone is one of the nation's greatest environmental and economic assets (Ocean Studies Board, 1999). A national migration toward coastal towns and villages occurred in the last half of the 20th century and continues today, Now over 80% of the American population lives within 50 miles of the coasts. By 2010 population density along ocean shores will be 400 people per square mile, compared to less than 100 per square mile for the rest of the nation. Fourteen of the country's 20 largest urban corridors are along the nation's coasts, and a major part of the U.S. economic infrastructure is near or on the ocean. Globally the figures in these categories are similar. Over 50%—some 3.2 billion people—live along a coastline today, and this figure is expected to rise to 75% by 2025 (Hinrichsen, 1999).

This burgeoning population depends on limited natural resources. Overfishing, mineral depletion, sewage disposal, aquifer deficiencies, vulnerability to coastal hazards, and beach and wetland loss are critical issues throughout the nation and the world. The natural health of the coastal environment is endangered and is a focal point for federal and local policy development. In truth, however, many management policies do not provide adequate solutions, commonly because they lack a scientific basis.

We live in a time of sea-level highstand, and accelerated rises are projected. Environmental change—gradual, rapid, and catastrophic—is an integral feature of high sea levels. To understand the history and processes driving coastal environmental changes, research on a range of spatial and temporal scales is needed. High-resolution geologic records of coastal change can extend the instrumental record to the recent past, and former intervals of sea-level highstand can help us understand the present.

Coastal sedimentary research is highly relevant to understanding coastal environments. Most coastal ecosystems depend upon sedimentary substrates and sedimentary transport processes for critical nutrient flux and trophic energy. Sedimentary processes are typically nonlinear and highly complex, and thus they are easily disrupted. Our understanding of the structure and function of sediment-dependent environments (reefs, wetlands, estuaries, beaches, etc.) is improving but remains inadequate. The ability to forecast coastal environmental change can be improved with focused research.

## No Sponsor for the Academic Community

The academic core of the U.S. coastal sedimentary research community has suffered from a lack of planning for its scientific future. The field has long been characterized by individual research efforts, but there are few unified and system-level research products that cross disciplinary lines. Major aspects of how and why coastal sedimentary processes interact across spatial and temporal scales remain unknown. With the exception of a small number of research efforts (e.g., the National Science Foundation [NSF] Land Margin Ecosystem Research Program), there is a lack of significant progress in understanding the linkages and interrelationships among and between shoreline environments.

This situation is now hindering research funding. For instance, within NSF, coastal sedimentary research is without a clear proponent in either the Earth or Oceans directorates (Baker and McNutt, 1998). Within the National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and to some extent the Environmental Protection Agency and NASA, funding is available for spatial and temporal analysis of coastal trends, but these efforts typically focus on what environmental tendencies occur and often do not answer why or how coastal change happens.

The Coastal and Marine Geology Program (CMGP) of the U.S. Geological Survey is charged with establishing the geologic framework of the U.S. coastal and marine regions (Ocean Studies Board, 1999). However, the CMGP is not driven

*Non–Steady State of the Inner Shelf and Shoreline: Coastal Change on the Time Scale of Decades to Millennia in the Late Quaternary, November 9–12, 1999, University of Hawaii, Honolulu. View the agenda and ~90 papers at http://soest.hawaii.edu/Coastal_Conf/.

by external proposal submission; instead, it responds to requests that originate outside the research sector. Thus, within the national academic community, the true value of coastal sedimentary research is underestimated.

At NSF, programmatic lines typically stop at the coastal zone. As a result, the true nature of coastal sedimentary research as an amphibious discipline cannot easily be accommodated. An important exception is the MARGINS Source to Sink Project (Nittrouer and Driscoll, 1999), which is nascent but promises significant advances in understanding sedimentary flux and partitioning. However, the MARGINS program will focus primarily on only two study sites (New Zealand and New Guinea), and thus does not represent a comprehensive programmatic solution for the U.S. community.

## Community Policy Consensus

Coastal environmental value is recognized in the missions of many federal agencies. However, research by the academic core is typically underutilized. The logical source of funding for fundamental research in coastal sedimentary processes and their consequences is NSF, but NSF's programmatic structure does not promote advances in coastal sedimentology. As a result, the true power of this field lies untapped despite the national and global need.

Participants agreed that the community of U.S. coastal sedimentary researchers must develop a vision and a research plan, both fundamentally and in terms of societal relevance. The plan should integrate a spectrum of traditional earth and ocean science fields to effectively mobilize and focus research in coastal change. The plan must provide direction for understanding why and how environmental processes and patterns occur and interact across temporal and spatial scales. The plan should recommend continued support for gifted individual researchers who will lead significant breakthroughs in coastal sedimentary research. In addition, a new strategic tool is required. Funding agencies must support integrated multidisciplinary teams of investigators working in specific coastal cells using models and field experiments that utilize observational, mapping, and drilling technologies. International collaboration has been the keystone of important progress in the past, and linkages with overseas investigators must be an integral part of new advances. Conference participants pledged their support for this effort.

## Community Science Consensus

A consensus was reached on the following science issues. Instrumental records of sea-level change can be connected to high-resolution geologic archives spanning the past 1–2 k.y. This will improve understanding of sea-level patterns and controlling factors such as El Niño–Southern Oscillation, steric effects, and the dynamic sea surface. Past Global Changes (PAGES) and Land-Ocean Interaction in the Coastal Zone (LOICZ) programs in this area should be supported by U.S. efforts.

Regional synthesis and correlation of local Holocene relative sea-level histories is critical. This is fundamental to separating the individual effects of forebulge collapse, neotectonics, and climate effects along U.S. and global coastlines. Isolating these signals will enhance our ability to forecast specific impacts of future sea-level variability. Studies of the timing and variability of last interglacial (and earlier) sea levels should emphasize dated samples lacking open-system behavior. Thermally ionized mass spectrometry (TIMS) Th-Pa methodology is useful at critical sites defining sea-level pivot points. Efforts should focus on publication of high-quality examples with high-resolution measurements of indicative sea-level position and chronology.

Mass-balance littoral sediment budgets should be emphasized in future studies of coastal change. Little is known of the residence times and exchange rates of coastal sediments in most types of littoral environments. Field experiments must be designed to minimize undefined residual budget components.

The geologic framework of U.S. and global coastal systems must be defined, including siliciclastic, carbonate, and mixed sedimentary systems. This effort should focus on understanding why variability exists and must not stop at defining what that variability is. Improved understanding of framework variability can then be correlated to modern dynamic processes of sediment-water interaction, including sedimentary fluxes, to establish a holistic and systemic understanding of coastal variability. Carbonate reefs are a special global treasure, but we lack a true understanding of the controls on their structure and evolution. More is known of their morphology on the kilometer scale and their biology on the centimeter scale, but less is known of the biolithology on the meter scale. Workers can unify this disparate understanding by focusing on the meter to dekameter scale of biolithologic, ecologic, and geochemical variability. This will help us to better understand the impact of increased ocean acidity, shifts in prevailing currents and sea surface temperatures, and changes in the quantity and geochemical character of terrestrial inputs.

Coastal ecologies and water quality depend upon sedimentary environments. Geochemical flux through the water column and sedimentary substrates should be the target of focused field experiments to delineate uptake, diagenesis, sequestration, and release of biogeochemically active chemical constituents. Finally, there was consensus among the community to extend the vision and planning advances made at the conference in Honolulu with an international workshop on coastal forecasting. The goal of the workshop should be to define a vision for the future of coastal sedimentary research and to identify critical areas of enhanced investigation within a national research framework.

## Acknowledgments

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*Geological Society of America and Geological Society of London*

*present*

# Earth System Processes

*a global meeting in*

## Edinburgh, Scotland

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### *The Problem*

The plate tectonics paradigm developed in the mid-20th century provides a basic description of the dynamic behavior of the Earth's rigid surface layer. A great breakthrough, it nonetheless constitutes only a starting point for understanding of the Earth System that sustains humankind and all known life. Even in the present period of increased scientific specialization, geoscientists have come to realize that it is by working closely with scientists in other fields that they can best contribute to this exciting, yet demanding, task. In particular, the interactions among the lithosphere, atmosphere, hydrosphere, cryosphere, and biosphere require integrated interdisciplinary study and have social and economic implications.

The Geological Society of America (GSA) and the Geological Society of London (GSL), two of the world's oldest and largest organizations of earth scientists, are combining their resources to co-convene a broad, interdisciplinary meeting to discuss the present state of knowledge of *Earth System Processes.*

### *The Themes*

The Earth System Processes meeting will focus attention on the two major themes that are most critical for advancing understanding of the way the planet works:

*Earth System Linkages* will explore the relationships between the solid Earth, the hydrosphere, atmosphere, cryosphere, and biosphere;

*Earth System Evolution* will examine the way in which the processes controlling the nature of the planet have changed since the birth of the solar system 4.5 billion years ago.

Both themes will involve comparison with other planetary systems in the solar system and beyond. Both will take into account critical extra-terrestrial influences.

Interested in submitting ideas for the development of the conference program?

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### *The Venue*

Teams of specialists with diverse backgrounds are already working together on interdisciplinary research seeking integrated solutions to the complex problems of Earth System science. These teams can be regarded as the modern embodiments of the solitary "naturalists" of the 18th and 19th centuries such as James Hutton, Charles Darwin, James Dwight Dana, and John Wesley Powell. The GSA and GSL believe that it is fitting, therefore, that a meeting on Earth System Processes convened at the start of the 21st century should take place in Edinburgh, Scotland. It was in that ancient city that James Hutton lived and studied, and Charles Darwin received his earliest education in the natural sciences as a medical student there. In addition to oral and poster presentations, the meeting will include visits to localities of note in the history of the earth sciences such as Siccar Point, Salisbury Craigs, and the Moine thrust belt. The meeting will step into the 21st century with associated interdisciplinary workshops to be held at state-of-the-art laboratories throughout Scotland and England.

Second circular available September 2000

Registration beginning November 2000

*For further information, please contact: Ian Dalziel, University of Texas at Austin (Ian@utig.ig.utexas.edu) or Ian Fairchild, Keele University (i.j.fairchild@keele.ac.uk)*

# The Science of VA-HUD and the 302(b)s

***Melody Brown Burkins,*** *GSA Congressional Science Fellow*

I do not remember being particularly eloquent in my Congressional Science Fellow interview, but I do remember my adamant, and parochial, answer to one question posed by an interviewer: "Do you believe science funding should be an entitlement?" Well, yes, I began to argue, science is a basic need of society, like food and water. There were several bemused looks around the table and at least one highly arched eyebrow as I continued. When it was over, I tried to take some solace in the fact that, though I had obviously sounded naive, I had sounded naive with conviction.

I have since come to terms with what my interviewers knew too well—in the world outside our universities, research labs, and classrooms, science funding is not always seen as a fundamental need of society. Instead, it is most assuredly seen as "discretionary," or optional, funding by those who make the budgetary rules. Furthermore, the science and technology dollars that do get allocated each year are hardly protected from one year to the next. Given the quirks of the federal budget process, science and technology programs must often compete directly with such seemingly disparate (yet important) initiatives as urban housing and rural development.

I have also realized that even a general understanding of the federal budget process is powerful information. True, the process is irritatingly political, always contentious, and often frustrating, but the creation of the federal budget is nevertheless the means by which hundreds of millions of dollars are allocated to scientists and their research institutions each year. It is no accident that all the major industries and interest groups in the United States, including major public and private science centers, have personnel dedicated to following budget maneuvers on the Hill.

In a previous essay for *GSA Today*, I argued that scientists should become more informed about the workings of public policy in order to best educate elected representatives about important science and technology issues. Here, I continue that argument with the suggestion that knowing the federal budget process is a must for scientists who want to become more involved in the policies that shape, and fund, their way of life.

## Federal Budget 101

In the annual process of creating a federal budget, there are a few key milestones to remember. First, in January, there is the President's budget request. This is the budget proposal that the Administration submits to Congress and that contains the President's goals and program priorities for the following fiscal year. This is also the budget that the President expounds upon in the State of the Union address, and it is the budget that federal agency directors vigorously defend to Congress throughout the following year.

Next, in April (or soon after), Congress follows the Administration's proposal with a concurrent budget resolution. This is the budget proposal developed and strongly influenced by majority leaders in Congress. Its purpose is to set broad revenue and spending targets for 19 "functional" areas (from agriculture to veterans' benefits) over the next fiscal year. However, the resolution is not law. This budget plan is instead the official congressional response to the President's budget proposal. Depending on the political climate, the difference between the two plans can be fertile ground for strong disagreement.

Immediately following its presentation of a concurrent budget resolution, Congress breaks its proposed budget into thirteen major appropriations bills (see Table 1). To do this, the House and Senate appropriations committees must allocate funds—called 302(b) allocations after Section 302(b) in the Budget Act of 1974—to the 13 subcommittees that oversee each appropriations bill. Of particular interest to scientists, and especially earth systems scientists, are the Interior and VA-HUD appropriations bills that set annual funding levels for the U.S. Geological Survey (USGS), the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Environmental Protection Agency (EPA), among other programs.

Throughout the spring and summer, all 13 subcommittees hold hearings, make compromises, and ultimately mark-up (finalize for an official committee vote) their appropriations bills. After each bill leaves committee, undoubtedly with some programs increased and others curtailed, it is ready for full House or Senate floor consideration.

Finally, sometime in October (it is hoped), the country receives an annual federal budget. This is the final budget that emerges after a full Congress—both House and Senate—further discusses, debates, and amends each of the 13 bills (as well as relevant tax legislation) AND receives a Presidential signature to make the budget into law. This process provides the legal authority for all federal agencies to obligate and/or spend funds in the next fiscal year. Once this is done, Congress breathes a collective sigh of relief, and then adjourns for its winter recess.

And, in January, the President's budget request arrives again....

## Fiscal Year 2001—A Possible Science Squeeze?

As I write this in April of 2000, Congress seems a long way from collective sighs of relief. Congress did pass its concurrent budget resolution—a plan totaling

Melody Brown Burkins will report on her congressional experiences at the GSA Annual Meeting in Reno. Her presentation, "Earth Scientists on Capitol Hill," will be on Wednesday, Nov. 15, 12:00–1:00 p.m. Free to meeting participants. Check your Annual Meeting Program for location.

Table 1. Federal 302(b) Appropriations Bills and Major Science Agencies

| 302(b) Appropriations Bills | Major Science and R & D Agencies |
|---|---|
| • Agriculture, Rural Development, and Related Agencies | USDA, USFS |
| • Commerce, Justice, State, and Judiciary | NOAA |
| • Defense | DOD |
| • District of Columbia | |
| • Energy and Water | DOE |
| • Foreign Operations | |
| • Interior | USGS, DOE |
| • Labor, Health and Human Services, Education (Labor-HHS) | NIH |
| • Legislative Branch | |
| • Military Construction | |
| • Transportation | |
| • Treasury, Postal, and General Government | |
| • Veterans Administration, Housing and Urban Development, and Independent Agencies (VA-HUD) | NSF, NASA, EPA |

$1.87 trillion, over $600 billion, or about 32% of the budget, in discretionary funds. However, though it was passed ahead of schedule, the plan is in no way bipartisan. In the House, the resolution passed along a largely party-line vote of 220 to 208 and, in the Senate, by a vote of 50 to 48 (four Republicans voted "no").

While partisan disagreement is expected, there are true differences of opinion concerning fiscal year 2001 spending. For example, the preliminary 302(b) allocations announced this week suggest that Congress will ask for significant decreases in several of the 13 appropriations bills, including the physical and natural science–rich VA-HUD and Interior appropriations bills. As currently proposed, the House allocation for VA-HUD is $403 million less than even an adjusted freeze of FY 2000 levels. The Interior bill is currently allocated $580 million less than last year.

## Until October—Then FY 2002

It is, of course, far too early to tell how these preliminary allocations will truly affect the program objectives of major earth science and research agencies in FY 2001. These numbers are not yet set in stone—the Senate has yet to propose its 302(b)s— and committee debates will undoubtedly alter the specifics. In fact, I would argue, the funding levels for scientific programs throughout the budget could largely depend on the science community's response to currently proposed allocations. As the budget process is sped up in anticipation of the presidential election, there is no better time than now to contact your representatives with your opinions about FY 2001 science-funding priorities. Remember: While members of Congress must take a national view of all budget decisions, the way in which those decisions directly affect citizens in their home state—especially citizens who take time to write—is never totally ignored.

Remember, too, that while one year's budget (FY 2001) is being debated in the halls of Congress, the next (FY 2002) is being planned. Scientists can have a say in this process through federal science agency leadership, but also through the collective voice of a large scientific society. Carefully remaining nonpartisan, many societies (including the American Association for the Advancement of Science, the Geological Society of America, and the American Geophysical Union) have published "white papers," or opinion pieces on science and technology issues. In addition, many societies hold a "Congressional Visits" day each spring. If you missed GSA's this year, start thinking about next.

However you do it, let your elected representatives, both local and national, know your views. Let them hear your concerns about science funding, long-term budget priorities, and the economic and social benefits of science-related programs in your community or state. Call, write, or make a short appointment with someone on your representative's staff. With hundreds of millions of dollars at stake each year, it never hurts to speak up.

If you would like to learn more about the FY 2001 budget (perhaps so that you can better craft that letter to your representative), the Science and Society Web pages of the Geological Society of America (www.geosociety.org) and the American Geophysical Union (www.agu.org) have links to several relevant pages. In addition, the American Association for the Advancement of Science (www.aaas.org) has an entire Web site devoted to FY 2001 budget analyses. Last but not least, the American Institute of Physics (www.aip.org) runs a valuable listserv that sends frequent and concise e-mail updates about legislative and budget events that most affect scientists and their research.

Keep watching those 302(b)s.

*Melody Brown Burkins, 1999–2000 GSA-USGS Congressional Science Fellow, serves on the staff of Senator Patrick J. Leahy (Democrat—Vermont).* *This one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award 1434-HQ-97-GR-03188. The views and conclusions contained in this article are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government or GSA.* *You can contact Burkins by mail at the Office of Senator Patrick Leahy, 433 Russell Senate Office Building, Washington, DC 20510, by phone at (202) 224-4242, or by e-mail at melody_burkins@leahy.senate.gov.* ■

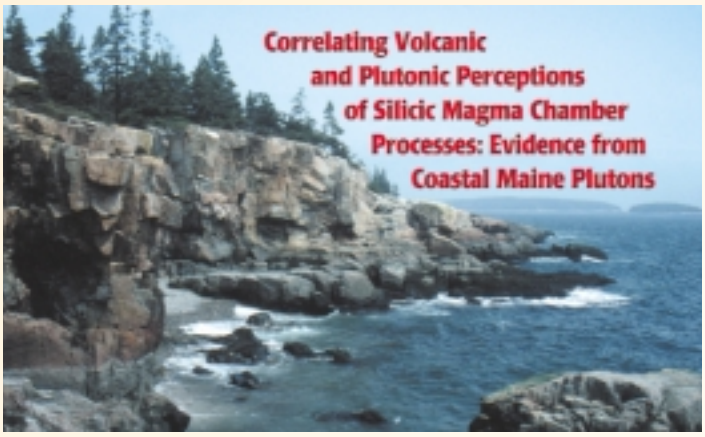



Photo: Coastal exposures of the Gouldsboro granite in Acadia National Park, Maine. Large silicic enclaves have been deeply eroded by wave action into the prominent caves above the high tide mark. Photo by Bob Wiebe.

## Ellsworth, Maine

Dates: September 14–19, 2000

Leaders: Bob Wiebe, Geological Sciences, Franklin and Marshall College; Don Snyder, Geological Sciences, University of Michigan; David Hawkins, Department of Geology and Geography, Denison University; Tod Waight, Danish Lithosphere Centre

***This forum will concentrate on the evidence for silicic magma chamber processes in the exceptional coastal exposures of shallow granitic plutons located in Maine. Parts of these plutons contain sections up to several kilometers thick that provide stratigraphic records of crystal accumulation and periodic injection of mafic magma and preserve spectacular magma mingling relations.***

These relations appear to be the plutonic record of mafic replenishment events so widely inferred from the study of silicic eruptive systems. While it is becoming increasingly recognized that comparable features are widespread in granitic plutons of all ages and tectonic settings, most petrologists are unaware of the potential impact of these magma chamber processes on the compositions of silicic volcanic and plutonic rocks. The forum will explore the implications of these stratigraphic sequences for the mineralogical and geochemical evolution of silicic magma chambers and the possible impact of the magma chamber processes on the chemical and mineralogical evolution of silicic volcanic rocks and granitic plutons. A diverse group of scientists interested in field, geochemical, experimental, and theoretical aspects of silicic plutonic and volcanic systems will include volcanologists and fluid dynamicists, as well as the more traditional workers on silicic plutonic rocks—those who focus on field, structural, petrographic, geochemical, and isotopic studies of granites.

Some basic questions we plan to address are:

- Is it possible to recognize the signature of a volcanic event in a plutonic system (and vice versa)?
- How do silicic magmas differentiate?
- How do injections of basic magma interact, both physically and chemically, with silicic magmas?
- What are the factors that influence the geochemical and isotopic signatures of silicic magmas?
- What do the field relations and structures in granitic plutons tell us about the emplacement of granitic magma and the solidification of silicic magma chambers?

### Itinerary

Thursday, September 14. Participants should attempt to fly into Bangor, Maine, before 6:00 p.m., in time for dinner and orientation. Vans will provide transport from the airport to the White Birches Motel.

Friday, September 15. The entire day will be spent on Mount Desert Island (Acadia National Park), examining the Cadillac Mountain intrusive complex, which exposes both the base and upper levels of a composite pluton with gabbro, diorite, and granite. We will examine (1) mafic-silicic layered rocks in the gabbro-diorite unit, near the base of the complex (mafic replenishments into a silicic magma chamber), (2) the "shatter zone" (possible evidence for roof collapse during an explosive eruption), and (3) intermediate and silicic enclaves in the high-level Cadillac Mountain granite (are these disrupted samples of hybrid magmas from the base of the chamber?).

Saturday, September 16. Although dominantly gabbroic in composition, the Pleasant Bay layered intrusion contains many layers of granitic and intermediate (hybrid) rocks, which demonstrate that it formed by extensive injections of basaltic magma into a silicic magma chamber. Four stops are designed to show the widest range of interactions between resident granitic material and mafic replenishments, including (1) hybrid layers that grade upward from chilled basaltic magma to granite, (2) mafic layers pierced by granitic pipes fed from underlying crystal mush, and (3) extensive networks of composite dikes consisting of chilled mafic magma in a granite host.

Sunday, September 17. In contrast to the first two intrusions, mafic input into the Gouldsboro granite-gabbro complex has produced little obvious hybridization; gabbro is present only at the base of the intrusion and consists of discrete chilled pillows and sheets. We will examine (1) the transition between interlayered granite-gabbro and the overlying massive granite, (2) the abundant, large silicic enclaves at the highest exposed levels of the granite, and (3) several examples of composite dikes with mafic margins and silicic interiors. These dikes appear to have formed when a basaltic dike penetrated the active silicic chamber, permitting escape of viscous silicic magma from along the margins of the chamber.

Monday, September 18. In the Corea rapakivi granite, including minor gabbroic rocks near the base of the pluton, we will examine (1) interactions between mafic replenishments and granitic magma with large K-feldspar crystals, (2) a higher-level contact of the granite with metavolcanic rocks where rapakivi textures are absent at the contact and become common toward the center of the granite, (3) depositional features and hybrid enclaves within the granite.

Tuesday, September 19. Transport to airport.

### Logistics, Participants, and Costs

Each day we will have breakfast at 7:00 a.m. and attempt to leave no later than 8:00 a.m. White Birches Motel will provide substantial box lunches and drinks. We anticipate dinners at about 7:00 p.m. and opportunities for discussion and informal presentations afterward, in a room provided with slide and overhead projectors. Hiking is not strenuous, and participants in reasonably good physical condition will be able to visit all localities. Participants must make their own travel arrangements to and from Bangor, Maine. A registration fee of $630 will cover all meals, lodging, field trip transportation, and park fees.

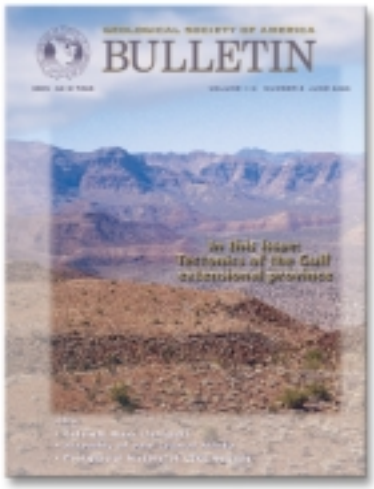
The forum is limited to 30 participants in order to permit easy access to outcrops and opportunities for discussion by all. Participation of graduate students is encouraged. Those interested should send a letter of application to Bob Wiebe. Selection of participants will be made by the field forum leaders; notification of acceptance will be no later than June 15, 2000. To reserve a place, the registration fee is due by *August 1, 2000*.

### For Information, Application, and Registration

Contact Bob Wiebe, Dept. of Geological Sciences, Franklin and Marshall College, Lancaster, PA 17604-3003, (717) 291-3820, fax 717-291-4186, r_wiebe@acad.fandm.edu. ■

# JUNE *Bulletin* and *Geology* Highlights

## In June *Bulletin*—




- Tectonics of the Gulf extensional province
- Calcium mass transport
- Assembly of east-central Alaska
- Postglacial history of Lake Agassiz

***For subscription information, call toll-free 1-888-443-4472, or e-mail member@geosociety.org.***

**Because *Bulletin* and *Geology* are now online (www.geosociety.org) as well as in print, their contents listings no longer appear in *GSA Today*, but here are June *Bulletin* and *Geology* highlights.**

## In June *Geology* —


- Strong, not weak, lower crust
- Li treatment for MORB
- Environmental sponge
- Dinosaurs going strong till last minute
- Scablands, gablands

# 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.**

## 2000

***July***

July 11–14, 1st International Professional Geology Conference, Alicante, Spain. Information: Yolanda Ruiz-Pérez, phone 34-91-5532403, 3944868, or 34-62-6365068, fax 34-91-5330343, eurgeomr@eucmax.sim.ucm.es or icog@icog.es.

July 13–18, 112th Meeting of the Astronomical Society of the Pacific, Pasadena, California. Information: www.aspsky.org/meetings/current.html or ldanly@du.edu.

July 17–20, 9th Annual Minerals Education Conference, Spokane, Washington. Information: Ken Assmus, (509) 624-1158 or www.nwma.org.

July 27–28, Improved Recovery Symposium—2000, Ahmedabad, India. Information: Convener IRS-2000, Institute of Reservoir Studies, Oil and Natural Gas Corp. Ltd., Chandkheda, Ahmedabad 380005, Gujarat, India, phone 91-79-7511630 or 7501704, fax 91-79-7501662, irs2000@irsongc.res.in.

***September***

September 17–20, AAPG Rocky Mountain Section Annual Meeting, Albuquerque, New Mexico. Information: Paul A. Catacosinos, 1001 Martingale Ln. SE, Albuquerque, NM 87123, (505) 299-3544, paulcat@attglobal.net.

***October***

October 23–25, Coaltrans 2000, Madrid, Spain. Information: Coaltrans Conferences Ltd., Nestor House, Playhouse Yard, London EC4V 5EX, UK, phone 44-207-779-8945, fax 44-207-779-8946, coaltrans@euromoneyplc.com, www.coaltransconferences.com.

***December***

December 2–7, Geochemistry of Crustal Fluids, Granada, Spain. Information: J. Hendekovic, European Science Foundation, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France, phone 33-388-767135, fax 33-388-366987, euresco@esf.org, www.esf.org/euresco.

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.

## *Giant Steps Through Time*

***Dublin, Ireland • September 16–October 1, 2000***


Cliffs of Moher. Photo by Jay Gregg.

### Scientific Leaders

John Morris, Barry Long, Brian McConnell, Conor MacDermot, and Pat O'Connor, Geological Survey of Ireland, Dublin; Patrick McKeever, Ian Mitchell, and Terry Johnston, Geological Survey of Northern Ireland. Coordinators: Enda Gallagher, Geological Survey of Ireland, gallaghe@tec.irlgov.ie; Jay M. Gregg, Dept. of Geology and Geophysics, University of Missouri—Rolla, greggjay@umr.edu

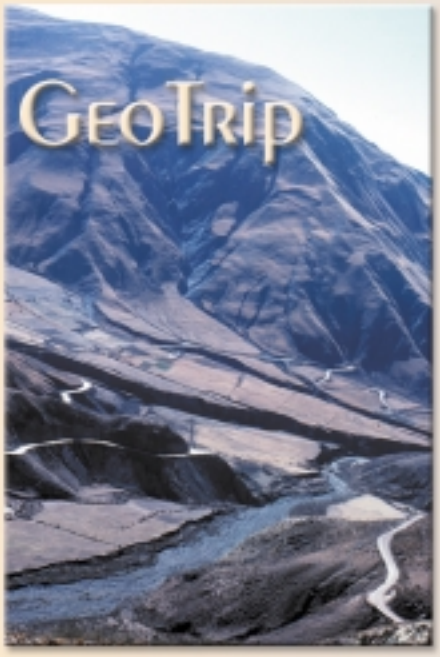
This cooperative trip between the Geological Surveys of Ireland and Northern Ireland will be led by eight professional geologists. All are experienced field trip leaders and acknowledged as leading experts in their respective fields within Irish geology.

### Description

Participants will be introduced to the wonderful diversity of Ireland's geology, contained within a surprisingly small area. To examine the same assortment of geological localities in the United States would require a considerable trek—perhaps from coast to coast. Not only is Ireland's geology diverse, it also contains numerous classic geologic localities, many of which we will visit during this trip. Participants will see the rocks that neptunists and vulcanists argued over, including Ireland's geologic jewel—the Giant's Causeway in Antrim. Equally impressive are the classic igneous ring complexes and volcanic centers of counties Louth, Armagh, and Down, including Slieve Gullion and Carlingford, which were among the first such features described anywhere in the world. The granites of counties Donegal and Galway exhibit a variety of granite emplacement mechanisms and include the localities where granitization was first proposed. How exactly does an orogeny work? The story of the Grampian orogeny can be read in rocks from Antrim in the northeast across to Galway on the west coast. Ireland's west coast, from Donegalto Clare, reveals many other geologic treasures, including a prograding deltaic sequence, exceptional fossil preservation, and karstic features. All these features are contained in a spectacular glaciated landscape, which, when combined with Ireland's unique culture, history, and folklore, adds a delightful extra dimension to the trip.

### Fees and Payment

$4,300 for GSA members; $4,400 for nonmembers. A $300 deposit is due with your reservation and is refundable through July 1, less $50 processing fee. The total balance is due August 1, 2000. FIRM minimum: 20; maximum: 25. Included: Round-trip airfare from Atlanta to Dublin; guidebook; ground transportation; lodging for 14 nights, based on double occupancy; and meals for 14 days. Not included: airfare to Atlanta and alcoholic beverages.




View of the Neogene Cordillera Oriental from the Cuestra del Obispo in Salta Province, Argentina. Photo by James H. Reynolds.

## *Deformation, Dinosaurs, and Darwin*

SPACE AVAILABLE!

*Salta, Argentina • July 24–August 13, 2000 • 21 days, 20 nights*

### Scientific Leaders

James Reynolds, Magstrat, LLC, Webster, North Carolina, and Brevard College, Brevard, North Carolina; Dorothy L. Stout, Cypress College, Cypress, California

Jim Reynolds has spent the past 15 years investigating the uplift history of the Andes. Using magnetostratigraphy, Jim and his colleagues are developing a relatively precise chronostratigraphy across the many tectonic provinces that we will visit. In addition to his work at Magstrat, LLC and Brevard College, he holds an adjunct position at the University of Pittsburgh. Dottie Stout has been leading geological expeditions around the world since 1978, exploring China, South America, Africa, Europe, Indonesia, Australia, and Russia. Dottie is past president of the National Association of Geology Teachers, is currently on GSA Council, and is temporarily on leave as a program director at the National Science Foundation.

### Description

This thousand-mile journey down the east side of the Andes encompasses a variety of the tectonic provinces associated with variations in the Nazca plate subduction angle that range from subhorizontal to moderately steep. The trip begins in Salta and Jujuy provinces in northwestern Argentina, where Proterozoic, Paleozoic, Mesozoic, and Cenozoic strata and structures are spectacularly displayed. Other sites to be visited: (1) The Train to the Clouds, Parque National de Reyes—a jungle excursion renowned for its animals and birds; environmental geology problems caused by active alluvial fans in the Quebrada de Humahuaca; and new interpretations and connections of Grenville rocks. Cambrian-Ordovician strata with North American affinities will be examined, as will views of a porphyry copper complex on the 20,000-ft-high Sierra de Famatina. (2) Valle de la Luna National Park, the area in which the oldest known dinosaurs were discovered, includes views of Aconcagua; a bus ride to Los Penitentes ski area along the route that Darwin took when he traversed the Andes from Valparaiso, Chile (weather dependent); Buenos Aires; and Iguazu Falls.

### Fees and Payment

$3,900 for GSA members; $4,000 for nonmembers. A $300 deposit is due with your reservation. Deadline extended to July 1, 2000. Minimum: 20; maximum: 30. Included: Guidebook, ground transportation, lodging for 20 nights, based on double occupancy, and meals for 21 days. Not included: airfare to Argentina and alcoholic beverages.

# CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-1133, or e-mail: acrawford@geosociety.org. Please include complete address, phone number, and e-mail address with all correspondence.

| Classification | Per Line for 1st month | Per line for each addt'l month (same ad) |
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## Positions Open

**MIT—PALEOCLIMATE SCIENCE FACULTY POSITION**

The Department of Earth, Atmospheric, and Planetary Sciences at MIT invites applications for faculty positions in the area of atmospheric, oceanic, and geological paleoclimate science. Rank and salary are open, but we particularly encourage potential junior faculty to apply. We seek creative applicants with broad research interests who have a strong understanding of fundamental biological, geological, chemical, and physical processes affecting the evolution of Earth's climate. The position is open to outstanding candidates in all areas of paleoclimatology. Observational and experimental approaches are favored; applicants capable of initiating and/or taking full advantage of the interdisciplinary nature of the department are encouraged to apply. Enthusiasm for teaching at the graduate and undergraduate level is essential at MIT.

Interested individuals should send curriculum vita and names of three references to: Professor Ron Prinn, Department Head, Attention PC Search, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139. MIT is an Equal Opportunity/Affirmative Action Employer. MIT is a non-smoking environment. More information on our department can be found at http://eaps.mit.edu.

**MIT—POSTDOCTORAL FELLOW**

The Earth Resources Laboratory (ERL) of the Department of Earth, Atmospheric, and Planetary Sciences at MIT invites applications for a Postdoctoral Fellow in Global Seismology. ERL activities are centered around theoretical, experimental, and observational research programs in basic science that have both industrial and academic applications. The laboratory has over 40 personnel, including faculty, research scientists, postdoctoral fellows, and Ph.D. and master's level graduate students. In addition, visiting faculty and researchers from universities and industry frequently participate in ERL research and educational activities.

The successful applicant will be expected to participate in a research group dedicated to basic research in earthquake location and the determination of the 3-D seismic structure of the crust and upper mantle from earthquake traveltime data. Candidates must have a Ph.D. in geophysics or related field. Broad background in regional and global seismology is desired, with strong skills in the development and application of computational methods for 3-D seismic modeling, raytracing, and the solution of large inverse problems. This position has a renewable one-year appointment at a salary of $40,000.

Applications for this position should be submitted to: Professor J. Grotzinger, Director of the Earth Resources Laboratory, Massachusetts Institute of Technology, Room E34-442, 77 Mass. Avenue, Cambridge, MA 02139-4307. MIT is an Equal Opportunity/Affirmative Action Employer. MIT is a non-smoking environment.

**MIT—POSTDOCTORAL FELLOW**

The Earth Resources Laboratory (ERL) of the Department of Earth, Atmospheric, and Planetary Sciences at MIT invites applications for a Postdoctoral Fellow in Seismic Interpretation. ERL activities are centered around theoretical, experimental, and observational research programs in basic science that have both industrial and academic applications. The laboratory has over 40 personnel, including faculty, research scientists, postdoctoral fellows, and Ph.D. and master's level graduate students. In addition, visiting faculty and researchers from universities and industry frequently participate in ERL research and educational activities.

The successful applicant will be expected to participate in a research group dedicated to basic research in seismic data acquisition, processing, and interpretation. Candidates must have a Ph.D. in geophysics or geology, strong interpretation skills, and some industry experience. Experience working with data sets from deepwater turbidite settings or carbonates is desirable. This position has a renewable one-year appointment at a salary of $40,000.

Applications for this position should be submitted to: Professor J. Grotzinger, Director of the Earth Resources Laboratory, Massachusetts Institute of Technology, Room E34-442, 77 Mass. Avenue, Cambridge, MA 02139-4307. MIT is an Equal Opportunity/Affirmative Action Employer. MIT is a non-smoking environment.

**MIT—POSTDOCTORAL FELLOW**

The Earth Resources Laboratory (ERL) of the Department of Earth, Atmospheric, and Planetary Sciences at MIT invites applications for a Postdoctoral Fellow in Elastic Wave Propagation. ERL activities are centered around theoretical, experimental, and observational research programs in basic science that have both industrial and academic applications. The laboratory has over 40 personnel, including faculty, research scientists, postdoctoral fellows, and Ph.D. and master's level graduate students. In addition, visiting faculty and researchers from universities and industry frequently participate in ERL research and educational activities.

The successful applicant will be expected to participate in a research group dedicated to basic research in seismic wave propagation in complex media. Candidates must have a Ph.D. in geophysics or related field, strong numerical modeling skills, and some background in seismic inversion methods. Experience in working with seismic reflection data sets is desirable. This position has a renewable one-year appointment at a salary of $40,000.

Applications for this position should be submitted to: Professor J. Grotzinger, Director of the Earth Resources Laboratory, Massachusetts Institute of Technology, Room E34-442, 77 Mass. Avenue, Cambridge, MA 02139-4307. MIT is an Equal Opportunity/Affirmative Action Employer. MIT is a non-smoking environment.

**MIT—SENIOR RESEARCH SCIENTIST**

The Earth Resources Laboratory (ERL) of the Department of Earth, Atmospheric, and Planetary Sciences at MIT invites applications for a Senior Research Scientist position in Exploration Seismology and Imaging. ERL activities are centered around theoretical, experimental, and observational research programs in basic science that have both industrial and academic applications. The laboratory has over 40 personnel, including faculty, research scientists, postdoctoral fellows, and Ph.D. and master's level graduate students. In addition, visiting faculty and researchers from universities and industry frequently participate in ERL research and educational activities.

Classifieds *continued on p. 62*

## GeoVentures Registration

Send a deposit to hold your reservation; please pay by check or credit card. You will receive further information and a confirmation of your registration within two weeks after your reservation is received.

| | Deposit Per Person | No. of Persons | Total Paid Deposit |
|---|---|---|---|
| GT002—Argentina | $300 | ____ | $_____ |
| GT005—Ireland | $300 | ____ | $_____ |
| | TOTAL DEPOSIT | | $_____ |

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Credit Card # Exp. Date

Signature

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

☐ I've enclosed no deposit, but I'm interested. Please send information.

MAIL OR FAX REGISTRATION FORM AND CHECK OR CREDIT CARD INFORMATION TO:
2000 GSA GeoVentures, Member Services
P.O. Box 9140, Boulder, CO 80301
*fax 303-447-1133 or 303-443-1510*

MAKE CHECKS PAYABLE TO: GSA 2000 GeoVentures

Classifieds *continued from p. 61*

The successful applicant for the Senior Research Scientist position will be expected to build a strong research program in theoretical and practical aspects of exploration seismology, to maintain and further develop relationships with industry, and to interact with visitors from US and foreign industry partners. Candidates must have a Ph.D. in geophysics (seismology) or related area, broad computer skills, and a strong background in theoretical and computational seismology. Experience in modeling of high frequency acoustic and elastic wave propagation in complex 2D and 3D media and the inversion for structural parameters of such media needs to be demonstrated by a strong record of publications and presentations at scientific meetings. Good interpersonal skills and a willingness to travel are also required. The Senior Research Scientist is equivalent in rank to the academic position of full professor, with principal investigator rights on government research grants, but no teaching obligations. Salary will be commensurate with experience.

Applications for this position should be submitted to: Professor J. Grotzinger, Director of the Earth Resources Laboratory, Massachusetts Institute of Technology, Room E34-442, 77 Mass. Avenue, Cambridge, MA 02139-4307. MIT is an Equal Opportunity/Affirmative Action Employer. MIT is a non-smoking environment.

**YOUNGSTOWN STATE UNIVERSITY**
**DEPARTMENT OF GEOLOGY**

Applications are now being accepted for two temporary full-time faculty positions in the Department of Geology for the 2000–2001 academic year. Both positions require individuals who have demonstrated excellence in teaching at the undergraduate level and are able to conduct research projects involving undergraduate students. Salary will be commensurate with candidate's degree and experience.

Geology/Environmental Studies Program: Ph.D. in Geology or related field required. Will consider ABD. Teaching responsibilities include Introductory Geology and Environmental Studies courses and one or more of the following: Environmental Geochemistry, Environmental Sampling, Water Quality, and Environmental Impact Assessment.

Geology: Ph.D. in Geology. Will consider ABD. Teaching responsibilities include Geomorphology, Introductory Geology courses, and either one of the following: Environmental Geology or Introductory Engineering Geology.

Send letter of interest, current résumé, official transcripts documenting academic credentials, and the names, addresses, and telephone numbers of at least three professional references to: Dr. Ikram Khawaja, Chairperson, Department of Geology, Youngstown State University, One University Plaza, Youngstown, OH 44555-0001. Applications will be accepted until positions are filled.

Youngstown State University is an Affirmative Action/Equal Opportunity Employer, committed to increasing the diversity of its faculty, staff, and students.

**GEOMORPHOLOGIST/WATERSHED SPECIALIST, CA**

Designs and monitors channel and wetland restoration efforts. Identifies sources of sediment or channel instability and recommends means for restoration. Strong geologic training in fluvial geomorphology or sedimentology required. Familiarity with standard hydrologic databases and aerial photograph/GIS analysis a plus. Demonstrated affinity for fieldwork during storms. Excellent written and presentation skills for both professional and lay audience expected. Minimum 3 years professional experience, plus research and publication potential, but can be much more senior. Attn: Leslie Mack, Balance Hydrologics, Inc., 900 Modoc St., Berkeley, CA 94707, office@balancehydro.com, fax: 510-527-8531.

**DIVISION OF EARTH SCIENCES**
**NATIONAL SCIENCE FOUNDATION**
**ARLINGTON, VA 22230**

NSF's Division of Earth Sciences seeks qualified candidates for 2 leadership positions:

Head, Special Projects Section (EP 00-12). This section coordinates the Division's multidisciplinary, educational, instrumentation and facilities infrastructure needs of the earth sciences.

Head, Research Grants Section (EP 00-13). This section coordinates the Division's core disciplinary programs (e.g., geology & paleontology, petrology & geochemistry, and hydrologic sciences and tectonics).

Appointment to these Senior Executive Service positions may be on a career or a 2- to 3-year limited term basis, with an ES-1 ($115,811) to ES-3 ($126,825) salary range. Alternatively, the incumbent may be assigned under Intergovernmental Personnel Act provisions. Applicants must have a Ph.D. or professional experience in at least one of the major subdisciplinary fields of the earth sciences, substantial research administrative experience, and demonstrated leadership ability.

The announcements, including position requirements and application procedures, are located on NSF's Homepage at www.nsf.gov/home/chart/work.htm. Applicants may also obtain a copy of the announcements by contacting the Executive Personnel and Development Branch on (703) 306-0755 (hearing impaired individuals may call TDD (703) 306-0189). Applications must be received by August 15, 2000.

NSF is an Equal Opportunity Employer.

**ADAMS STATE COLLEGE**

INSTRUCTOR GEOLOGY AND ENVIRONMENTAL SCIENCE: Part-time laboratory instruction of general education science courses. Details: http://www.adams.edu/res_services/employ-main.htm or rgbenson@ adams.edu or 719-587-7921. ASC is an AA/EOE.

ASSISTANT PROFESSOR GEOLOGY AND ENVIRONMENTAL SCIENCE: Teaching of lecture and laboratory courses in hydrology, geomorphology, physical geography, with GIS, and general education science courses in a small field-oriented expanding department. Details: http://www.adams.edu/res_services/employ-main.htm or rgbenson@adams.edu or 719-587-7921. ASC is an AA/EOE.

**ASSOCIATE DEAN**
**SCIENCE & MATHEMATICS DIVISION**
**SEATTLE CENTRAL COMMUNITY COLLEGE**

Administrative position available as Associate Dean of the Science & Mathematics Division at Seattle Central Community College. Closes June 28, 2000. Master's in science or mathematics required, Ph.D. in same with full-time teaching experience in a postsecondary institution preferred. Salary: $55,000 to $63,000. Job #20-112-RS. Apply at Human Resources, SCCD, 1500 Harvard Ave., Seattle, WA 98122 or (206) 587-4155. Via the internet: http://www.sccd.ctc.edu/~humres. AA/EEO Employer.

**WESTERN KENTUCKY UNIVERSITY**
**DEPARTMENT HEAD POSITION**
**GEOGRAPHY, GEOLOGY, OR GEOSCIENCE SPECIALIZATION**

We seek a dynamic individual to fill the position of Department Head beginning January 1 or July 1, 2001. Applications are invited from persons specialized in Geography, Geology, or a related area in Geoscience. Basic qualifications must include an earned Ph.D., an outstanding record of academic and professional accomplishment, a strong vision for developing innovative Geoscience programs across discipline boundaries, and a strong commitment to undergraduate education.

In addition to the basic qualifications, the successful candidate will possess the desirable skills needed to manage diverse academic programs, to communicate with administration, and to lead effectively a diverse group of Geoscience professionals. The ideal candidate will possess proven and substantial leadership, administrative, and pedagogical skills, including undergraduate teaching, scientific research, project management, grants administration, and professional collaboration.

The Department of Geography and Geology has the largest single concentration of academic geoscientists in the Commonwealth of Kentucky. Our faculty, research programs, and facilities provide students with unique curricular opportunities in a variety of subdisciplines such as karst hydrology, climatology, city and regional planning, environmental and sedimentary geology, fossil fuels resources, and international studies. Applied research experiences are offered students through the Department's internationally recognized Center for Cave and Karst Studies, its Kentucky Climate Center, its College Heights Weather Station, and the Hoffman Environmental Research Institute. The Department presently offers degree programs in Cartographic and Mapping Techniques(AS), Geography(BS), Geology(BS), and the Geosciences (MS). Western Kentucky University, with 15,000 undergraduates and graduates, including more than 900 students of diverse ethnic backgrounds and 250 international students from 46 countries, has a strong commitment to achieving diversity among its faculty and staff. It is an affirmative action/equal opportunity employer. We are particularly interested in receiving applications from members of under-represented groups such as women and people of diverse ethnic backgrounds. Detailed information about the Department is available at http://www2.wku.edu/geoweb.

Send letter of application, vita, a separate detailed statement of departmental vision and leadership philosophy, and the names and e-mail addresses of three personal references to: Search Committee, Department of Geography and Geology, Western Kentucky University, 1 Big Red Way, Bowling Green, KY, 42101-3576. Review of applications will begin on August 15, 2000, and will continue until the position is filled.

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**Center for Environmental Analysis—Centers for Research Excellence in Science and Technology (CEA-CREST)** A major goal of CREST is to increase the number of under-represented students with Ph.D.'s in science, mathematics, engineering, and technology. CEA-CREST provides generous financial support for students: $8,000/yr undergraduate research assistantships and $15,000/yr fellowships for master's degree students, plus funds for travel to national scientific meetings. Additional support for graduate students is available through teaching assistantships and numerous financial aid options. For more information please contact: CEA-CREST, California State University, Los Angeles, 5151 State University Drive, Los Angeles, CA 90032-8970. Telephone: (323) 343-5799, email: ceacrest@calstate-la.edu, Web site: http://cea-crest.calstatela.edu.

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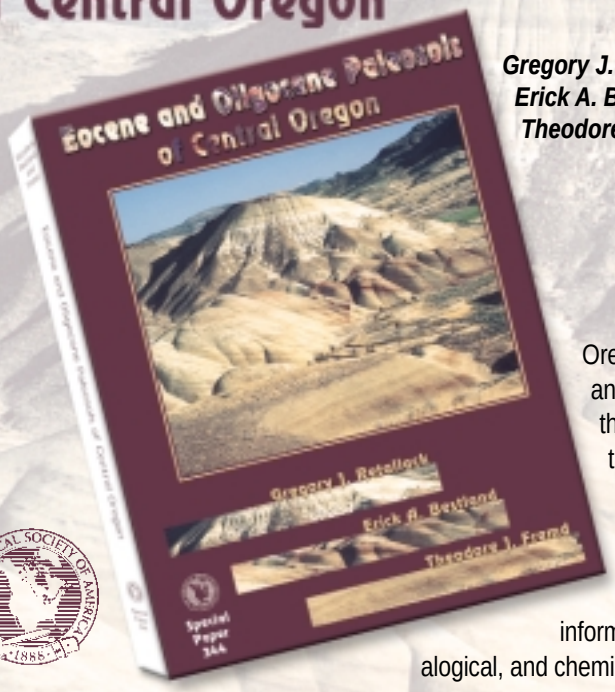


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