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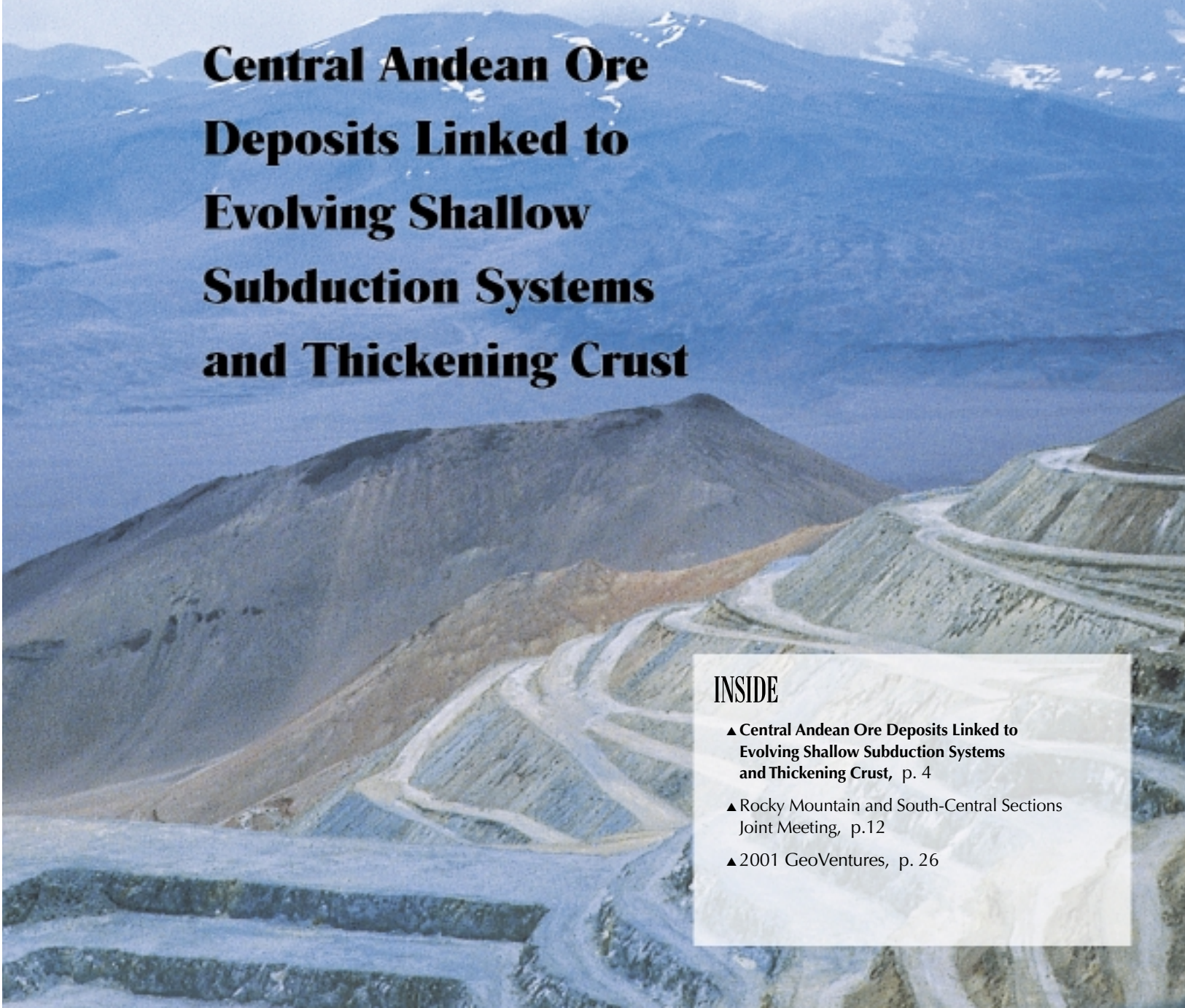
Central Andean Ore Deposits Linked to Evolving Shallow Subduction Systems and Thickening Crust



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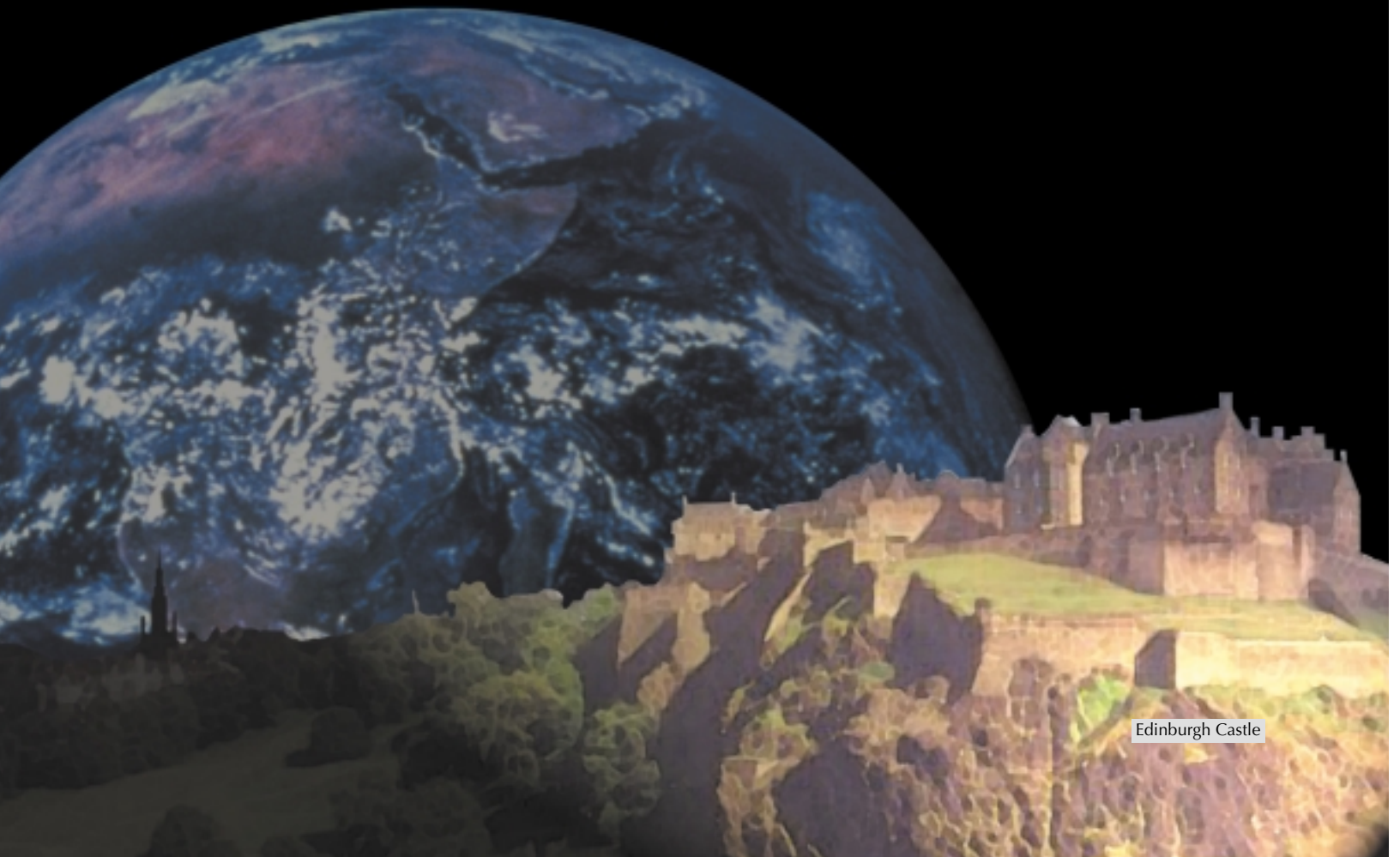

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science article

Cover photo shows the Marte gold mine in the 12 Ma Pastillos Volcano of the Maricunga Belt in the foreground and a late Pliocene volcanic center (La Barda) in the postmineralization Andean central volcanic zone to the east.

Central Andean Ore Deposits Linked to Evolving Shallow Subduction Systems and Thickening Crust

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ABSTRACT

Major Miocene central Andean (lat 22°–34°S) ore districts share common tectonic and magmatic features that point to a model for their formation over a shallowing subduction zone or during the initial steepening of a formerly flat subduction zone. A key ingredient for magmatism and ore formation is release of fluids linked to hydration of the mantle and lower crust above a progressively shallower and cooler subducting oceanic slab. Another is stress from South American–Nazca plate convergence that results in crustal thickening and shortening in association with magma accumulation in the crust. Fluids for mineralization are released as the crust thickens, and hydrous, lower crustal, amphibole-bearing mineral assemblages that were stable during earlier stages of crustal thickening break down to dryer, more garnet-bearing ones. Evidence for this process comes from trace-element signatures of pre- to postmineralization magmas that show a progression from equilibration with intermediate pressure amphibole-bearing residual mineral assemblages to higher pressure garnet-bearing ones. Mineralization over the shallowing subduction zone in central Chile (28°–33°S) is followed by cessation of arc volcanism or migration of the arc front away from the trench. Mineralization in the central Altiplano-Puna region (21°–24°S) formed above a formerly flat subduction zone as volcanism was reinitiating. Thus, hydration and crustal thickening associated with transitions in and out of flat-slab subduction conditions are fundamental controls on formation of these major ore deposits.

INTRODUCTION

Some of the world's richest and largest copper and gold deposits are associated with Miocene magmatism in the central Andes. This paper reviews how the formation of major ore deposits between 22° and 34°S can be linked to the late Cenozoic magmatic and tectonic response of the mantle and lower crust to the formation and subsequent steepening of shallow subduction zones (Figs. 1 and 2). Mineral districts discussed are the El

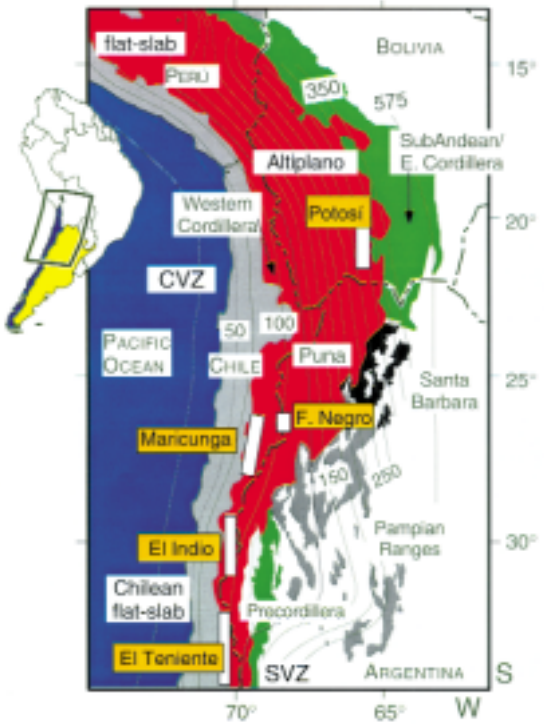

Figure 1: Central Andean map showing major Miocene mineralized areas (white boxes, yellow labels) relative to: (a) depth contours in km to Wadati-Benioff seismic zone of subducting Nazca plate (from Cahill and Isacks, 1992), (b) southern (SVZ) and central (CVZ) volcanic zones and Chilean and Peruvian flat-slab regions, (c) regions >3000 m in elevation (in red), and (d) foreland fold-thrust belts: Precordillera and Subandean–Eastern Cordillera thin-skinned belts (green), Santa Bárbara thick-skinned belt (black), and Pampean block uplifts (gray).

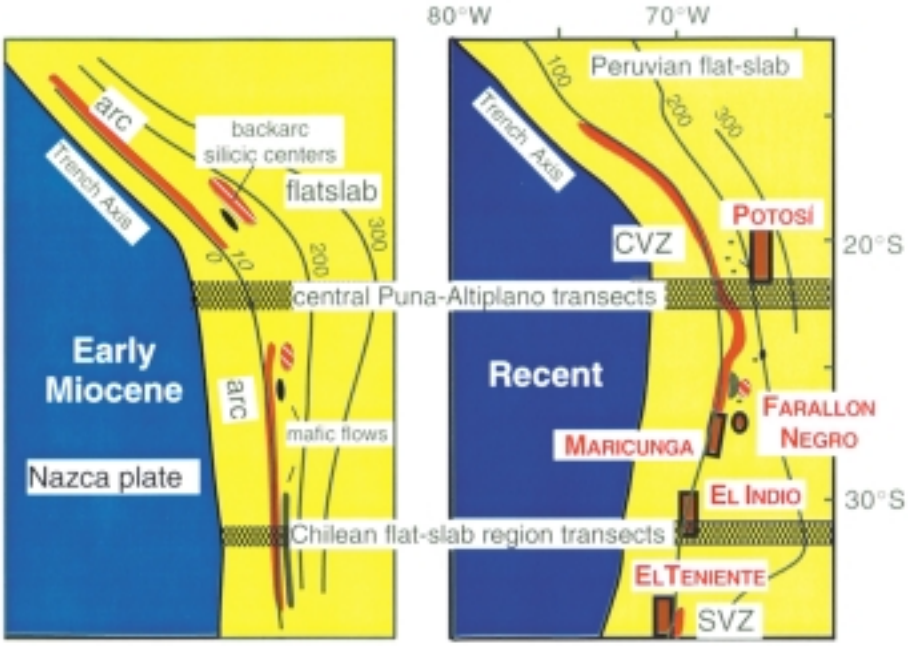

Figure 2: Early Miocene and Recent maps showing depth changes to Wadati-Benioff zone proposed by Isacks (1988) along with arc volcanic front (red), backarc mafic centers (black), and large ignimbritic centers (red stripes) from Kay et al. (1999). Miocene ore districts shown in brown boxes. Patterned bands are locations of reconstructed Miocene to Recent lithospheric cross sections in Figures 3 and 4.

Indio and Maricunga gold belts, the Farallon Negro copper-gold district, the El Teniente copper belt, and the Potosí silver-gold district. In the model, mineralization is linked to changes in crustal and lithospheric thickness induced by the evolving geometry of the subducting Nazca plate. Fluids for mineralization that are ultimately derived from the hydrated mantle above the subducting slab are released as wet amphibole-bearing lower crust thickens and transforms into dryer, garnet-bearing crust above a shallowing or recently shallow subduction zone. The model has implications for Miocene deposits over the shallow subduction zone in Peru and for Tertiary Laramide deposits in western North America.

TECTONIC SETTING OF MIOCENE CENTRAL ANDEAN ORE DEPOSITS

Major Miocene central Andean ore districts are located in extinct Miocene volcanic belts underlain by thickened continental crust (50–70 km thick; Isacks, 1988) on the arc side of major fold-thrust belts. This paper explores why they occur where they do. Figure 1 shows mineral districts between 22° and 34°S relative to modern central Andean geologic provinces and contours to the Wadati-Benioff seismic zone. The most prominent province, the Puna-Altiplano Plateau with its widespread Miocene to Recent volcanic cover and average elevation of 3700 m, is second on Earth only to the Tibetan Plateau in area and height. To the north and south, the Puna-Altiplano merges with the Main Cordillera of the high Andes. Most investigators attribute uplift and crustal thickening of the Puna-Altiplano and the Main Cordillera to Miocene crustal shortening with magmatic addition playing a secondary role (e.g., Isacks, 1988; Allmendinger et al., 1990, 1997). Prominent fold-thrust belts to the east provide a temporal record of this crustal shortening. These belts include the Subandean and Eastern Cordillera and Santa Bárbara Ranges east of the plateau, and the Precordillera and block-faulted Pampean Ranges east of the Main Cordillera.

A distinctive feature of the central Andes is the relatively shallow dip (<30°) of the subducting Nazca plate beneath South America compared to other circum-Pacific subduction zones. As recognized by Barazangi and Isacks (1976) and refined by Cahill and Isacks (1992), the Nazca plate can be divided at depths of ~90–135 km into nearly flat segments, above which there is no volcanism, that are flanked by relatively steeper segments associated with active volcanism (Fig. 1). The Chilean flat-slab segment between 28° and 33°S has a relatively smooth northern transition and an abrupt southern transition to the steeper segments (Fig. 1). In terms of this modern slab geometry, the El Indio belt is above the center of the Chilean flat slab, the Maricunga–Farallon Negro district above the northern transition, the El Teniente district above the southern transition, and the Potosí district above the steeper slab to the north.

Rationalizing the relationship among late Cenozoic central Andean uplift, crustal thickening, and Miocene mineralization requires understanding how the geometry of the subducting Nazca plate has changed since the breakup of the Farallon plate and the initiation of fast, nearly orthogonal convergence at ~26 Ma (Pardo Casas and Molnar, 1987). The model for evolving slab geometry used here is that proposed by Isacks (1988) on the basis of seismologic, structural and topographic constraints and modified by Kay et al. (1999) on magmatic considerations. The basic premise is that the slab beneath the modern shallow subduction zone has shallowed as the slab below the central Puna-Altiplano has steepened. Figure 2 compares the end-member early Miocene and modern situations, and Figures 3 and 4 show reconstructed lithospheric sections depicting the temporal evolution of transects through the Chilean flat slab and the Puna-Altiplano.

CHEMICAL CLUES TO TEMPORAL CHANGES IN MAGMATIC AND TECTONIC PROCESSES ASSOCIATED WITH MINERALIZATION

Important clues to processes occurring over a shallowing subduction zone come from magmas containing chemical components from the evolving slab, the overlying

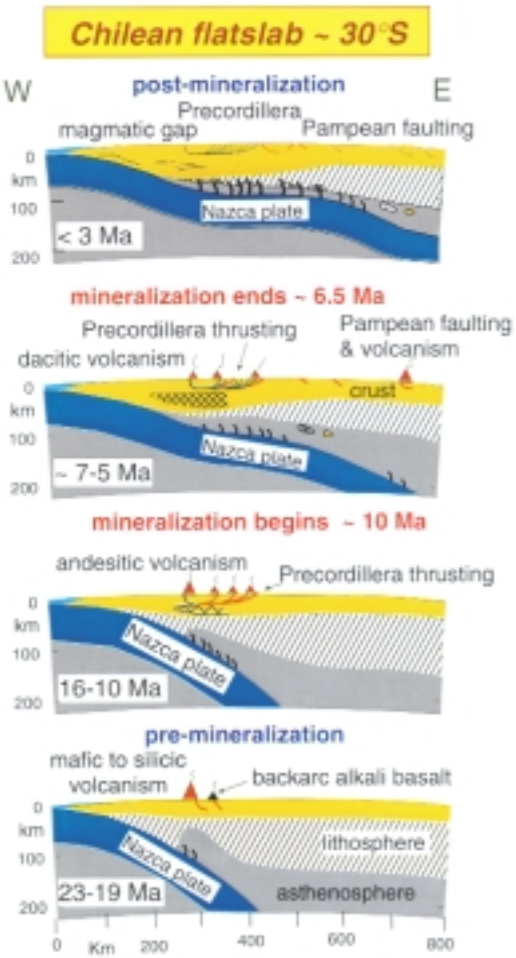

Figure 3: Schematic lithospheric cross sections across Chilean flat-slab transect at lat ~30ºS showing temporal changes in subducting slab geometry, crustal thickness, and areas of active volcanism and deformation before, during, and after mineralization. Size of volcanic centers reflect erupted volume. Hatched wedges represent areas of ductile thickening of the lower crust. Active faults shown in red. Figures based on Kay et al. (1991, 1999).

mantle wedge, and the crust. Uniquely, diagnostic chemical fingerprints can put restrictions on evolving temperature-pressure, chemical, and fluid profiles in the mantle and crust. Chemical analyses of more than 500 pre-, syn-, and postmineralization samples from the El Indio, Maricunga–Farallon Negro, and El Teniente districts all show the relatively high K, Ba, and Th, and low Ta concentrations expected in magmas erupted over a subduction zone (Kay et al., 1999). Central to the discussion below are the rare earth elements (REE), which show a relatively small range of La/Sm ratios and a wide range of Sm/Yb ratios (Fig. 5). Increasing Sm/Yb ratios mostly reflect pressure-dependent changes from clinopyroxene to amphibole to garnet in the mineral residue in equilibrium with evolving magmas (review in Kay and Kay, 1991). Following the proposition of Hildreth and Moorbath (1988) that arc magmas in a compressional regime evolve from mafic parent magmas in the lower crust and using Andean southern volcanic zone magmas and crustal thicknesses as depth indicators, Sm/Yb ratios can serve as guides to relative crustal thicknesses. Because breakdown pressures are influenced by factors like bulk composition and temperature, inferred depths are approximations. As a rough guide in mafic lavas, clinopyroxene is dominant at depths of <35 km, amphibole from ~30–45 km, and garnet at >45–50 km.

MAGMATISM, DEFORMATION, AND MINERALIZATION OVER A SHALLOWING SUBDUCTION ZONE

The lithospheric cross sections in Figure 3 illustrate a working model for the post–early Miocene shallowing of the Chilean subduction zone that accounts for magmatic, structural, and basin evolution over the modern flat-slab region and its borders (e.g., Kay et al., 1991, 1999; Jordan et al., 1993; Kay and Abbruzzi, 1996). Shallowing from ~18–8 Ma can account for decreasing amounts of volcanism and cessation of andesitic volcanism by ~9 Ma in the Main Cordillera, as well as an eastward broadening of the volcanic arc, the compressional deformation front, and the foreland basin system into the Precordillera. Continued shallowing of the slab after ~7 Ma can explain eastward expansion of deformation and magmatism into the Pampean Ranges, and the end of volcanism across the transect at ~5 Ma as the asthenospheric wedge became too thin in the west and the slab too dehydrated in the east to flux mantle melting. In concert with shallowing, the mantle and crust over the slab became increasingly hydrated under the Main Cordillera and the zone of hydration broadened eastward as decreasing asthenospheric circulation increasingly limited melting and fluid removal (e.g., Kay and Gordillo, 1994). As shallowing proceeded, magmatically weakened lower crust beneath the Main Cordillera thickened (Kay et al., 1991) in conjunction with crustal shortening in the Precordillera and the Sierras Pampeanas (e.g., Allmendinger et al., 1990), as well as with shortening in the forearc. Mass balance considerations require contemporaneous thinning of the continental lithosphere (Kay and Abbruzzi, 1996).

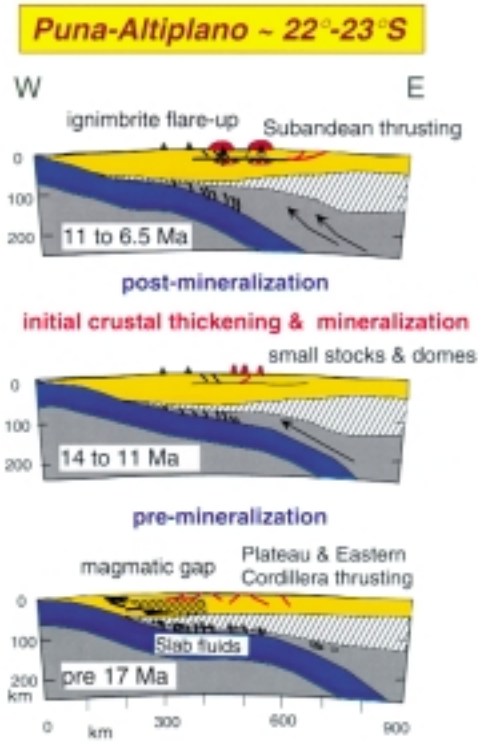

Figure 4: Schematic lithospheric cross sections along the central Puna-Altiplano Plateau transect lat ~22°–23°S showing temporal changes in subducting slab geometry, crustal thickness and areas of active volcanism and deformation before, during, and after mineralization. Red striped regions are crustal magma chambers below master fault detachment that feed ignimbrites (in red). Figure based on Kay et al. (1999).

Important Miocene mineralization took place in the Chilean flat-slab region as the subduction zone was shallowing. Evidence for the temporal and spatial association between mineralization and Miocene magmatic stages and deformational events over the shallowing subduction zone beneath the El Indio, Maricunga–Farallon Negro, and El Teniente mineral districts is summarized in Table 1 and discussed below. Within the region, ages of mineralization, like average crustal thicknesses and subduction zone angles, decrease to the south and east.

The El Indio Transect. The El Indio transect is located in the Main Cordillera above the middle of the present flat slab. Major mineralization can be associated with the last two of three volcanic stages in this

TABLE 1. LATE OLIGOCENE TO RECENT TECTONIC, MAGMATIC, AND MINERALIZATION HISTORY OF THE CHILEAN FLAT-SLAB REGION

Ma	26°–28°S Maricunga Transect Thicker Crust	29°–31°S El Indio Belt Intermediate Thickness Crust	32°–34°S El Teniente District Thinner Crust
7–5	Flat-slab magmatism ends; arc migrates east on margins of flat slab; uplift, crustal thickening.		
	Au–Farallon Negro ~7–6 Ma Jotabeche dacite/Pircus Negras andesite (~60–65 km)	*Au–El Indio ~ends at ~6.5 Ma* Vallecito Fm./ Vacas Heladas Ignimbrite (~60 km)	*Cu–El Teniente south ~4.9 Ma* *Cu–Los Bronces ~7–5 Ma* (>45 km)
11–7	Silicic magmatism to north; last andesitic lavas in flat-slab region; andesitic stratovolcanoes to south. Copiapó Ignimbrite Complex		
~17–9	Andesitic to dacitic stratovolcano complexes; Precordillera deformation and crustal thickening.		
	Au–Gold Porphyries ~12–10 Ma Cadillal Group Ojos de Maricunga Group (>50 km)	*Au–El Indio ~begins at ~10 Ma* Tambo Formation ~13–9 Ma Cerro de Las Tórtolas Fm. ~17–14 Ma (>45 km)	*Cu-Pachon in north ~10–9 Ma* El Teniente (Farallones Fm.) Volcanic/Plutonic Complex (~35-40 km)
20–18	Relative magmatic lull, deformation, and crustal thickening.		
26–20	Arc and backarc magmatism in all regions; more dacitic to andesitic in north; more bimodal to south.		
	Au–La Coipa-like domes ~23–21Ma Refugio/La Coipa Group (andesite) (~40–45 km)	Las Máquinas backarc basalt ~23 Ma Escabroso Formation ~21–17 Ma Tilito Formation ~27–21 Ma (~35-40 km)	 Coya Machalí Formation (~30–35 km)

Note: See Kay et al. (1999) for further references to these transects.

area. Each successive volcanic stage has a distinctive distribution and composition, shows a decrease in overall erupted volume, and is generally bounded by compressional deformational peaks (Kay et al.,1991, 1999). The initial Doña Ana Group is characterized by voluminous 27–21 Ma andesitic to rhyodacitic tuffs that unconformably underlie 21–17 Ma mafic andesite flows and are cut by small shallow intrusives (Martin et al., 1997). Small ~23 Ma (Las Máquinas) backarc alkali basalt flows are related to faults. Low-pressure pyroxene-bearing mineral residues complimentary to these magmas (Fig. 5; Kay et al., 1991) are consistent with ascent from lower levels of a normal thickness crust over a relatively steep subduction zone. This first volcanic stage terminated with high-angle reverse faulting in the Main Cordillera and initiation of thrust faulting in the Precordillera (Jordan et al., 1993). The second volcanic stage in the Main Cordillera is composed dominantly of ~17–14 Ma and ~13–9 Ma hornblende-bearing andesitic to dacitic units (Martin et al., 1997). Their REE patterns are consistent with equilibration in a thickening crust in which the mafic mineral residue changed from amphibole to garnet-bearing in the final stages (Fig. 5; Kay et al., 1991). This second stage also included small backarc amphibole-bearing andesitic to dacitic centers that extended into the Precordillera. The end of the second volcanic stage overlaps the peak of Precordillera thrust faulting at ~11–9 Ma (Jordan et al., 1993) and initiation of the major mineralization episode in the El Indio belt at ~10 Ma which lasted until 6.5 Ma (Clavero et al., 1997; Bissig et al., 2000). The terminal volcanic stage consists of minor ~7–6 Ma hornblende-bearing dacitic centers with amphibole-bearing residual mineralogy in the Main Cordillera (Vallecito in Fig. 5) and Precordillera, and mafic andesitic to dacitic centers in the Pampean Ranges (Kay and Gordillo, 1994).

The Maricunga Transect. Deformational and magmatic peaks in the Maricunga transect to the north near the boundary with the steeper slab are virtually analogous to those in the El Indio belt, but initial mineralization is older (Kay et al., 1994; Mpodozis et al., 1995). This mineralization at 23–21 Ma is linked to dacitic dome complexes emplaced near the end of a 26–21 Ma volcanic peak (Vila and Sillitoe, 1991; Mpodozis et al., 1995). Unlike first-stage El Indio magmas, REE patterns of these magmas point to amphibole-bearing lower crustal residues (Fig. 5) consistent with a thicker crust over a shallower subduction zone (see Fig. 2). This episode is followed by deformation and diminished volcanism from 20 to 18 Ma. Andesitic units that erupted at the beginning of the next volcanic stage from 17–12 Ma have steeper REE patterns consistent with a more garnet-rich residual mineralogy at deep levels of a thicker crust. In accord with this observation, regional uplift in the middle Miocene is signaled by thick sequences of alluvial sediments (Atacama gravels) which show syntectonic deformation east of the arc (Gardeweg et al., 1997). The second mineralization episode is linked to the emplacement of 13–10 Ma fault-controlled "gold porphyries" (e.g., Marte; Sillitoe et al., 1991) near the end of the second volcanic stage. REE patterns of these magmas again indicate an amphibole-bearing mineral residue. Mild extension and normal faulting at this time are consistent with models of stress relaxation during porphyry mineralization (Tosdal and Richards, 2001). The final stages of Maricunga belt volcanism are dominated by the ~11–7 Ma dacitic units from the Copiapó center, and 7–5 Ma Jotabeche rhyodacitic and Pircas Negras mafic andesitic flows. These postmineralization flows, which have REE patterns that indicate equilibration with garnet-bearing residues (Fig. 5), erupted through very thick crust as the arc front began to migrate eastward (Kay et al., 1999). The final mineralization in this transect at 7–6 Ma occurred in the Farallon Negro volcanic field to the east (Sasso and Clark, 1996), which erupted as volcanism migrated eastward and the crust thickened in association with uplift of the Pampean Ranges.

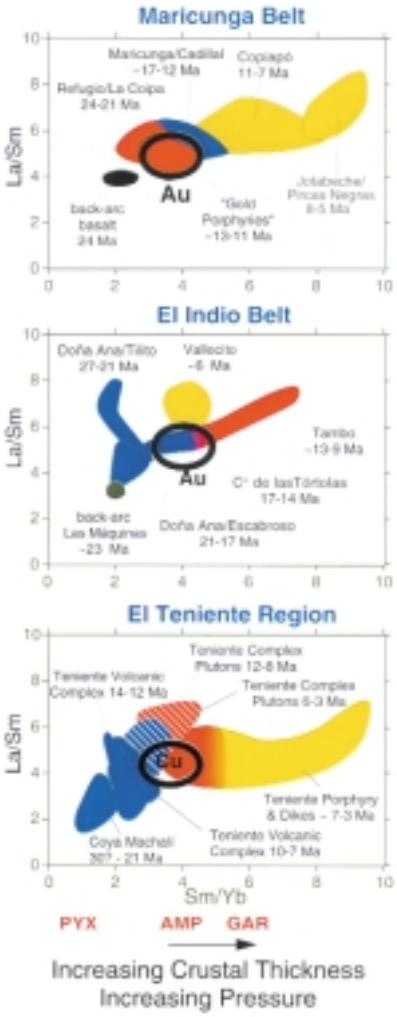

Figure 5: Plots of La/Sm (light REE) vs. Sm/Yb (heavy REE) ratios for more than 500 magmatic rocks from the Maricunga–Farallon Negro, El Indio, and El Teniente districts. Premineralization or between mineralization (Maricunga belt) units are in blue, synmineralization units in red, and postmineralization units in yellow. Hatched fields are plutonic units. Thick lines enclose fields for magmas erupted near times of gold (Au) and copper (Cu) mineralization. Presence of plutonic units and Cu rather than Au in the El Teniente district reflects greater erosion in this region. Samples in Au and Cu field have Sm/Yb ratios magmas in equilibrium with amphibole-bearing residual mineral assemblages in transition to garnet-bearing. Data sources in Kay et al. (1999) and Kay and Mpodozis (1999).

El Teniente Transect. El Teniente transect volcanism at the southern border of the flat-slab region also occurred in three stages separated by deformational peaks (Kurtz et al., 1997; Kay et al., 1999). Unlike the Maricunga transect, ages of shallowing of the subduction zone, crustal thickening, and mineralization are younger than in the El Indio belt. Voluminous mafic to silicic magmas of the first volcanic stage erupted through a thin crust in a neutral to slightly extensional tectonic regime. They were followed by an ~19–16 Ma lull associated with compressional deformation leading to initial uplift and crustal thickening (Kurtz et al., 1997). Magmatism resumed with the formation of the ~15–7 Ma Teniente volcanic and plutonic complex east of the older arc front. Like chemically equivalent early-to-middle Miocene El Indio belt magmas (Fig. 5), these premineralization Teniente Complex units have pyroxene to amphibole-dominated residual mineralogy. This magmatic stage ended with deformation (Godoy et al., 1999) and rapid regional uplift (~3 mm/year; Kurtz et al., 1997). Late Miocene to early Pliocene porphyries and dikes equilibrating with garnet-bearing residual assemblages (Fig. 5) were emplaced as the frontal volcanic arc south of 33°S shifted eastward to the present southern volcanic zone. Mineralization is associated with late Miocene tourmaline-bearing breccia complexes whose ages decrease from north to south: Pelambres–El Pachon deposit at 32°S at ~10–9 Ma, Rio Blanco–Los Bronces deposit at 33°S at ~7–5 Ma, and El Teniente deposit near 34°S at ~5 Ma (see Skewes and Stern, 1994, 1997). Skewes and Stern (1994) argue that metal-rich fluids forming these deposits are released as long-lived plutons cool and solidify in the dying magmatic arc over the shallowing subduction zone.

MAGMATISM, DEFORMATION, AND MINERALIZATION OVER A FORMERLY SHALLOW SUBDUCTION ZONE

Important central Andean Miocene mineralization also occurred in the northern Puna and southern Altiplano near 21°–23°S in an area where the present slab dip is steep

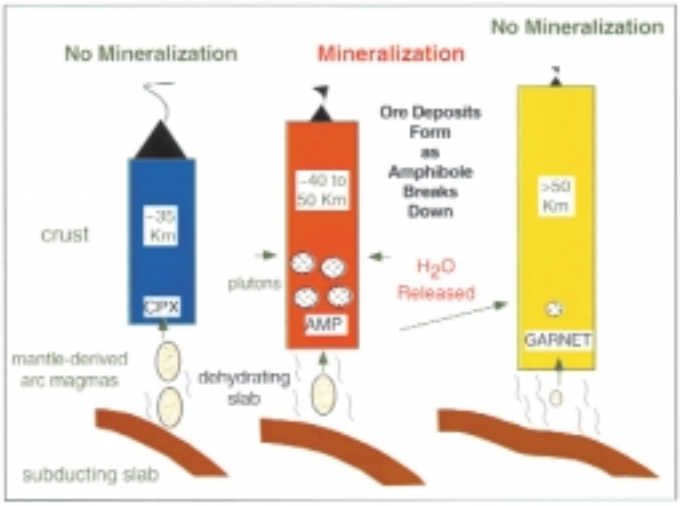

Figure 6: Cartoon showing genetic model for major Miocene central Andean ore districts. Stage 1 shows magmas equilibrating with pyroxene-bearing mineral residues in normal thickness continental crust over relatively steep subduction zone. Stages 2 and 3 show magmas equilibrating with amphibole-bearing and garnet-bearing mineral residues in deep parts of thickening crust over shallowing subduction zone. Mineralization occurs between stages 2 and 3. Critical ingredients are a hydrated mantle above a shallow subduction zone, storage of fluid in amphibole and hydrous magmas in the deep crust, and release of that fluid in conjunction with breakdown of amphibole-bearing crustal assemblages in crustal melt zones during subhorizontal shortening and thickening of ductile, magma-injected crust.

(Fig. 1). This mineralization is associated with a group of 14–12 Ma stocks and domes, and includes the giant silver deposit in the Cerro Rico de Potosí stock (13.8 Ma; Zartman and Cunningham, 1995). Lithospheric cross sections from 18 to 7 Ma in Figure 4 for the transect show the distribution of volcanism and deformation, slab geometries, and crustal thicknesses proposed by Kay et al. (1999). The existence of an early-to-middle Miocene shallow subduction zone (Fig. 2) is consistent with a volcanic gap (Coira et al., 1993) associated with widespread late Oligocene–early Miocene deformation in the southern Altiplano (Allmendinger et al., 1997). As in the modern Chilean flat-slab region, a thin asthenospheric wedge is interpreted to have inhibited arc magmatism while enhancing mantle hydration above a shallowly subducting slab (James and Sacks, 1999). Steepening of the slab in the middle Miocene increased the volume of the asthenospheric wedge promoting melting of the overlying hydrated mantle and lower crust. Heating of the crust by mantle-derived magmas in a compressional regime provides a mechanism for ductile thickening of the lower crust and plateau uplift. Mineralization at ~14–12 Ma appears to be associated with the first "wet" magmas erupted as the slab steepened and the crust thickened. Continued crustal thickening accompanied eruption of huge late Miocene plateau ignimbrite sheets as brittle deformation terminated under the plateau region and upper crustal deformation migrated eastward. Plateau uplift accompanied Subandean Belt thrusting as both movement on thrusts and large ignimbrite eruptions were triggered by horizontal compressional collapse of the melt-weakened crust. Subsequent volcanism was progressively concentrated to the west as the slab continued to steepen and the lithosphere thickened in response cooling and underthrusting of the Brazilian shield (Allmendinger et al., 1997). No major mineralization is associated with post-10 Ma volcanic units in the transect (Coira et al., 1993).

MODEL FOR MINERALIZATION OVER A SHALLOWING SUBDUCTION ZONE AND A THICKENING CRUST

The discussion above shows that common features of giant Miocene Andean ore deposits include formation over a shallowing or formerly shallow subduction zone in a thickened crust near the end or at the beginning of a volcanic episode. Magmas erupted near times of mineralization are in equilibrium with an amphibole-bearing mafic mineral residue that is changing to garnet. These features are incorporated in the general model in Figure 6 which builds on long-standing ideas of associating these deposits with hydrous magmas over subduction zones (e.g., Barnes, 1997).

Linking mineralization with a shallowing (or formerly shallow) subduction zone over a thickening crust is important as decreasing mantle flow in the cooling wedge above the dehydrating, shallowing slab increasingly limits melting and fluid removal from the wedge. Melts entering the thickening lower crust from this wedge become increasingly hydrous as fluids are progressively concentrated in the cooling mantle. As shown in stage 1 of Figure 6, arc magmas erupted through a normal thickness crust before the slab shallows have anhydrous residual mineral assemblages and are not linked to large ore deposits. In contrast, arc magmas formed above the cooling, hydrating mantle in stage 2 of Figure 6 contain fluids that cause amphibole to crystallize in them as they are underplated and intruded into a thickening crust. This process can occur for as much as 6–8 m.y. before mineralization as shown by eruption of amphibole-bearing Miocene lavas in the El Indio and El Teniente belts.

An implication for mineralization is that breakdown of amphibole can release a significant amount of fluid during melting resulting in hydrous magmas. Fluid can come from amphibole in underplated magmas and their cumulate and melt residues, as well as from metamorphosed amphibole-bearing lower crustal units. These fluids can be liberated as magma are emplaced and cooled in shallow level magma chambers. Oxidizing conditions, which prevent the early removal of sulfide minerals and allow metals to be concentrated in the residual fluids of crystallizing magmas are consistent with trace-element signatures (e.g., small Eu anomalies with low Sr contents; see Kay et al., 1991, 1999).

The observation that major central Andean Miocene ore deposits generally form near the end of a deformational peak in a setting where compression leads to crustal shortening and thickening highlights a role for thickened crust in the breakdown of hydrous minerals. REE patterns of silicic melts from the lower crust are the best indicators of the change from intermediate pressure, hydrous amphibolite/garnet amphibolite to high-pressure dry granulite/eclogite metamorphic facies residues. Sm/Yb ratios of samples in Figure 5 indicate that major periods of central Andean Miocene mineralization occurred as the mafic mineral residue changed from hornblende to garnet. Garnet-dominated signatures are present in most postmineralization silicic magmas erupted in the Maricunga, El Teniente, and El Indio belts. Major ore deposits are not found associated with magmas like those in stage 3 of Figure 6 as their anhydrous garnet-dominated mafic mineral residues lack adequate fluid sources.

Another essential factor linking fluid sources associated with ore deposits to tectonic stresses is that magmas intruding a thickened crust under compression have difficulty ascending and evolve at depth leading to high intrusive/extrusive ratio magmatic systems. Storage at depth promotes repeated crustal melting, enhances crustal ductility, and makes the crust susceptible to horizontal compressional failure leading to crustal shortening and thickening. Such conditions promote pressure-induced amphibole breakdown in lower crustal melt zones. Multiple melt and freeze cycles in these melt zones could enhance metal enrichment. The erupted magmas are a combination of crustal and mantle components that last equilibrated with lower crustal mineral residual assemblages. This is essentially the MASH process of Hildreth and Moorbath (1988). The importance of uplift and solidification of long-lived magmatic systems to metal-rich fluid release over a shallowing subduction zone is addressed for the El Teniente district by Skewes and Stern (1994). Temporal coincidence of ductile crustal thickening beneath the arc and upper crustal shortening in the backarc is evident in the Chilean flat slab (e.g., Kay and Abbruzzi, 1996), and has been proposed for the El Teniente (e.g., Kurtz et al., 1997; Godoy et al., 1999) and Maricunga (Kay et al., 1994) transects.

Crustal thickening due to shortening must also be compensated in the lithospheric mantle. Thickening of the lithosphere reduces space for the asthenospheric wedge above the shallowing slab and forces

retreat of the melt zone towards the backarc. As such, a thicker crust and a shallower slab under the El Indio belt than under the Maricunga and El Teniente belts can account for volcanic quiescence in the former, and eastward migration of the frontal arc in the latter. An unresolved question is the role of subduction erosion (forearc removal of the hanging wall of the plate above the subduction zone) and the mechanical removal of basal continental lithosphere and continental crust in the arc and backarc as the subduction zone shallows and the crust thickens. Such lithospheric thinning allows for the return of a thickened asthenospheric wedge renewing magma production above the slab, and could be important in explaining multiple mineralization episodes such as those in the Maricunga and El Indio belts.

TIMING OF TECTONIC AND MINERALIZATION EVENTS

Mineralization events generally correspond to crustal deformational peaks which can be argued to be approximately contemporaneous along the Andean front from Peru to Chile. Sébrier and Soler (1991) suggest that peaks near ~17 Ma, ~10 Ma, ~7 Ma, and ~2 Ma occurred at times of little or no westward retreat of the subducting Nazca plate relative to South America. Such a regime could be related to changes in plate directions and spreading rates. Whether mineralization occurs in a given place depends on local crustal thickness, asthenospheric wedge volume, and the geometry of the subducting plate. This unifying model links mineralization to the changing dip of shallow subduction zones beneath continents.

ACKNOWLEDGMENTS

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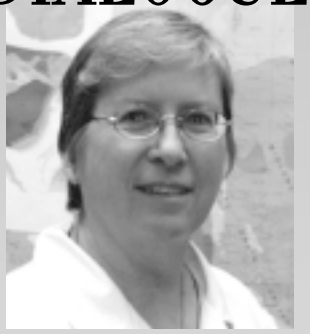
DIALOGUE

Field Forums: A Successful Beginning for a New Initiative



Sharon Mosher, *President of GSA*

A fundamental part of our science involves testing our ideas and models with the reality exposed in the field. What we observe there often forces us to search for new explanations to old questions and inspires us to ask new ones. The final results of the processes we study, regardless of our methods, are revealed in the world's geology. In 2000, GSA initiated field forums to increase interaction among geoscientists in the field, promoting open and frank discussion of critical questions, ideas, models, and data in an informal field setting.

Field forums bring together scientists who are working on similar problems, but with different perspectives, disciplinary backgrounds, and/or methods of analysis, to discuss their data and ideas at outcrops where the relevant geology is well expressed. This type of conference can be instrumental in advancing our science. Nothing compares with actually seeing the rocks and having scientists with different interpretations or approaches discuss their data and interpretations. This exchange of information leads to better understanding of the geologic processes by all participants and has the potential to resolve scientific controversies. It also allows cross calibration—each person finds out what others mean when describing a geologic feature or process or what criteria others use to make interpretations.

Because discussion is so critical, field forums are not structured like standard field trips. The purpose is not to see as much geology as can be crammed into a day. (No outcrops by headlights or flashlights!) Instead, the pace and itinerary are arranged to balance the need for discussion and for visiting enough outcrops to provide a sufficient variety of geology to fulfill the purpose of the forum. Informal evening discussions help tie together various individual discussions and points of debates that started on the outcrop and are a good time for learning more about unfamiliar techniques or concepts.

Similar to Penrose conferences, the intent of field forums is to stimulate and enhance individual and collaborative research and to accelerate the advance of the science, but, in this case, by interactions in the field. With a good mixture of participants, people will be exposed to different approaches and perspectives, which may lead to collaborative research or individuals trying new approaches. An informal field atmosphere is also conducive to building better personal relationships among researchers, which may lead to closer cooperation. Even if participants continue to work independently, the experience of sharing ideas and interacting with others working on similar problems should further their own research and may stimulate new ideas and questions to be investigated. The benefit to students who attend should be tremendous.

The first two field forums were very successful. Letters from participants indicated that the forums clearly fulfilled the goals of this new initiative. The topics were diverse: processes at the base of glaciers (held at Matanuska Glacier, Alaska), and processes in silicic magma chambers (held in coastal Maine). The next field forum on bolide impacts on wet targets will be held in April in the southwestern United States. For more information on any of these forums, see www.geosociety.org/profdev/f_forum.htm.

If you have an idea for a field forum or for a Penrose conference that would work better in a field setting, contact Edna Collis, ecollis@geosociety.org. Field forums are an enjoyable way to expand our professional horizons.

Students: Sign Up for the 2001 Shlemon Mentor Programs

This spring, all six GSA sections will participate in hosting the Roy J. Shlemon Mentor Programs in Applied Geology. These specially designed workshops bring professionals from corporations and select government employees (from state geological surveys and the U.S. Geological Survey) to GSA section meetings. The informal programs include lunch and are targeted toward advanced undergraduate and graduate students.

Typical topics discussed include tips for getting practical summer experience; interview tips for getting that first real job; information on the value of professional registration and how to get it; an appraisal of the potential job market; and encouragement! Other topics participants want to discuss are open for consideration, and questions are welcomed.

Be sure to sign up for the Shlemon Mentor Program for your section meeting. Preregistration is recommended in order to secure a seat. Attendance at these workshops is free or low cost ($3–$5) and includes lunch. You need not be a member of GSA to attend the Shlemon Programs. Also, general section meeting registration is not required if you want to attend only the Shlemon Mentor Program.

Shlemon Mentor Program Spring 2001 Line-Up

Cordilleran Section
Monday, April 9, and Tuesday, April 10, noon–1:30 p.m., Universal City Sheraton, Universal City, CA. The speakers for each day's program are different, so plan to attend both days! Cost: Free, lunch included.

North-Central Section
Monday, April 23, noon–1:30 p.m., Bone Student Center, Bloomington-Normal, IL. Cost: Free, lunch included.

Northeastern Section
Monday, March 12, 11:30 a.m.–1:30 p.m., Valcour Room, Sheraton Conference Center, Burlington, VT. Cost $5, lunch included.

Rocky Mountain and South-Central Sections
Tuesday, May 1, all-day program, beginning at 9 a.m., Sheraton Old Town Hotel, Albuquerque, NM. Attend an informal information exchange between mentors and students from 9–11:30 a.m., followed by lunch. Then, take a field trip in the afternoon to the Sandia fault with a consulting engineering geologist, a consulting environmental geologist, and a state geological survey geologist specializing in surficial processes and geological mapping in the Albuquerque area. Cost: Free, lunch included.

Southeastern Section
Friday, April 6, noon–1:30 p.m., Sheraton Capital Center, Raleigh, NC. Cost: $3, lunch included.

For more information about any of the Shlemon Programs, please contact Karlon Blythe, Program Officer, kblythe@geosociety.org, (303) 447-2020, ext. 136.

2001 GSA SECTION MEETINGS

NORTHEASTERN SECTION

March 12–14, 2001 — Sheraton Burlington Hotel, Burlington, Vermont. Information: Tracy Rushmer, Dept. of Geology, University of Vermont, Perkins Hall, Burlington, VT 05405-0122, (802) 656-8136, trushmer@zoo.uvm.edu.
Register onsite.

SOUTHEASTERN SECTION

April 5–6, 2001 — Sheraton Capital Center, Raleigh, North Carolina. Information: Edward Stoddard, Dept. of Marine, Earth & Atmospheric Sciences, North Carolina State University, Raleigh, NC 27695-8208, (919) 515-7939, skip_stoddard@ncsu.edu.
Register onsite.

CORDILLERAN SECTION

April 9–11, 2001 — Sheraton Universal Hotel, Universal City, California. Information: Peter W. Weigand, Dept. of Geological Sciences, California State University–Northridge, 18111 Nordhoff Street, Northridge, CA 91330-8266, (818) 677-2564, peter.weigand@csun.edu.
***Preregistration deadline:* Mar. 19, 2001.**

NORTH-CENTRAL SECTION

April 23–24, 2001 — Bone Student Center, Normal, Illinois. Information: Robert S. Nelson, Illinois State University, Dept. of Geography–Geology, Campus Box 4400, Normal, IL 61790-4400, (309) 438-7808, rnelso@ilstu.edu.
***Preregistration deadline:* Mar. 16, 2001.**

ROCKY MOUNTAIN & SOUTH-CENTRAL SECTIONS

April 30–May 2, 2001 — Sheraton Old Town Hotel, Albuquerque, New Mexico. Information: John Geissman, University of New Mexico, Dept. of Earth & Planetary Sciences, 203 Northrop Hall, Albuquerque, NM 87131-1116, (505) 277-3433, jgeiss@unm.edu.
***Preregistration deadline:* Mar. 23, 2001.**

Final Announcement

Rocky Mountain (53rd) and South-Central (35th) Sections, GSA

JOINT ANNUAL MEETING

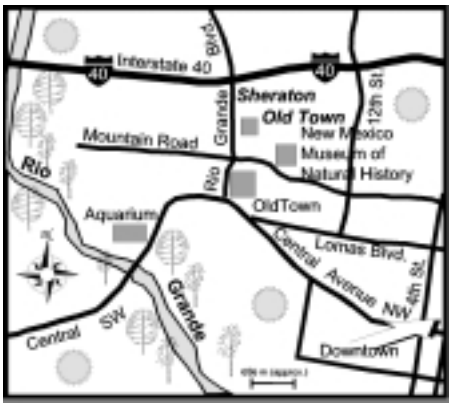
Albuquerque, New Mexico
Sheraton Old Town Hotel
April 30–May 2, 2001

www.geosociety.org/sectdiv/rockymtn/01rm-scmtg.htm

The Rocky Mountain and South-Central Sections of GSA and the Rocky Mountain Section of the Paleontological Society of America will meet jointly at the Sheraton Old Town Hotel in Albuquerque, New Mexico. The meeting is sponsored by the University of New Mexico Department of Earth and Planetary Sciences and Institute of Meteoritics, assisted by the New Mexico Bureau of Mines and Mineral Resources and the Department of Earth and Physical Sciences at Sul Ross State University.

ENVIRONMENT

With scenery that is a veritable textbook of geology, New Mexico has from early days attracted pioneer earth scientists like Jules Marcou, J.S. Newberry, F.V. Hayden, Benjamin Silliman Jr., J.W. Powell, G.K. Gilbert, Clarence Dutton, Waldemar Lindgren, N.L. Darton, Kirk Bryan, C.V. Theis, C.E. Jacob, and E.H. Colbert. Pre-Columbian native Americans digging for turquoise and Spanish conquistadors seeking the gold of Cibola were forerunners of geologists who made New Mexico a leading producer of oil and gas, coal, uranium, copper, molybdenum, gold, silver, and potash. The Albuquerque area lies near the intersection of five major geologic provinces. To the west and northwest is the Colorado Plateau and San Juan Basin region. To the north and northwest are Precambrian-cored foreland uplifts of the Nacimiento and southern Sangre de Cristo and Taos ranges. Features related to the Cenozoic Rio Grande Rift continue southward from south-central Colorado through central New Mexico and merge with the Basin and Range province of southern New Mexico. To the east of the Sandia Mountains and behind Albuquerque lies the Great Plains province.



The weather in north-central New Mexico in late April is splendid, with highs in the 70s and low 80s and cool evenings. Albuquerque, in particular the Old Town area, is host to numerous excellent New Mexican–style restaurants suiting a range of budgets. The Old Town section of Albuquerque, a block from the meeting center, contains numerous shops and restaurants; nearby are the New Mexico Museum of Natural History and Science, Albuquerque Art Museum, and the Albuquerque Aquarium and Botanic Center.

REGISTRATION

Preregistration deadline: March 23, 2001
Cancellation deadline: March 30, 2001

Please preregister to qualify for lower fees and to assist the local committee in preparing. Online preregistration at www.geosociety.org is strongly encouraged. You may also use the form accompanying this issue. Full payment MUST accompany your preregistration.

Registration is required for all who attend technical sessions, guest activities, or the exhibit hall. Either a registered professional or student must accompany guest registrants (nongeologist spouses or friends). Students must show a current ID for reduced rates. If you preregister, your badge will be mailed to you two weeks prior to the meeting. **All registrations received after March 23 will be held for on-site processing and charged the on-site rates.**

All requests for registration additions, changes, and cancellations must be made in writing and received by March 30, 2001. There will be no refunds for cancellations made after this date.

ON-SITE REGISTRATION

On-site registration will begin Sunday afternoon, April 29, at the Sheraton Old Town Hotel.

ACCESSIBILITY FOR REGISTRANTS WITH SPECIAL NEEDS

We are committed to making the meeting accessible to all people. Please indicate any special needs on your registration form.

TECHNICAL PROGRAM

Oral sessions will typically include 15 minutes for presentation and five minutes for questions and discussion. Two standard 35-mm slide projectors, one overhead projector, one computer-interfaced projector, and two screens will be provided for each technical session. Please bring your own loaded carousel trays, if at all possible. A speaker ready room, equipped with projectors, will be available for review and practice. For additional technical services, please contact Zach Sharp, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131-1116, (505) 277-2000, fax 505-277-8843, zsharp@unm.edu.

Poster sessions will be centrally located adjacent to the exhibit area and will allow for four hours of display time; the authors must be present for two hours. Each poster presenter will be provided with at least one eye-height board, about 4 x 8 feet, and one board 4 x 4 feet. Access to electrical outlets and furniture for poster sessions must be requested well in advance. For assistance, please contact Zach Sharp (contact information above).

Contact the Technical Program Chair, Michael E. Campana, (505) 277-3269, aquadoc@unm.edu, if you have any questions.

SYMPOSIA

1. **Validating Models of Subsurface Flow and Transport.** Daniel B. Stephens, Daniel B. Stephens and Associates, Inc., (505) 889-7752, danstephens@dbstephens.com.
2. **Ouachita-Marathon Tectonics: Current Research and Speculations—A Tribute to George Viele.** William A. Thomas, University of Kentucky, (606) 257-6222, geowat@pop.uky.edu; and Kent C. Nielsen, University of Texas—Dallas, (972) 883-6837, knielsen@utdallas.edu.
3. **Geologic Framework of the Middle Rio Grande Basin.** Jim Cole, U.S.

Geological Survey, (303) 236-1417, jimcole@usgs.gov; and Paul Bauer, bauer@nmt.edu, and Sean Connell, New Mexico Bureau of Mines and Mineral Resources, connell@gis.nmt.edu.

4. **Hydrogeology of the Middle Rio Grande Basin.** James R. Bartolino, U.S. Geological Survey, (505) 830-7936, jrbartol@usgs.gov.
5. **Proterozoic Tectonics of the Southwestern United States.** Karl E. Karlstrom, University of New Mexico, (505) 277-4346, kek1@unm.edu; and Mike Williams, University of Massachusetts, mlw@geo.umass.edu.
6. **Geophysics of the Rio Grande Rift and Southern Rocky Mountains.** G. Randy Keller, University of Texas—El Paso, keller@geo.utep.edu; and W. Scott Baldridge, Los Alamos National Laboratory, (505) 667-4338, sbaldridge@lanl.gov.
7. **NAGT Session I: Geoscience Education and Research in American Indian and Hispanic Communities.** Steve Semken, Dine College, scsemken@shiprock.ncc.cc.nm.us.
8. **NAGT Session II: Development and Use of Web-based Resources for College Instruction.** Kent C. Nielsen, (972) 883-6837, knielsen@utdallas.edu; and Rebekah K. Nix, University of Texas—Dallas.
9. **Timing of Ancestral Rocky Mountain Orogeny.** Spencer G. Lucas, New Mexico Museum of Natural History, (505) 841-2873, slucas@nmmnh.state.nm.us; and Steve Cather, New Mexico Bureau of Mines and Mineral Resources, steve@gis.nmt.edu.
10. **Meso- to Neoproterozoic of the Western United States: Record of Supercontinent Assembly and Breakup and a Snowball Earth?** Carol Dehler, Utah State University, chuaria@cc.usu.edu; and Karl E. Karlstrom, University of New Mexico, (505) 277-4346, kek1@unm.edu.

THEME SESSIONS

1. **Undergraduate Research Poster Session.** *(Sponsored by the Geology Division of the Council on Undergraduate Research.)* This session showcases senior theses and other undergraduate research projects. A student must be listed as the lead author and be the major preparer of the poster. Information: Jeff Connelly, University of Arkansas at Little Rock, (501) 569-3543, jbconnelly@ualr.edu; or Kim Hannula, Fort Lewis College, (970) 247-7278, hannula_k@fortlewis.edu.
2. **Climate Change, Hydrology, and Water Allocation in the Western United States.** Michael E. Campana, University of New Mexico, (505) 277-3269, aquadoc@unm.edu.
3. **Forest Fire Impacts on Hydrochemistry and Hydrology.** Patrick Longmire, (505) 665-1264, plongmire@lanl.gov, and Bruce Gallaher, (505) 667-3040, gallaher@lanl.gov, Los Alamos National Laboratory.

FIELD TRIPS

Unless otherwise noted, all field trips begin and end at the Sheraton Old Town Hotel, Albuquerque. For details about particular field trips, contact the field trip leaders listed below or Karl E. Karlstrom, Field Trip Coordinator, (505) 277-4346, kek1@unm.edu. We hope there will be a strong link between symposia and related field trips.

Preregistration for all field trips is strongly encouraged because of participant limitations. All participants are accepted on a first-come, first-served, basis through GSA headquarters. Trip costs include transportation for the trip, field notes, and other services as noted by the following symbols: B—breakfast, L—lunch, D—dinner, ON—overnight lodging.

All field trip registrants must register for at least one day of the meeting. Registration after the preregistration deadline is possible if field trip logistics and space permit; please contact the GSA registration coordinator or Karl Karlstrom at the University of New Mexico. On-site registration for postmeeting trips may be possible during the meeting in the registration area.

If GSA must cancel a field trip due to logistics or registration requirements, a full refund for the field trip will be issued after the meeting. Be aware of cancellation deadlines and possible penalties imposed by airlines. You may wish to cancel flight arrangements if a trip you have registered for is canceled.

Premeeting

1. **Volcanology and Hydrothermal Systems of Valles Caldera and the Jemez Mountains.** One day, April 29; max. 25; cost $25. Fraser Goff, Los Alamos National Laboratories, fraser@lanl.gov. A one-day trip to the spectacular Jemez Mountains, a discussion of the history of volcanism, including caldera eruptions at 1.6 and 1.2 Ma; and discussion of hydrothermal systems associated with this volcano. (L)
2. **Stratigraphy and Tectonic Evolution of the Albuquerque Basin, Central Rio Grande rift.** April 27–29; max. 24; cost $75 (trip will return to Albuquerque each evening; lodging is not included in the cost). Sean D. Connell, New Mexico Bureau of Mines and Mineral Resources—Albuquerque Office, New Mexico Tech, 2808 Central Ave. SE, Albuquerque, NM 87106, (505) 366-2534, fax 505-366-2559, connell@gis.nmt.edu; David W. Love; and Spencer G. Lucas. Deposits of the Santa Fe Group (upper Oligocene-Pleistocene) record the evolution of the Albuquerque basin, which has been the subject of recent multidisciplinary studies. Participants will gain an understanding of the variety of rift-related sediments, stratigraphic architecture, and geomorphology of the Albuquerque basin through a series of traverses, and will examine sediments associated with an initial, internally drained phase of basin development and compare with the later, externally drained phase. Visits to newly described stratigraphic sections with discussions of sediment dispersal patterns, age constraints, development of the ancestral Rio Grande in central New Mexico, subsurface stratigraphy, Pleistocene incision of basin fill, and implications for conceptual hydrogeologic models will also be presented. Hiking over fairly rugged terrain (up to 3 km) required on some stops. (L)
3. **Proterozoic Ductile Thrust Belt in the Manzano Mountains.** April 28–29, max. 35; cost $50 (trip will return to Albuquerque each evening; lodging is not included in cost). Karl E. Karlstrom, University of New Mexico, (505) 277-4346, kek1@unm.edu. The Sandia-Manzano uplift, the rift flank of the Rio Grande rift, provides a well-exposed cross section of the Proterozoic Manzano ductile thrust belt. New mapping, a new lithologic subdivision, and geochronology provide a better understanding of the tectonic evolution of Proterozoic basement in this region. This includes: development of a supracrustal sequence that progressed from greenstones to mature quartzites, emplacement of a voluminous 1.65 Ga plutonic complex synchronous with top–N ductile thrusting at 1.65 Ga. This was overprinted by new deformation at 1.44–1.42 Ga that was synchronous with 1.4 Ga plutonism and regional metamorphism. Participants will examine rocks and structures in this belt in the context of the tectonic evolution of the southwestern U.S., and discuss evidence for interpreting the polyphase middle crustal tectonism recorded by these rocks. Themes for discussion will be: tectonic significance of the quartzarenite-alkali rhyolite association; timing and significance of triple point metamorphism; nature and timing of movements on shear zone boundaries; tectonic significance of the 1.4 Ga tectonism and A-type plutonism; and evidence for and significance of the slow cooling history of these middle crustal rocks. Walking over rugged terrain is planned. (L)
4. **NAGT Field Trip: Learning Geology in the Field—Old Mountain Belts to Young Volcanoes near Albuquerque.** One day, April 28; open only to K–12 teachers; max. 24; cost $25. Gary Smith, gsmith@unm.edu, Aurora Pun, apun@unm.edu, Alex Castrounis, indy500@unm.edu, University of New Mexico; and Kent Nielsen, University of

Texas—Dallas, Knielson@utdallas.edu. A problem-solving tour of the Albuquerque area featuring interpretation of all rock types, rift structure and landforms, unconformities, entrenchment of the Rio Grande and Quaternary volcanism. (L)

5. **Scenic Geology of Tent Rocks, Jemez Mountains.** One day, April 29; max. 25; cost $25. Gary Smith, University of New Mexico, gsmith@unm.edu. A leisurely, highly photogenic hike, suitable for spouses and children in addition to hard-core geologists, among the erosional hoodoos and slot canyons of Tent Rocks, a possible future national monument. Incredible 3-D exposures of normal faults, remarkable rhyolitic pyroclastic stratigraphy, intriguing volcaniclastic fluvial and eolian sedimentology, and insights into Quaternary landscape development at the junction of the Rio Grande rift and Jemez Mountains volcanic field. (L)

SHORT COURSES AND WORKSHOPS

NEW: GSA is pleased to introduce the new Partnering Short Course Program, offering short courses specifically designed to appeal to the members of GSA and a partnering Associated Society. The first two short courses offered are brought to you through the partnerships between SEPM (Society of Sedimentary Geology) and NGWA (National Ground Water Association) and GSA.

Premeeting

1. **GSA and SEPM Partnership Short Course: Paleosols for Sedimentologists.** Sun., April 29, 8 a.m.–5 p.m., Sheraton Old Town Hotel, Albuquerque. Greg H. Mack, Dept. of Geological Sciences, New Mexico State University; Ph.D., Indiana University. Mack specializes in interpretation of the influence of tectonism and paleoclimate on depositional environments of Phanerozoic siliciclastic sediment. His research involves the use of paleosols to interpret Permian, Cretaceous, and late Tertiary paleoclimate. The potential of paleosols to aid in solving a variety of problems related to earth history has started to be realized during the past two decades. Reconstruction of ancient climate, stream behavior within sedimentary basins, semiquantitative determination of subsidence and sediment accumulation rates, and delineation of terrestrial paleoecosystems are examples of research areas significantly advanced by the study of paleosols. Despite this increased interest, many sedimentary geologists are not thoroughly conversant in paleosol recognition and applications as an interpretative tool. This course focuses on the fundamental aspects of paleosol description, recognition, and interpretation, concentrating on (1) field and petrographic features indicative of paleosol development, (2) key terminology applicable to paleosols, and (3) interpretative uses of paleosols for reconstructing basin histories and paleoclimates. Max.: 30; cost: $99 (includes course manual and refreshments). CEUs: 0.8.

2. **GSA and NGWA Partnership Short Course: Environmental Geochemistry of Metals: Investigation and Remediation.** Sun., April 29, 8 a.m.–5 p.m., Sheraton Old Town Hotel, Albuquerque. Patrick Longmire, Los Alamos National Laboratory. Longmire earned a Ph.D. in earth sciences with emphasis in aqueous geochemistry from the University of New Mexico. With more than 26 years of experience in groundwater geochemistry, he is currently a senior hydrogeochemist at Los Alamos National Laboratory, where he conducts applied research in geochemistry and contaminant transport. He is an NGWA certified groundwater professional, a former associate editor for the journal *Ground Water*, and an instructor for the NGWA course "Geochemical Modeling of Ground Water." Soil and groundwater at many mining, industrial, and waste disposal sites are contaminated by metals, radionuclides, and other inorganic chemicals. Learn how to design effective sampling programs that support intrinsic remediation and chemical manipulation of metal-inorganic solute plumes in groundwater. This short course emphasizes hydrogeochemical processes and field implementation procedures for quantifying, assessing, and remediating metal-contaminated sites. Data collection and analyses, quantification of contaminant mobility, and understanding regulatory considerations involved in implementing viable restoration and remediation options are also presented. Case histories and class exercises focusing on geochemical processes, intrinsic remediation, and chemical manipulation are included. Whether you are in the mining business, an environmental regulator, or cleaning up a contaminated industrial site, you won't want to miss this course. Max.: 30; cost: $195 (includes course handouts).

3. **Short Course: Standard Guides for the Collection of Hydrogeologic Field Data.** Sat., April 28, 8 a.m.–5 p.m., Sheraton Old Town Hotel, Albuquerque. John E. Moore, Moore123@aol.com, PELA and Associates and John Patterson and Associates. Moore is a skilled teacher and manager of hydrologic investigations. He has 28 years of experience as hydrologist with the Water Resources Divisions of the U.S. Geological Surveys in Nevada, Colorado, Nebraska, Florida, and Virginia. He is currently a senior hydrogeologist with PELA and Associates (Alabama), John Patterson and Associates (Denver), and Adjunct Professor at Metropolitan State College in Denver. This course presents the standard guides used to collect hydrologic and hydrogeologic field data, focusing on field methods for determining environmental site characteristics and collection of samples for physical and chemical characterization. These standard guides were developed to produce uniform high-quality data. Guides for water-level measurements, well drilling, soil sampling, aquifer tests, design and installation of monitor wells, hydrogeologic site investigations, groundwater sample collection, and report preparation will be presented. Max.: 30; cost: $160 (includes course manual containing guides discussed in course).

During Meeting

4. **Roy J. Shlemon Mentor Program in Applied Geology: Environmental and Engineering Geology in Urban Areas: Examples From Albuquerque, New Mexico.** *(Sponsored by GSA.)* Tues., May 1. Classroom session 9–11:30 a.m.; field trip 1–5 p.m. Lunch provided. For further information, contact Karlon Blythe at GSA, Kblythe@geosociety.org. Many future geology graduates will start their careers performing applied geologic studies in or near urban areas. The demands of privately funded projects with hard deadlines and the nature of urban land use offer challenges quite different from those of geology field camp exercises out in the boondocks. This mentorship short course, open to undergraduate and graduate students, will emphasize solving geologic problems, project management, and client relationships in the urban environment. The mentors include a consulting engineering geologist, a consulting environmental geologist, and a state geological survey geologist specializing in surficial processes and geological mapping in the Albuquerque area. Max.: 25; free. Preregistration is required, although meeting registration is not required to attend only this workshop.

STUDENT TRAVEL SUPPORT

The GSA Rocky Mountain and South-Central sections have travel grants available for GSA Student Associates who are presenting oral or poster papers as authors or co-authors. Students must currently be enrolled to be eligible. Rocky Mountain Section students should contact Kenneth E. Kolm, Colorado School of Mines, (303) 273-3932, kkolm@mines.edu. South-Central Section students should visit the South-Central Section Web site, www.geosociety.org/sectdiv/southc/, and click on "Travel Grants" for application instructions. Contact Elizabeth Anthony at eanthony@geo.utep.edu for more information. Applications for travel funds should be submitted as soon as possible.

STUDENT AWARDS

Each section will give awards of $200, $100, and $50 for the best oral and poster

student papers at the meeting. Awards will be based on the quality of both the research and presentation. To be eligible, a student must be the lead author and presenter of the work. The abstract must be clearly identified as a student paper.

BUSINESS MEETINGS

Rocky Mountain Section Business Meeting. Tues., May 1, noon, Sheraton Old Town Hotel. Cost: $15.

South-Central Section Business Meeting. Tues., May 1, noon, Sheraton Old Town Hotel. Cost: $15.

EXHIBITS

Exhibits will be centrally located in the Sheraton Old Town Hotel, adjacent to a refreshment area. The cost of a standard booth is $250 for commercial exhibitors and $150 for educational or nonprofit institutions. For further information, please contact Mike Spilde, Exhibits Coordinator, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131-1116, (505) 277-5430, mspilde@unm.edu.

ACCOMMODATIONS

A block of rooms has been booked at the Sheraton Old Town Hotel, the site of the meeting, at the rate of $95 per night for single or double room. (Please note that a room tax will be added to this rate.) For reservations, call the Sheraton Old Town Hotel directly and identify yourself as a participant in the GSA Rocky Mountain and South-Central Meeting. PLEASE NOTE: Rooms at the Sheraton are being held for the GSA meeting only through March 15, 2001, so please register for a hotel room as soon as possible. Sheraton Old Town Hotel, 800 Rio Grande Blvd. NW, (505) 843-6300, 1-800-237-2133.

Other nearby hotels: Best Western Rio Grande Inn, 1015 Rio Grande Blvd. NW, (505) 843-9500, 1-800-528-1234; Ramada Inn, 717 Central NW, (505) 924-2400; Econo Lodge Old Town, 2321 Central NW, (505) 243-8475, 1-800-553-2666.

TRAVEL

Albuquerque is served by a modern international airport with direct routes to many cities in the Rocky Mountain and South-Central regions. Car rentals may be arranged at the Albuquerque Airport. Several hotels, including the Sheraton Old Town, have courtesy shuttles to and from the airport for their guests. All hotels and motels listed in the accommodations section are located within 1 km of Old Town. Access to I-40 and I-25 is straightforward from the Old Town area, but please note that the intersection between the two interstates is under major construction.

SPOUSE AND GUEST ACTIVITIES

Spouses and guests may take advantage of the diversity of cultures and scenery in the Albuquerque area through daily historical tours of the city. In addition, trips to Acoma Pueblo can be arranged through the Indian Pueblo Cultural Center near Old Town. Shuttle busses run from Old Town to Santa Fe. A trolley serving the Old Town, downtown, and major shopping mall areas of Albuquerque stops at the Sheraton Old Town.

SPECIAL EVENTS

The New Mexico Museum of Natural History and Science, a short walk from the Sheraton Old Town, will have an open house on the evening of Tuesday, May 1. The event includes admission to the museum, tours of parts of the museum, a partially hosted bar and a New Mexican–style buffet, with all the food you can eat. Total cost for the evening is $28 per person, with reduced prices for children (see registration form).

ADDITIONAL INFORMATION

For other information concerning technical sessions, field trips, registration, accommodations, and activities, please contact the General Chair, John Geissman, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131-1116, (505) 277-3433, fax 505-277-8843, jgeiss@unm.edu, or the Technical Program Chair, Michael E. Campana (505) 277-3269, fax 505-277-8843, aquadoc@unm.edu.

ANNOUNCEMENTS

MEETINGS CALENDAR

2001 MEETINGS

June 24–28	Earth System Processes, Edinburgh, Scotland. Information: GSA at www.geosociety.org, or Geological Society of London at www.geolsoc.org.uk. (Preregistration deadline: April 30, 2001.)
July 30-August 3	50th Annual Denver X-ray Conference, Steamboat Springs, Colorado, USA. Information: Conference Coordinator, International Centre for Diffraction Data, 12 Campus Blvd., Newtown Square, PA 19073, (610) 325-9814, fax 610-325-9823, dxc@icdd.com, www.dxcicdd.com. (Call for papers deadline: March 16, 2001.)
August 20–21	Ground Penetrating Radar (GPR) in Sediments: Applications and Interpretation, London, England. Information: Charlie Bristow, c.bristow@ucl.ac.uk, Harry Jol, jolhm@uwec.edu, www.geo.vu.nl/~damr/GPRconf2001/. (Abstracts deadline: April 30, 2001.)
September 3–5	21st International Association of Sedimentologists Meeting of Sedimentology, Davos, Switzerland. Information: IAS–2001 Secretariat, Geological Institute ETH–Zentrum, 8092 Zurich, Switzerland, info@ias-2001.ethz.ch, fax +41-1-632-1080, www.ias-2001.ethz.ch.

2002 MEETINGS

June 24–28	10th International Conference on Luminescence and ESR Dating (LED2002), University of Nevada, Reno, Nevada. Information: Conference Secretary, LED2002@dri.edu, www.dri.edu/DEES/LED2002.

Only new or changed information is published in *GSA Today*.
A complete listing is posted in the **Calendar** section at www.geosociety.org.

In Memoriam

Robert J. McDermott, SJ
Los Angeles, California
December 24, 2000

Martin Prinz
New York, New York

Warren M. Woodward
Penn Valley, California
November 23, 2000

Half Zantop
Hanover, New Hampshire
January 27, 2001

GSA Foundation is Seeking a President

The GSA Foundation seeks a geoscientist, preferably with national recognition for achievements in the geosciences and administration, to be its president. The individual should have a strong interest and experience in, or working knowledge of, fund-raising and development. Primary responsibilities will include oversight and direct participation in fund-raising for GSA programs and activities; identifying, cultivating and soliciting major donor prospects, including individuals, corporations, and foundations; stewardship of funds; and staff administration. This person will be expected to have a major role in designing and implementing a strategic fund-raising and development plan for the Foundation and to closely and regularly interact with the GSA's chief executive officer, members of GSA's staff, the GSA Foundation Board of Trustees, and the GSA Council. The president reports to the GSA Foundation Board of Trustees and is assisted in the Foundation by a full-time director of operations and a data manager.

The position could range from three-quarter time to full time, with the bulk of the activities to be conducted from the Society's headquarters in Boulder, Colorado, although full-time relocation to the Boulder area may not be required. A range of compensation options exists, depending on experience and qualifications of the candidate and the length of the appointment. Interested persons should send a letter of application, resume or curriculum vita, and the names, addresses, and telephone numbers of three references to GSA Foundation Board of Trustees Search Committee, c/o Donna Russell, GSA Foundation, P.O. Box 9140, Boulder, CO 80301-9140. Nominations of potential candidates by members of the geoscience community also are encouraged. Effective closing date for the applications is March 15, 2001, with a target starting date of July 1, 2001. The GSA Foundation is a nonprofit corporation and an Equal Opportunity, Affirmative Action Employer.

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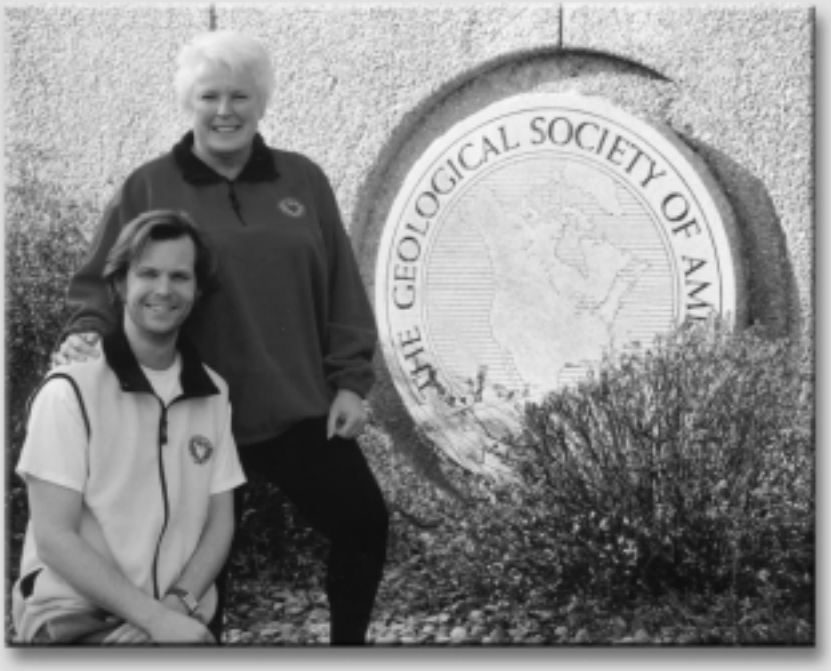

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GSA Foundation Update

Avoid the Year-End Rush: There is No Better Time to Give a Gift of Stock

Julie A. Wetterholt, *Director of Development*

Who says typical year-end gifts to charity can only be made in December? Early in the year can be an excellent time to give, particularly if you own appreciated stock that you think might be ready for a downturn, especially in light of the recent turbulent times on Wall Street.

Gifts of stock are an economical way to give. Donors receive a deduction equal to the fair market value of shares that are owned more than one year. And donors aren't taxed on the gains, as they would have been if the shares were sold. The other benefit is that a gift of stock does not deplete your cash and usually enables you to give more in the process.

By giving shares of stock to GSA Foundation now, you can lock in any gains and provide support for GSA's programs for the entire year of 2001. Any growth will be permanently freed from all taxes, including capital gains and "death taxes." Call Donna Russell, Director of Operations, at the Foundation office, 1-800-472-1988, ext. 154, for instructions on making a gift of appreciated stock or mutual fund shares. It's as easy as a call to your broker and to the Foundation and you'll be avoiding the year-end rush!

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Most memorable early geologic experience

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—Elwood R. Brooks

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Robert J. Watters Named GSA Engineering Geology Division–AEG Richard H. Jahns Distinguished Lecturer

Bob Watters will be available throughout 2001 as the Richard H. Jahns Distinguished Lecturer. His two talks on the topic of landslides emphasize different slope stability themes. One talk, "Importance and limitations of geology, strength data, and modeling studies to understanding slope instability," draws on his consulting and research experiences of more than 20 years, illustrates how slope failures occur even when competent investigations and analysis are performed, and is orientated toward engineering.

In his second talk, Watters discusses how recent research is improving volcano hazard assessment by incorporating engineering geology in appraisals. "Realism in volcano hazard zonation: Does geoengineering help provide a more accurate assessment?" is a great lecture for those who are more geologically inclined.

Contact Watters for more details or to arrange a talk for your GSA, Association of Engineering Geologists, or American Society of Civil Engineers group, or for your university or college class or seminar. Watters, a professor of geological engineering at the Mackay School of Mines, can be contacted at the Department of Geological Sciences, Mackay School of Mines, MS 172, University of Nevada, Reno, NV 89557, (775) 784-6069, fax 775-784-1833, watters@mines.unr.edu.

The Biggs Award

To reward and encourage teaching excellence in beginning professors of earth science at the college level, GSA announces

The Tenth Annual Biggs Award for Excellence in Earth Science Teaching for Beginning Professors

Eligibility
Earth science instructors and faculty from all academic institutions engaged in undergraduate education who have been teaching full time for 10 years or fewer. (Part-time teaching is not counted in the 10 years.)

Award amount
An award of $750 is made possible by support from the Donald and Carolyn Biggs Fund, the GSA Geoscience Education Division, and GSA's Science, Education, and Outreach Programs. This award also includes up to $500 in travel funds to attend the award presentation at the GSA Annual Meeting.

Deadline
Nominations for the 2001 Biggs Earth Science Teaching Award must be received by May 1, 2001.

For more information, contact: Leah Carter, Program Officer, Grants, Awards, and Medals, The Geological Society of America, P.O. Box 9140, Boulder, CO 80301, lcarter@geosociety.org, (303) 447-2020, ext. 137.

for Excellence in Earth Science Teaching

Reminder: Call for Nominations

The **John C. Frye Environmental Geology Award** is awarded for an outstanding paper on environmental geology published by GSA or by one of the state geological surveys during the preceding three full calendar years. The award's $1,000 cash prize is presented in cooperation with the Association of American State Geologists. Nominated papers must establish an environmental problem or need; provide substantive information on the basic geology or geologic process and relate it to the problem or need; suggest solutions, provide appropriate land-use recommendations, or resolve the problem or need based on the geology; and present the information in a manner that is understandable and directly usable by geologists. Nominations must include a paragraph stating the pertinence of the paper and are due by **March 31, 2001**.

Nominations for the following **National Awards are due April 30, 2001**: The William T. Pecora Award, the National Medal of Science, the Vannevar Bush Award, and the Alan T. Waterman Award.

Materials and supporting information for any of the nominations may be sent to Grants, Awards, and Medals Program Officer, GSA, P.O. Box 9140, Boulder, CO 80301-9140. For more detailed information about the nomination procedures, see www.geosociety.org. (Go to About Us, then to Medals and Awards.)

GSA supports efforts to increase awareness of the value of geoscience within the greater scientific community, society at large, and among our own members. This column highlights efforts that contribute to the claim that geoscience matters. To submit information about similar efforts, contact Chief Science Officer Cathleen May at cmay@geosociety.org.

Sustainability: A Frank and Earnest Discussion

Twenty-five people asked each other a simple question last fall: What really matters when we talk about sustainability? Given the complexity of the question, their collective answer was simple. The quality of human life, the size and distribution of the human population, the expectations of society, the availability and distribution of water and energy resources, the technologies needed to make resources available, and global inequity of material standards of living are "what matters." Obvious as this may seem, such clarity and consensus is historically atypical in a group representing perspectives as diverse as this one did. I've abstracted the following, including quotations, from the report on a conference held October 8–11, 2000.

Representatives from the life and ecological sciences, social and economic sciences, earth sciences, government, humanities, and agriculture gathered at Arbor Day Farm in Nebraska City. The organizing committee (Lee Gerhard, Pat Leahy, and Victor Yannacone) had designed an integrative and sophisticated agenda for participants. It began with the premise: "Earth is a finite dynamic system with practical limits on both the quality and quantity of its natural resources." Convinced that earth resources and biogeochemical processes are among the ultimate arbitrators of the human condition, the organizers required that the group address sustainability of both water and energy resources. The quality of human life and the aspirations of society became the thematic template upon which the speakers and participants built their discussions.

The conference report, compiled by chair Lee Gerhard, documents that participants learned from each other. They expanded their understanding of the scope and complexity of the sustainability equation. Such understanding on the part of the earth science community is essential if we are, as the report claims, "ethically required to provide policy leadership concerning earth resources."

Conference participants determined that the operating definitions of "sustainable" and "sustainability" must come in the form of questions: Sustaining what? For whom? At what level of consumption? And for how long? Then they added the "equitable distribution of water and energy to all the peoples of the world" to the defining equation. Working from questions rather than from assumptions and limited definitions, the group enlarged their view of the issues.

Society's Expectations: Population Counts and History Matters

"If human population continues to increase geometrically, and the quantity of either potable water or economical energy is truly finite, improving the quality of life for most individuals…is unlikely." Conference participants agreed on this depressing, but pragmatic conclusion. Modifying the mindset of society to encompass this reality, however, requires a paradigm shift. Timothy Weiskel talked to participants about the evolution of human society. When humans achieved, through agriculture, the ability to develop sessile societies, population growth became part of the power base necessary to possess and defend resources. Weiskel calls this a "cultural constraint on our ability to adjudicate" the issue of global equity in access to resources.

Possessive mindsets include expectations that worked for society up to now, but that are not likely to be adaptive from this point forward. "Rising expectations of an improved material standard of living for all people exacerbates potential shortages of natural resources." Not surprisingly, "globalization of expectations" accompanies the evolution of a global economy. Expectations about water resources include, historically, an entitlement mindset. Charles Kreitler suggested that to address consumptive demands for water, we might have to begin treating water resources as a commodity whose price would rise relative to demand. Kreitler also pointed out that water issues are local issues when it comes to sustainability. He asked, "Should we look for a global solution to a local problem, or try to solve the local problem locally?" James Triplett claimed that when it comes to water, "Supply is not the problem. The location and distribution of the supply are the problems…. So we are really left with making informed decisions about allocation."

"We didn't leave the Stone Age because we ran out of stone." This remark from Marlan Downey, President of the American Association of Petroleum Geologists (AAPG), ensured that the discussion of sustainable energy would not become mired in comparing supply and demand curves for petroleum. Instead, participants simply assumed an eventual collision between growing demand and finite resources, and went on to discuss out-of-the-box solutions. According to the report, "Geologists don't have to be bound by current paradigms of energy supply." According to Jack Schmitt, "Almost all discussions about technology are about creating ways to continue to use the same fuel mix already in place. The most important role of technology may be to replace current energy paradigms rather than [to] extend their life."

Participants moved away from the simplistic notion that energy sustainability can be defined as meeting societal demand in perpetuity. There are so many variables that it may not be useful to view it in that manner. The definition of energy sustainability is constrained as much by rising global population, social expectations, and technology advances as it is by any finite volume of energy resources. The breakout group on energy concluded that society will have sustainable energy supplies, by definition (no energy, no society). But they rightly questioned the cost to lifestyle and quality of life goals. Thinking globally, the group considered that European and North American social values may not be attainable, or even desirable for other societies, although they may well aspire to the same comfortable material standard of living. The energy group concluded: "Providing energy supply sustainability in the long term will require unorthodox thinking and population stability."

Understanding Isn't Enough

Beyond diligent learning, the conference organizers desired a product of some sort—a collectively aimed dart landing somewhere near the bull's-eye of what must be done toward sustainability. They asked participants to address two crucial questions: (1) How can we clarify and improve public understanding of energy and water issues? and (2) What earth science components should be included in national energy and water policies?

The breakout group on energy concluded: "To begin to address the larger issues of sustainability, we must engage the public and give them ownership of the issues." They concluded that neither our public education system nor the efforts of earth science societies have worked, saying, "There needs to be a program that identifies the problems, gives a blueprint for the answers, builds consensus, and maintains its focus over a very long period of time." Their top 10 recommendations for energy policy include developing a grass-roots public education effort to convince people that our energy future requires us to lose our addiction to fossil fuels and to convince people in the United States that

continuous unlimited growth cannot be sustained without a significant decline in lifestyle.

The breakout group on water concluded: "Although society is dependent on energy, life itself is dependent on water," and exponential population growth is an issue overriding all others. They pointed out that the pubic generally does not understand the true cost of water. Water must be fully valued if it is to be conserved. Water has high "place value" and the geography of human population growth, consumptive use, and water quality are factors that must frame all questions of sustainable water resources. The group pointed out that the local nature of many water issues sometimes yields sophisticated public understanding, input, and action. In their top 10 recommendations, the group urged that national and regional water policy should recognize the full costs of access to water resources, including the depletion of fossil waters and the disposal of wastewater. "In general, water is valued too cheaply for effective management." The group also recommended: "Policy should regard water supply as a single system based on watershed management."

Bravo!

Recognition matters. The geoscience community owes AAPG and the Division of Environmental Geosciences thanks and acknowledgment for pursuing this topic in a meaningful way. For at least three years, through two conferences, Lee Gerhard prodded, provoked, and cajoled a relatively small group of leaders from diverse communities to get together and talk about these issues. He believed that we would all learn something important if we stayed in the same place long enough to really engage each other in conversation and debate.

Based on the conclusions of the first conference, held in Taos, New Mexico, in the fall of 1998, I thought Lee was wrong. I didn't believe anybody had learned much of anything. In fact, I was wrong. Conclusions reached at the Arbor Day Farm conference demonstrate that the geoscience community is learning how to talk with, think with, and learn with colleagues from other quarters. This means, in my opinion, that the geoscience community is ready to begin making a meaningful and essential contribution to the sustainability conversation. Lee, my hat is off to you, and I wish I'd been in Nebraska last fall.

Cathleen May, *GSA Chief Science Officer*

The Arbor Day conference was sponsored by the Division of Environmental Geosciences, the American Association of Petroleum Geologists; the Institute for Earth Science and the Environment (IEE), GSA; the American Geological Institute; the U.S. Geological Survey; the U.S. Department of Energy; and the University of Kansas Energy Research Center. IEE's financial support was made possible through the generosity of Carol Mann and the John F. Mann fund in the GSA Foundation.

Ed. note: Part I of the following article, which provided guidelines for public speaking, appeared in the February issue of *GSA Today* (available for viewing at www.geosociety.org). If you have a story to share about a meeting presentation, good or bad, that you have seen—or given!—send it to jhammann@geosociety.org.

WHEN PRESENTATIONS GO BAD:

A Commentary—Part II

Kristan Cockerill, *Biosphere 2 Center, Columbia University, P.O. Box 689, Oracle, AZ 85623, USA, and* ***Tim F. Wawrzyniec,*** *Bureau of Economic Geology, University of Texas, Austin, TX 78713-8924, USA*

The age of desktop publishing has been both a blessing and a bane to those of us trained in communication and visual arts. When used appropriately, new technology can sometimes save even poor speakers. But there are far too many cases of digital presentations gone bad. That is, speakers use the technology without considering basic communication or visual art principles.

Audiovisual materials are meant to support a presentation; they are NOT the presentation. Commonly committed errors include trying to cram too many slides into one talk, trying to cram too much information onto a single slide, or using distracting color schemes or patterns.

Following are basic guidelines for designing and using visual aids to accompany your presentation.

Remember Murphy's Law

First and foremost, be prepared for equipment to fail. Either be prepared to talk without your visual materials or have a backup system.

Computers and Presentation Software

Personal computing hardware and software technology has advanced sufficiently to allow speakers to create highly portable, versatile digital presentations. This has been both the boon and the bane for many. On one hand, it allows for colorful, dynamic presentations that can be edited up to the last minute. On the other hand, such presentations are subject to two types of problems.

The first is equipment failure. If the computer decides not to work for whatever reason, you'd better have a backup hard copy of the presentation. Second, because software often includes color schemes and canned templates complete with animation, you have the opportunity to be graphically creative. Unfortunately, many of the schemes and tools made available provide few or no guidelines on what works visually, what color combinations lead to eyestrain, or which types of text or graphic elements do not reproduce well on the big screen.

Use the following guidelines when designing your next digital presentation.

Preparing Slides Using a Computer

General Rules

- Avoid using patterns and screens; stick with solid colors. If you are using only black and white, it is simpler and cheaper to make overheads of your figures using a conventional laser printer.
- Be brief and to the point on text slides; use an outline at most. Wordy introduction or conclusion slides distract your audience from the primary source of information, which is you, the speaker. Use graphics and photos to support your key points.
- Keep figures and maps simple, as they are displayed for only a short time. The more complex the slide, the less useful it will be. Too many times we've heard speakers say, "I know this is busy, but you only need to look at this tiny point." The audience will not look only at the tiny point, but will try to decipher the complex visual, missing whatever you are trying to explain.

Use of Color

- Use dark backgrounds and lighter lettering for digital or slide presentations, and use light backgrounds and darker lettering for overheads.
- Avoid combining contrasting colors (e.g., purple background and primary yellow text). Such combinations are eye catching, but do not always reproduce well (photographically or in a digital projection). Moreover, high-contrast combinations can lead to eyestrain. This is one of the reasons why using color can be more pleasing to the eye than using black-and-white overheads. If you like yellow text on a purple background, use a pastel shade rather than a bright primary yellow. It will be easier to read and just as eye catching. Avoid using primary colors in figures. The extreme contrast makes the figure "vibrant," which distracts from the data.
- Avoid graphic elements that consist largely of some bright color. The object can lead to saturation during reproduction in a digital camera or during digital projection and it can be difficult to adjust the equipment without washing out other features in your slide.
- Choose colors that minimize contrast but allow the text or lines to stand out. We've observed that digitally drafted slides work best with darker background colors and text and lines that are bright but complementary to the entire color scheme. Stick with earth tones and avoid primary colors unless you are trying to emphasize some specific, very small component of the entire slide.

Text Slides

- Text size should be no less than 14 to 18 points and no more than 36 points. Anything outside this range will be too small to read or will overemphasize the BIG text.
- Serif typefaces such as Times or Palatino have characters with stems (serifs) that can fade during transfer to film or during projection. If you must use serif fonts, use BOLD to ensure that each character reproduces well. Your audience does not have much time to read your slides, so, as with content, keep the typeface simple.
- Avoid dark lettering on dark backgrounds. The same goes for baby blue lettering on baby pink backgrounds—yes, it has been done; the offenders need not be mentioned by name. When in doubt use white on dark backgrounds and black on light backgrounds.
- Avoid drop shadows, outlined, or embossed text, which generally does not reproduce well.

Maps and Figure Slides

- Use pastels or earth tones on maps and avoid complex patterns and fine lines. Maps convey a great deal of information; bright colors and complex patterns strain the eyes or may be downright revolting, thus defeating the purpose. Your audience has only seconds to a minute or two to read your map; keep it simple and they will remember more.
- Use a line size of between one and four points. The most important lines in the figure should be the thickest.
- Use dashed lines only where absolutely necessary.
- Avoid placing text over lines. Unless you mask out the line, the text is hard to read.
- Use color to differentiate sets of data represented in a single graph. The convention of using different shapes defeats the flexibility of using color, and the symbols are often hard to differentiate.

Shooting Slides on a Digital Camera

Use a digital camera to achieve the best results for slides. If you don't have access to one, professional production is available for between $1 and $4 per slide. The greatest value in using this technology is that the entire image of the slide will be in focus. Using a digital camera generally saves you money compared with shooting the slides off the computer screen.

Shooting Slides from a Computer Screen

This procedure can be both expensive and difficult; it can, however, be mastered with time. We have yet to meet anyone who has not burned through three or four rolls of film trying to get their slides just right. The greatest difficulty arises from the fact that many computer screens have some degree of curvature, and if the camera is not set properly, portions of the slide will not be in focus. Likewise, the camera focal plane must be sub-parallel to the computer screen. Color saturation, where the colors appear to bleed into one another, is also a major headache. For some success in shooting slides from computer screens, settle on a standard color scheme and do the following.

- Test different film types and brands. Some films are good at capturing certain wavelengths of light, while others may result in poor color reproduction.
- Use slower films (<200 ASA).
- Use larger f-stops (smaller aperture) for maximum depth of field. This will help prevent capture of the curvature of the screen or any tilting of the screen with respect to the camera.
- Use shutter speeds slower than 1/60 sec. We have achieved good results using shutter speeds of 1/30 sec.
- Shoot slides off of a flat-screened monitor.

These are only guidelines; there is no guarantee (implied or otherwise) of success. We recommend having your slides professionally produced.

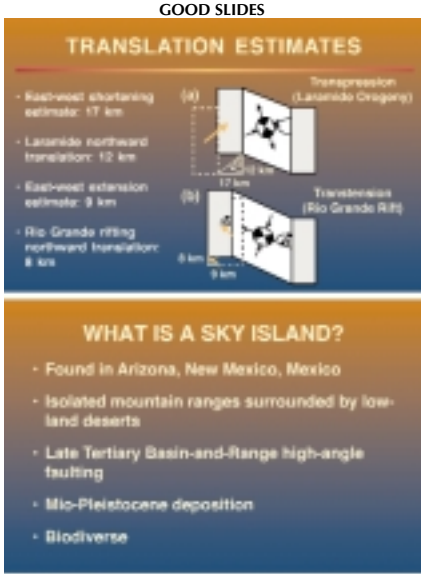
Don't Let This Be You!

We hope these suggestions help you produce a more effective presentation, which will help you disseminate your ideas. Keep in mind, however, that your presentation may be doomed by any of the following. (We have seen many examples of these; no names are provided to protect the guilty.)

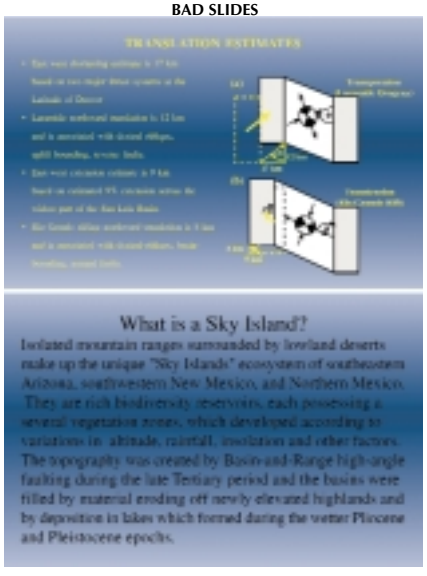
- You have put together 180 slides in two carousels. You have 10 minutes to talk, and you are changing slides on the average every 6.66 seconds. It takes a great projectionist 3 seconds to focus an image, which gives your audience 3.66 seconds to view two slides; witnessed, GSA New Orleans, 1996.
- Using pink text over a sky-blue background that fades to white along the vertical sides; witnessed, a department seminar.
- You or the person who produced your color scheme is completely color-blind; although we cannot prove it, we have suspected it on numerous occasions.
- Forgetting to turn off the auto-focus. Auto-focus, much like a frictionless surface, exists only in the form of a mathematical abstraction or in regions of space where presentations are not typically given. It is produced for the sole purpose of allowing a speaker to blame the fuzzy nature of his/her slides on the supposed incompetence of the student projectionist rather than the poor quality of his/her slides; witnessed, GSA 1994, 1995, 1996, 1997, 1998, 1999, 2000.
- Complete lack of useful content due to incoherence, poor preparation, and/or indecipherable audiovisuals; witnessed, GSA 1994, 1995, 1996, 1997, 1998, 1999, 2000.

Avoid these pitfalls. Use our guidelines to prepare your next talk, and you should have an improved approach to speaking and to using audiovisual supports. Your audience will appreciate it! ▲

GOOD SLIDES



BAD SLIDES



Left: Good figure and text slides use a minimum of text, a large enough type size, and correct color contrast. **Right:** Bad figure and text slides are wordy, use small type, and are difficult to read.

2001 GeoVentures

Lago Argentino. Photo by J. Reynolds.

GeoTrip

New Year's at the End of the World: The Geology of Southern Patagonia, Including Tierra del Fuego
Dec. 26, 2001–Jan. 10, 2002
15 days, 14 nights
Scientific leaders: James Reynolds, 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.

Since 1978, Dottie Stout has been leading geological expeditions around the world, including trips to China, South America, Africa, Europe, Indonesia, Australia, and Russia. Dottie is past president of the National Association of Geology Teachers and is temporarily on leave as a program director at the National Science Foundation.

Description

Our trip will start in Ushuaia, Argentina, the southernmost city in the world, at the base of the Cordillera Darwin on the Beagle Channel along the southern shore of Tierra del Fuego. The austral summer can be pleasant, but is seldom truly warm. We'll look at the glaciers, rocks, and the tectonic setting along the channel before we cross the mountains to the Patagonian steppes that comprise the northern part of the island. After crossing into Chile and taking the ferry across the Straits of Magellan to the South American mainland, we'll head eastward along the straits through the oil and gas fields to the penguin rookery near Punta Dungeness, Argentina. We'll observe the interplay between sea-level changes, glaciations, waves, currents, and extreme tidal ranges that shaped the coastline, while dodging the numerous rheas and guanacos on the plains. From there, we'll go to Río Gallegos and then to Glaciers National Park in the Patagonian Andes. We'll watch icebergs calve off of the Perito Moreno glacier into Lago Argentino, take a daylong boat trip on the lake, and slalom through the icebergs while Andean condors soar overhead. A low pass through the mountains will take us to Torres del Paine National Park in Chile to see the most spectacular mountains in the Andes. After a boat trip up the Ultima Esperanza fjord at Puerto Natales we'll head to Punta Arenas and our flight home.

Fees and Payment

$4,200 for GSA members, $4,300 for nonmembers. A $300 deposit is due with your reservation and is refundable through Sept. 1, less a $50 processing fee. Total balance is due Sept. 1. Minimum: 20; maximum: 30. Included: Guidebook; airfare from Atlanta to Ushuaia via Buenos Aires; ground transportation; lodging for 13 nights (double occupancy); and meals for 14 days. Not included: Airfare to and from Atlanta, Georgia; and alcoholic beverages.

Perito Moreno glacier. Photo by J. Reynolds.

GeoHostel

Impacts of Coastal Development on the Barrier Islands
Inlet Inn, Beaufort, North Carolina
April 21–26, 2001
5 days, 6 nights
Scientific leaders: David M. Bush, State University of West Georgia, Carrollton, Georgia; Robert S. Young, Western Carolina University, Cullowhee, North Carolina.

David Bush received his B.S. in geology from the State University of New York, College at Oneonta, and both his M.S. and Ph.D. in geology from Duke University. As a postdoctoral research associate with the Program for the Study of Developed Shorelines at Duke University, his research focused on coastal hazards, risk assessment mapping, and property damage mitigation. He has experience in areas including the U.S. Atlantic and Gulf of Mexico coasts, the Bahamas, the Caribbean, and others. He was part of the National Academy of Sciences post-disaster field study teams after hurricanes Gilbert and Hugo. He helped plan the U.S. Decade for Natural Hazard Reduction and is senior author of *Living with the Puerto Rico Shore*, *Living by the Rules of the Sea*, and *Living on the Edge of the Gulf: The West Florida and Alabama Coasts*, plus articles on coastal hazards, risk assessment, and property damage mitigation. David serves on the editorial board of *Environmental Geosciences*.

Above and below: Hurricane Floyd damage, North Carolina, September 1999. Photo by D. Bush.

Robert Young received a B.S. in geology from the College of William and Mary and an M.S. in Quaternary studies from the University of Maine. He was a James B. Duke Doctoral Fellow at Duke University, where he received a Ph.D. in geology. Robert serves on the editorial boards of the *Journal of Coastal Research* and *Environmental Geosciences*. He is currently the technical program chair for GSA's 2001 Annual Meeting. Rob has been working in the area of coastal hazards, coastal storm processes, and coastal planning for the past 10 years,

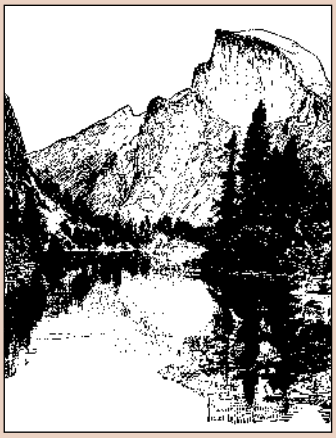
focussing on the U.S. east coast, the Caribbean, and Central America. He has conducted post-storm reconnaissance after the impact of nearly every major hurricane to strike the U.S. mainland and several in the Caribbean and has written numerous papers on coastal processes, numerical modeling, risk mapping, and property damage mitigation.

Description

This GeoHostel will be interesting and challenging to the professional geologist, yet understandable and fascinating to others. We'll examine the dynamics of beach and barrier island processes with emphasis on the interaction of nearshore processes with human development. We'll discuss coastal hazards; assessment of risk for property damage from hurricanes and coastal storms; how development increases risks of living in the coastal zone; and coastal management issues of dealing with eroding shorelines, all illustrated during various field stops. Trips will begin and end in Beaufort, N.C. Hikes will not be strenuous. The weather is generally pleasant and sunny at this time of the year. Time will be available for visiting the North Carolina Aquarium, Mariners Museum, and Duke University Marine Laboratory.

Fees and Payment

$1,000 for GSA members, $1,050 for nonmembers. A $100 deposit is due with your reservation and is refundable through April 1, less a $20 processing fee. Total balance is due April 1. Maximum: 32. Included: Classroom programs and materials; field trip transportation; lodging for six nights (single occupancy, or double for couples); breakfast and lunch daily; and welcoming and farewell events. Not included: Airfare to and from Beaufort, North Carolina; transportation during hours outside field trips; alcoholic beverages; and other expenses not specifically included.



GeoVentures 2001 for GSA Members and Friends

For complete details on GeoVentures or for full itineraries, contact Edna Collis, GeoVentures coordinator, 1-800-472-1988, ext. 134, fax 303-447-1133, ecollis@geosociety.org.

Participants must be 21 or older and in good health. Any physical condition requiring special attention, diet, or treatment must be reported in writing when reservations are made. We'll do our best to accommodate special needs, including dietary requirements and physical disabilities.

Deposits and payments are refundable, less a processing fee, up to the cutoff date. Termination by an individual during a trip in progress for any reason will not result in a refund, and no refund will be made for unused parts of trips. For details on accommodations and occupancies, see trip descriptions, contact Edna Collis, or visit www.geosociety.org/meetings/gv/index.htm.

GeoHostel

Geology of Glacier National Park, Montana
Glacier Park Super 8 Motel, Columbia Falls, Montana
July 14–19, 2001

SOLD OUT!

Along the "Going to the Sun" highway, Glacier National Park, Montana. Photo by Rob Thomas.

REGISTER TODAY!

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.

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

	Deposit Per Person	No. of Persons	Total Paid Deposit
Patagonia	$300	____	$_____
North Carolina	$100	____	$_____
		TOTAL DEPOSIT	$_____

☐ VISA ☐ MasterCard ☐ American Express ☐ Discover

Credit Card # Exp. Date

Signature

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

MAIL OR FAX REGISTRATION FORM AND CHECK OR CREDIT CARD INFORMATION TO:
2001 GSA GeoVentures, Member Services
P.O. Box 9140, Boulder, CO 80301
fax 303-447-1133 or 303-443-1510

MAKE CHECKS PAYABLE TO: GSA 2001 GeoVentures

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.

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Positions Open

COLUMBIA UNIVERSITY'S BIOSPHERE 2 CENTER ANNOUNCES FACULTY POSITION FOR EARTH SEMESTER PROGRAM

Assistant or Associate Professor, Earth System Science. Columbia University will expand its Arizona campus education programs over the next five years. The Earth Semester is a 16-credit, interdisciplinary, undergraduate program in Earth System Science and Policy held at Columbia's Biosphere 2 Center in Oracle, Arizona. Faculty appointments are made through Columbia's Department of Earth and Environmental Science. We are currently seeking a teacher/scholar in the area of Earth System Science. We are especially interested in candidates with a background in climate or geohydrology. Teaching and postdoctoral experience are desirable. The appointment will be made at the Assistant or Associate Professor level, depending on experience, and will begin July 2001. A letter of interest highlighting the applicant's educational philosophy and research interests, and names of 3 references should accompany a C.V. Materials for all positions should be sent to: Human Resources, Biosphere 2 Center, P.O. Box 689, Oracle, AZ 85623 by April 15, 2001. Review of applications will occur on a rolling basis, so applicants are encouraged to send materials early. Columbia University is an Equal Opportunity Employer. Minorities and Woman are encouraged to apply.

INSTITUTE FOR ENERGY RESEARCH UNIVERSITY OF WYOMING

The Institute for Energy Research is seeking four new Ph.D.-level geoscientists. IER is an applied research institute with a global portfolio of research and service projects for the oil and gas industry. Service projects include reservoir characterization, petroleum systems analysis, and high-resolution hazards assessments. Active research programs include 3-D reservoir modeling, deltaic and turbidite sedimentation, and multidisciplinary issues in enhanced oil recovery.

We seek scientists with industry or academic experience and a publication record. Experience with Landmark software is an advantage. The following specializations are priorities.

Seismic stratigraphy. Experience in sequence stratigraphy and sedimentology is required. Skills in subsurface mapping and well log correlation are desirable.

Reflection seismology. Experience in acquisition and processing of seismic reflection data and ability to conduct AVO and attribute analyses.

Outcrop and core sedimentology. Experience in depositional systems interpretation and reservoir architecture required. Skills in geostatistics or reservoir modeling desirable.

Reservoir characterization. Experience in petrography, reservoir diagenesis, and modeling required. Experience with fission track analysis desirable.

Individuals with skills in closely related sub-disciplines (e.g., basin modeling, geochemistry, and structure) are encouraged to apply.

These are soft money positions. The successful candidates will initially participate in ongoing projects and will be strongly encouraged to help establish new research and service projects.

IER is part of the Department of Geology and Geophysics and enjoys strong interaction with faculty, students, and post-docs. We have state-of-the art laboratories in nearly all geoscience sub-disciplines and a complete suite of Landmark software. There are strong links to the Petroleum Engineering and Applied Mathematics programs on campus.

Review of applications date from March 15 to March 30. However, all positions will remain open until the desired individuals are on board. Salaries are competitive with industry standards.

Please submit applications to: Dag Nummedal, Professor and Director, Institute for Energy Research, P.O. Box 4068, Laramie, WY 82071-4068, e-mail: Nummedal@uwyo.edu, http://ier.gg.uwyo.edu.

The University of Wyoming is an affirmative action/equal employment opportunity institution.

GEOLOGIST/DIRECTOR OF REMEDIAL SERVICES

Must have M.S. in geological science. Must have 9 months experience in job offered or 9 months experience in job related as geologist. Must have PG (professional geologist) and REP (Registered Environmental Professional) registrations. Perform site assessment, EIA (Environmental Impact Analysis) and RI/ FS (Remedial investigations/ Feasibility Studies). Management system installation & designing for AS/ SVE (Air Sparging/ Soil Vapor Extraction), P&T (Pump & Treat), USTs/ ASTs; and decommissioning of abandoned systems. Perform hazardous/ non-hazardous waste sampling using Hazmat management training; geological mapping; Lithostratigraphic logging; correlation and facies analysis. Design monitoring, recovery, AS, and SVE wells. Conduct aquifer characterization, plume delineation, hydrogeologic/chemical data management. Simulate flow/contaminant transport models using MODFLOW. Develop and utilize QA/QC (Quality Assurance/ Quality Control) procedures. Conduct/review geotechnical site investigations. Application and interpretation of environmental and OSHA health and safety regulations. Develop innovative concepts/methodologies. Perform project/business development. Develop/edit technical specs, system design, proposals, plans and reports. Make seminar & conference presentations.40 hours per week, 8:00 a.m. to 5:00 p.m., Salary $32,600 per year. Qualified applicants send resumes with social security numbers to the Indiana Workforce Development, 10 N. Senate Ave., Indianapolis, IN 46204-2277, Attention: Mr. Gene R. Replogle. Refer to ID # 8101112.

DEPARTMENT OF EARTH SCIENCES DALHOUSIE UNIVERSITY AND THE CANADIAN INSTITUTE FOR ADVANCED RESEARCH

Applications are invited for a probationary tenure-track assistant professor position in earth surface processes–landscape evolution. The successful candidate will strengthen surface processes at Dalhousie by teaching undergraduate and graduate classes, supervising M.Sc. and Ph.D. students, and by developing and maintaining a vigorous externally funded research programme. S/he will also be appointed a "Scholar" in the Earth System Evolution Programme (ESEP) of the Canadian Institute for Advanced Research (CIAR). Candidates should have an interest in quantitative interdisciplinary research in relationships between surface processes and Earth evolution. The successful candidate will have a record of research achievement, contribution to the discipline, and assessed potential necessary to be appointed by CIAR. As a member of ESEP, the incumbent will be partly supported by CIAR and during this time will benefit from reduced teaching responsibilities and from association with an international network of researchers in earth system sciences. A Ph.D. is required and post-doctoral experience is normally expected.

Applicants should submit a c.v.; a statement of research /teaching objectives and the name, address, phone, and e-mail of four referees. The deadline for applications is April 9, 2001; however, late applications will be considered if the position has not been filled. Applications should be sent to: Chair, Earth Surface Processes Search Committee, Department of Earth Sciences, Dalhousie University, Halifax, NS, Canada B3H 3J5, phone (902) 494-2358, fax (902) 494-6889, e-mail: earth.sciences@dal.ca.

For more specific information, access our Web sites: http://is.dal.ca/~es/es-home.htm; www.ciar.ca; http://adder.ocean.dal.ca/esep.

DALHOUSIE UNIVERSITY is an Employment Equity/Affirmative Action Employer. The university encourages applications from qualified women, Aboriginal peoples, racially visible people, and persons with a disability.

GEORGIA SOUTHERN UNIVERSITY STATESBORO, GEORGIA

The Department of Geology and Geography and the Georgia Southern University Museum invite applications for a dual appointment as a tenure-track Assistant Professor of Geology and Curator of Paleontology.

The Department of Geology and Geography seeks a paleontologist who will enhance course offerings and provide disciplinary expertise in an undergraduate geology program. Primary instructional responsibility will be introductory courses such as History of Life and Historical Geology. Upper division courses will include Invertebrate Paleontology and, potentially, Stratigraphy and Sedimentation. The successful candidate will be expected to sponsor student research. Service to the department, college, university, and the larger community is expected of all faculty members. Scholarly research, publication, and related professional activities are required for reappointment, promotion, and tenure.

As Curator of Paleontology the primary responsibilities will be to: (1) study and curate the existing collection according to accepted museum standards, (2) develop the collection through field studies and donations, (3) complete basic preparation or replication of specimens for exhibition or oversee the completion of that work by contractors, (4) prepare brief research reports and draft and review label copy for permanent and changing exhibits, and (5) process loans to and from the collection. The curator will also work cooperatively with research requests from other scholars and museums concerning the collection.

Preference will be given to candidates with research interests in the Atlantic Coastal Plain. Preference will also be given to candidates with prior undergraduate teaching experience and prior work in museum curatorship. The Ph.D. degree in geology or a closely related field must be completed by the position starting date of August 1, 2001. Salary will be commensurate with qualifications.

APPLICATION INFORMATION: Please direct a letter of application including a statement of research and teaching interests, a curriculum vitae, supporting documentation (such as reprints and evidence of teaching effectiveness), and the names, addresses, and telephone numbers for three references to: Dr. Fredrick J. Rich, Search Committee Chair, Department of Geology and Geography, Georgia Southern University, Statesboro, GA 30460-8149. The postmark deadline for applications is March 23, 2001.

The names of applicants and nominees, resumes, and other general non-evaluative information are subject to public inspection under the Georgia Open Records Act. Persons who need reasonable accommodations in order to participate in the application process should notify the Search Committee Chair. Georgia Southern University is an Equal Opportunity/Affirmative Action Institution.

CENTRAL MISSOURI STATE UNIVERSITY DEPARTMENT OF EARTH SCIENCE

Non-tenure track Instructor with possible renewal beginning August, 2001. Ph.D. or ABD in geology required. Previous teaching experience preferred. Seeking a broadly trained individual capable of effective undergraduate instruction in a department of six faculty members. The department offers B.S., B.A., and B.S.E. degrees. Responsibilities include teaching multiple sections of Introductory Geology and possibly two upper level courses per year from the following: geochemistry, ground water geology, and oceanography. Send letter of application, resume, transcripts of undergraduate and graduate work, and names, addresses, phone numbers, and e-mail addresses of three professional references to Chair—Search Committee, Department of Earth Science, Central Missouri State University, Warrensburg, MO 64093-5054. Evaluation begins March 1, 2000, and continues until filled. AA/EEO/ADA.

INSTRUCTOR (M.S. LEVEL) IN GEOLOGY UNIVERSITY OF SOUTHERN INDIANA

The Department of Geology at the University of Southern Indiana invites applications for a full-time position at the Geology Instructor level, beginning August 2001 and renewable on a yearly basis. The department seeks a creative and energetic geologist in any area of geology. The successful applicant will teach and develop introductory laboratory sessions (including field experiences) at the undergraduate level, conduct an evening lecture in physical geology, and will maintain and enhance the department's teaching collections and equipment. A

master's degree in geology is required. The university is committed to excellence in teaching, scholarship and professional activity, and service to the university and community. Minorities and women are encouraged to apply. Please submit a letter of application, including a brief statement of teaching experience and scholarly interests, a resume, and name/address and phone/e-mail for three references for review beginning March 20, 2001, to: Dr. Kent W. Scheller, Acting Chairman, Department of Geology and Physics, University of Southern Indiana, Evansville, IN 47712. Additional information may be obtained from http://deepcnet.usi.edu/geology. USI is an Affirmative Action/Equal Opportunity Employer.

BASIN ANALYSIS/EXPLORATION GEOPHYSICS UNIVERSITY OF ALASKA FAIRBANKS

The Geophysical Institute and the Department of Geology and Geophysics at the University of Alaska invite applications for a 12-month (9.75 months research, 2.25 months teaching) tenure-track Assistant or Associate Professor position to begin fall 2001. We seek a creative scientist with expertise in both quantitative modeling and geophysical exploration methods and research interests in applying these methods to the interpretation of sedimentary basins and mountain belts. A Ph.D. in an appropriate field is required and experience in the interpretation of 2-D and 3-D seismic reflection, gravity, and well data is highly desirable. Teaching responsibilities include undergraduate and graduate courses in exploration geophysics and basin analysis. The successful candidate is expected to develop an externally funded research program, supervise M.S. and Ph.D. students, and collaborate with existing faculty of the Tectonics and Sedimentation research group with interests in structural geology and tectonics, clastic and carbonate stratigraphy and sedimentology, geochronology, and paleomagnetism. An important objective of this position is to help the group expand its research into the subsurface, particularly in Alaska's basins with petroleum potential. Additional opportunities exist to interact with Institute researchers in crustal dynamics, seismology, volcanology, remote sensing, and glacier and sea ice studies. Relevant research facilities include the Arctic Region Supercomputing Center and the Geophysical Institute's Geochronology Laboratory and staffed machine and electronic shops.

Please send a UA application, résumé and publication list, statement of research and teaching experience and interests, copies of key publications, and names, addresses, telephone numbers, and e-mail addresses of three references to: Wesley K. Wallace, Chair, Basin Analyst/Exploration Geophysicist Search Committee, Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320, USA; phone (907) 474-5386, fax -5163, e-mail wallace@gi.alaska.edu. Screening of applications will begin on April 1, 2001, but applications will be accepted until the position is filled. The vacancy announcement is posted at: http://www.gi.alaska.edu/admin/human_resources/. Additional information is available on the Geophysical Institute at http://www.gi.alaska.edu/, on the Tectonics and Sedimentation research group at http://www.gi.alaska.edu/TSRG/, and on the Department of Geology and Geophysics at http://www.uaf.edu/geology/.

For purposes of collective bargaining, this position is represented by a union. The successful candidate will be obligated to pay to the union an agency fee as a condition of employment.

The University of Alaska is an equal opportunity/affirmative action employer and educational institution. Your application for employment with the University of Alaska is subject to public disclosure under the Alaska Public Records Act.

IGNEOUS PETROLOGIST UNIVERSITY OF NEW BRUNSWICK DEPARTMENT OF GEOLOGY

The University of New Brunswick, Department of Geology, invites applications for a tenure track position as Assistant Professor in Igneous Petrology effective July 1, 2001.

The successful candidate will possess a Ph.D. with demonstrated research and teaching records. The successful applicant will be expected to develop a self-sustained research program. All aspects of igneous petrology will be given consideration. Research facilities include electron microprobe, analytical SEM and TEM, XRD, ICP-OES, CL, fluid inclusion microscopy and an excellent in-house thin sectioning workshop. Related research activities within the Department include tectonics, ore genesis and mineral exploration, high-temperature mineral solubility studies, hydrogeology, GIS-lab and Planetary & Space Science Centre.

Interested persons should submit a letter of application, current curriculum vitae with names, addresses (including email) and telephone numbers of three (3) references to: Dr. Joseph C. White, Chair, Department of Geology, University of New Brunswick, P.O. Box 4400, Fredericton, N.B., E3B 5A3 Canada.

E-mail submissions to geology@unb.ca followed by hard copies are welcomed.

This competition will close March 31, 2001.

In accordance with Canadian Immigration requirements, this advertisement is directed in the first instance to Canadian citizens and permanent residents. The University of New Brunswick is committed to the principle of employment equity.

EXCELLENCE IN UNDERGRADUATE EDUCATION INTRODUCTORY GEOLOGY/FIELD GEOLOGY

The Department of Geological Sciences at the University of Nevada, Reno, invites applications for an assistant professor, with emphasis on promoting learning excellence in lower division geology courses and in assisting with field geology courses. The position is a 0.5 FTE 9-month nontenured academic appointment, with opportunities to secure additional funding for programs of learning excellence with other faculty. A Ph.D. is required at the time of appointment. The successful candidate will be able to demonstrate their excellence in teaching introductory level geoscience courses and in introducing new and innovative teaching techniques. An ability to motivate undergraduate students to learn and a commitment to promoting excellence in education in the geosciences are essential. A background and interest in field geological instruction, excellent oral and written communication skills, and an ability to develop useful interactions with colleagues are also essential to the position. Preferred qualifications include post-doctoral experience, demonstrated capability to develop new and innovative introductory courses, ability to develop proposals for research in the science of teaching and geological field experience. When appointed, the successful candidate will be expected to teach introductory courses at the undergraduate level and provide instructional and administrative support to field geology courses. This faculty member will be expected to develop interdisciplinary interactions with faculty in other colleges and to develop curricula in Earth Science Education in conjunction with local school districts and faculty in the College of Education. When appointed, this faculty member will be expected to develop research funding for the development of new and innovative instructional programs that relate to a broad range of students in the university who take undergraduate geoscience courses. This new faculty member will fully participate in departmental matters including committees at the departmental and college levels.

Salary is competitive and commensurate with experience. Additional compensation may be provided for teaching part of the summer field geology camp. The date of appointment will be July 1, 2001. Persons interested in being considered for this position should provide a concise statement describing undergraduate teaching goals and accomplishments, a current curriculum vita, and the names, addresses and telephone numbers of at least four references to Ms. Melissa Bell, Search Coordinator, Mackay School of Mines, MS 168, University of Nevada, Reno, NV 89557 USA. Telephone: (775) 784-6987; e-mail bell@mines.unr.edu. For additional information, contact Dr. James V. Taranik, Regents Professor and Search Committee Chair, Department of Geological Sciences, MS 172, University of Nevada Reno, Reno, NV 89557 USA, Telephone: (775) 784-4258; e-mail: jtaranik@mines.unr.edu. For full consideration, applications should be received by April 2, 2001.

The Department of Geological Sciences consists of 26 full-time teaching and research faculty, including those in the Nevada Seismological Laboratory, who are committed to excellence in education. The department is also enhanced by more than 27 cooperating faculty from the Nevada Bureau of Mines and Geology and the U.S. Geological Survey within Mackay School of Mines, and from the Desert Research Institute, the statewide research division of the University and Community College System of Nevada. Our department offers B.S., M.S., and Ph.D. degrees in geology, geophysics, geochemistry, geological engineering and hydrogeology. The department of has some of the most modern facilities and equipment in the nation, thanks to the strong commitment of the State of Nevada and major gifts from the W.M. Keck Foundation.

Our faculty and students are active in regional, national, and international research programs. The department is situated in one of the most diverse geological environments in North America and field-related studies and research are among the strengths of our programs. For more information on the department, our faculty and our programs please visit our Web page at www.mines.unr.edu/geology/. EEO/AA.

GEOBIOLOGY PENN STATE

The Department of Geosciences at Penn State invites applications for a tenure-track faculty position in geobiology emphasizing organism-environment interactions. We seek an individual with broad training in geosciences and/or biosciences and who will complement our existing strengths in geobiology, Earth system history and biogeochemistry. Candidates' interests in organism-environment interactions may include, but are not limited to, vertebrate paleontology, invertebrate paleontology, paleobotany, micropaleontology, biodiversity dynamics, paleoecology, paleoceanography, and paleoclimatology. Strong quantitative skills and interdisciplinary training are desirable. This position is part of an intercollege hiring initiative on organism-environment interactions jointly funded by the Penn State Environmental Consortium and the Department of Geosciences.

We will fill the position at the Assistant Professor or early Associate Professor level. Applicants should demonstrate potential for developing a vigorous research program and high-quality teaching at both the graduate and undergraduate levels. Review of applications will begin immediately and will continue until the position is filled. Interested candidates should submit the following application materials: a complete vita, a statement outlining teaching and research interests, examples of published work, and the names and addresses of at least four (4) references. Send application materials to: Head, Department of Geosciences, 503 Deike Building, The Pennsylvania State University, University Park, PA 16802.

Penn State is committed to affirmative action, equal opportunity, and the diversity of its workforce. For more information on the Department of Geosciences go to http://www.geosc.psu.edu.

COLBY COLLEGE NSF AIRE FELLOW IN GEOLOGY

Colby College invites applications for a 12-month NSF AIRE Fellowship in the Department of Geology. As one of ten NSF AIRE award recipients, Colby College has been recognized as a leader and innovator in creating synergy between its research and educational mission. To date, the Division of Natural Sciences has sponsored four (4) AIRE Fellows under the present grant.

The successful candidate will work with a senior faculty mentor and participate in the development of a non-majors, laboratory-based Introductory Environmental Geology course, the development and implementation of a JanPlan laboratory-based Natural Hazards course, and assistance in the development of a JanPlan Paleoenvironments/Paleoclimatology course. It will be possible for the candidate to teach a distribution course in the person's area of expertise in the spring semester. Candidates with broad research interests in environmental and/or paleoenvironmental applications will be given preference. The AIRE Fellow will be provided some travel and research funds.

Applicants need to send a letter of application, a current curriculum vitae, statements of teaching and research interests, and three letters of recommendation to: Dr. Robert A. Gastaldo, Chair, Department of Geology, Colby College, 5807 Mayflower Hill, Waterville, ME 04901-8858, (ragastal@colby.edu).

Applicants are expected to have their Ph.D. in hand at time of appointment; starting date between July 1 and Sept. 1, 2001. Review of applications will begin on March 16, 2001, and will continue until the position is filled. For more information about the college and the AIRE Fellowship, please see: http://www.colby.edu/NSF_AIRE/. Colby is an Equal Opportunity/Affirmative Action employer. Applications and nominations of women and minorities who would enrich the diversity of the campus community are strongly encouraged.

ASSISTANT PROFESSOR IN IGNEOUS OR METAMORPHIC PETROLOGY UNIVERSITY OF NEW ORLEANS

The Department of Geology and Geophysics invites applications for a tenure track position in igneous or metamorphic petrology to begin fall 2001. We seek a person who will undertake an innovative teaching and research program on high-temperature earth processes. We are particularly interested in individuals with multidisciplinary approaches or who welcome interaction with research groups in tectonics, mineralogy, sedimentary petrology, and geochemistry. The successful candidate will be expected to develop an active research program with external funding, teach undergraduate and graduate courses, and supervise graduate students at the M.S. and Ph.D. levels. The department maintains a full-suite of analytical tools for modern petrologic research as well as a new computational facility through the Keck Foundation (see www.uno.edu/geology).

Applicants should submit a curriculum vitae, a statement of research and teaching interests, and the names of at least three references to: Terry Pavlis, Search Committee Chair, Department of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148. We will begin evaluating applications March 15, 2001.

The University of New Orleans, a member of the Louisiana State University System, is an equal opportunity/affirmative action employer.

ASSOCIATE MICROSCOPIST

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UNIVERSITY OF IDAHO
DISTINGUISHED PROFESSOR
IN SUBSURFACE SCIENCE

The Department of Biological and Agricultural Engineering invites nominations and applications for the position of Distinguished Professor in Subsurface Science. This is a tenured, full time, 12-month/year position at Idaho Falls. The campus is ideally located adjacent to the Idaho National Engineering and Environmental Laboratory (INEEL) and near Yellowstone and Teton National Parks. The research and teaching effort will focus on strengthening the strategic alliance of the University of Idaho and INEEL in the area of vadose zone hydrology and contaminant transport. **Research Duties:** Develop a nationally recognized research program in vadose zone hydrology and contaminant transport. The research will focus on arid and semi arid environments characterized by a thick and fractured vadose zone. **Teaching Duties:** Develop and teach courses focused on analysis of flow and transport in the vadose zone and support hydrology courses at the graduate level, and provide academic and research advice to undergraduate and graduate students. **Required Qualifications:** Excellence in research in the vadose zone; demonstrated ability to participate in and lead interdisciplinary research teams; Ph.D. in agricultural, biological, civil, environmental engineering or related discipline. **Desired Qualifications:** Demonstrated ability in teaching courses at the undergraduate and graduate level. Demonstrated ability in advising and directing graduate students. Registered Professional Engineer or eligible to take the P.E. exam for the State of Idaho. **Contact/Application Procedure:** Submit application letter including a statement of interests and goals, curriculum vitae, most recent peer reviewed publication, and the names, addresses, telephone numbers, and e-mail addresses of three references to: Dr. James A. DeShazer, Head, Department of Biological & Agricultural Engineering, University of Idaho, P.O. Box 440904, EP 419, Moscow, Idaho 83844-0904. Telephone: (208) 885-6182. FAX: (208) 885-7908, E-mail: baengr@uidaho.edu. **Closing Date for Applications:** Will close when a sufficient number of qualified candidates have been identified, but not earlier than March 15, 2001. Information on the University of Idaho, the UI Department of Biological and Agricultural Engineering, Idaho Water Resources Research Institute and the Idaho National Engineering and Environmental Laboratory can be obtained from: www.if.uidaho.edu, www.uidaho.edu, www.uidaho.edu/bae, www.uidaho.edu/rsrch/iwrri, and www.inel.gov. A complete description can be obtained from www.uidaho.edu/bae. To enrich education through diversity, the University of Idaho is an equal opportunity/affirmative action employer.

LABORATORY COORDINATOR
DEPARTMENT OF GEOLOGY AND
ENVIRONMENTAL GEOSCIENCES

The Department of Geology and Environmental Geosciences at Lafayette College, Easton, PA, is accepting applications for a full-time, nontenure-track position for a laboratory coordinator. Applicants must have at least an M.S. in geology. Responsibilities will include teaching introductory geology laboratories, assisting with upper-level geology courses, laboratory preparation and set up, and on occasion, teaching introductory geology lectures. The lab coordinator will also curate the rock and mineral and map collections used for teaching and provide field and electronic support. A strong computer background including proficiency using both Macintosh and Windows based PCs and associated hardware/software such as a slide maker, scanner, digitizer, etc. is essential. The position begins summer/fall 2001. Please include a resume, a description of experience and capabilities, graduate and undergraduate transcripts, and reference letters from at least three references to: Dr. Dru Germanoski, Head, Department of Geology and Environmental Geosciences, Lafayette College, Easton, PA 18042; e-mail germanod@Lafayette.edu. Lafayette College is committed to equal opportunity. Women and minorities are encouraged to apply. We will begin reviewing applications March 1, 2001, and applications will be accepted until the position is filled.

Services and Supplies

RECENT, RARE, AND OUT-OF-PRINT BOOKS. Find our online catalog at http://home.earthlink.net/~msbooks for books on geology, mining history, ore deposits, U.S. Geological Survey, and western Americana; e-mail: msbooks@earthlink.net. For free printed catalogs, send your request and area(s) of interest to MS Book and Mineral Company, P.O. Box 6774, Lake Charles, LA 70606-6774.

Opportunities for Students

Graduate Assistantships at Texas Christian University. The Geology Department and Center for Remote Sensing and Energy Research has assistantships available for M.S. students for the spring and fall semesters. Financial aid includes a nine-month stipend for two years, full tuition waiver, and funds to support thesis research. Areas of department expertise include hydrology, remote sensing, environmental geology and geochemistry, carbonate and clastic sedimentology, petroleum geology, paleovolcanology, structure and tectonics, Precambrian geology, and computer applications in geology. Field research is carried out in Scotland, the Sierra Nevada in California, and Africa, as well as Texas and Oklahoma. Contact Dr. R. Hanson at 817-257-7996; hanson@gamma.is.tcu.edu. Additional information about the department can be found on our Web site at http://geowww.geo.tcu.edu.

The Department of Earth Sciences at Florida International University has assistantships available for qualified M.S. and Ph.D. students beginning fall semester 2001. Aid includes teaching assistantships and full tuition waivers for FL resident or nonresident students. Openings are available in diverse research areas include structural geology/tectonics, igneous geochemistry/petrology/ore genesis, mineral physics, paleontology, stratigraphy, paleomagnetism, geophysics/remote sensing and biogeochemistry. Students seeking further information on the faculty and research opportunities in the Department of Earth Sciences at FIU are invited to explore our Web site at www.fiu.edu/orgs/geology. For application materials, contact Dr. Andrew Macfarlane, FIU Department of Earth Sciences, 107th Avenue/University Park, Miami, FL 33199, or e-mail macfarla@fiu.edu.

Two openings at LUMCON (Louisiana Universities Marine Consortium, http://www.lumcon.edu) are anticipated for graduate students in chemical oceanography/ biogeochemistry beginning in the summer or fall of 2001. Students may enroll at Tulane University (Institute for Earth and Ecosystem Science, http://www.tulane.edu/~iees/#research) or Louisiana State University (Department of Oceanography and Coastal Studies, http://www.ocean.lsu.edu/). The students will be expected to develop appropriate projects within the framework of ongoing research in Dr. Rodney Powell's laboratory. Projects will deal with either trace metal or nutrient cycling in the marine environment. If interested, please contact Dr. Powell via e-mail (rpowell@lumcon.edu mailto:rpowell@lumcon.edu) or phone (504-851-2825).

Research and Teaching Assistantships at Temple University: Research and Teaching Assistantships are available for the fall term (September 2001) in our Masters Program in Geology at Temple University. The 2-year Masters Program offers advanced courses and thesis research opportunities in environmental geology, hydrogeology, geochemistry, environmental geophysics, cyclic stratigraphy, soil science/paleosols, K-T boundary studies, and materials science. Financial support for every student includes stipend, book allowance, and full tuition for 2 years. Research Assistantships and summer support are available for studies in cyclic stratigraphy of Cretaceous rocks in Dorset, England, and the French Jura; in Cenozoic paleosols, vertebrate taphonomy and paleoenvironments in Badlands National Park, South Dakota, in development of a ZrO2-based high-temperature pH electrode, and environmental geophysics. Graduates of our program have an excellent record of employment and acceptance into doctoral programs. For information and applications please write, call or e-mail Edwin J. Anderson, Department of Geology, Temple University, Philadelphia, PA 19122, tel. (215) 204-8249, fax (215) 204-3496, e-mail andy@astro.temple.edu. Applications will be accepted until these positions are filled. Please visit our Web site at http://www.temple.edu/geology for additional information.

Graduate Opportunities in Igneous Petrogenesis. Graduate assistantships M.S. or Ph.D. are available in the Department of Geology and Geophysics at the University of Missouri—Rolla for energetic individuals interested in studying igneous petrogenesis in the Coastal Maine Magmatic Province. Funded research projects include investigation of the dynamics of felsic magma chambers invaded by mafic magmas and use of the timing and character of igneous rocks to unravel mechanisms of terrane accretion during continental collision. All projects involve components of field work and detailed petrographic, geochemical, and isotopic characterization of zoned minerals and whole rocks. Many aspects are collaborative and students will interact with researchers from several universities. The University of Missouri—Rolla is located in the scenic Ozark Plateau and is known for its abundance of outdoor activities and low cost of living. The department offers a wide range of specialties in geology environmental geochemistry, economic geology, petroleum geology, sedimentology, basin analysis, sequence stratigraphy, biostratigraphy, and environmental and exploration geophysics. Assistantships are available for M.S. and Ph.D. candidates for fall 2001. For further information, visit our Web site at http://www.umr.edu/~geo-geop/ or contact Dr. John P. Hogan at the Department of Geology and Geophysics, University of Missouri—Rolla, Rolla, MO 5409. E-mail: jhogan@umr.edu.

The Geological Society of America

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Boston 2001: A GEO-ODYSSEY

November 1–10, 2001

On every odyssey there are milestones

Premeeting Field Trips, November 1–4
Short Courses and Workshops, November 3–4
Exhibits Open, November 4–7
Technical Program, November 5–8
Postmeeting Field Trips, November 9–10

Abstracts Deadline: July 24, 2001

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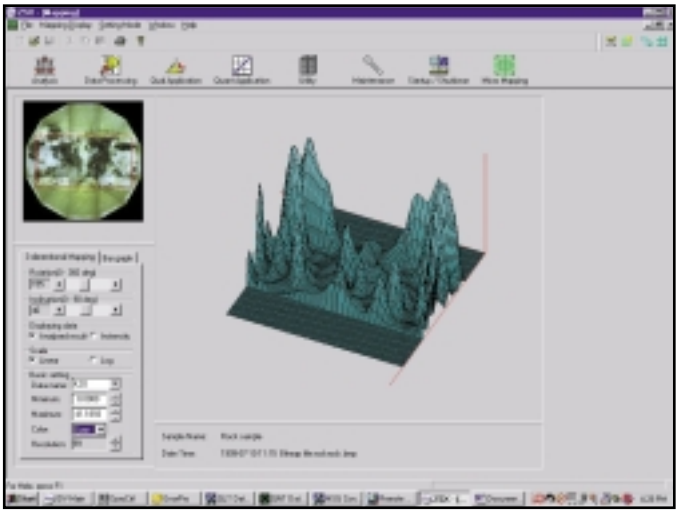

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