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Subduction zone backarcs, mobile belts, and orogenic heat

Inside:

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by L. Bruce Railsback

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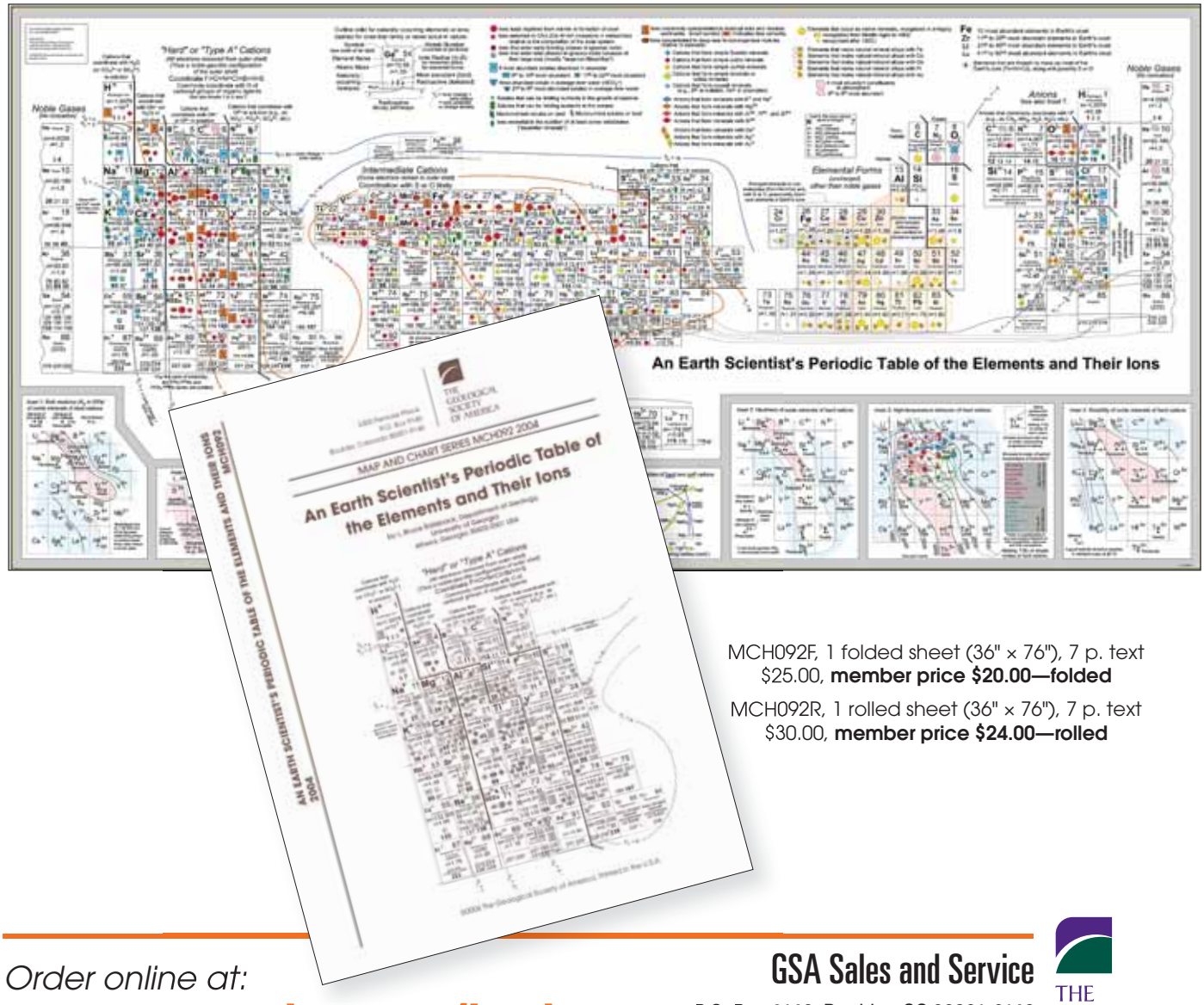

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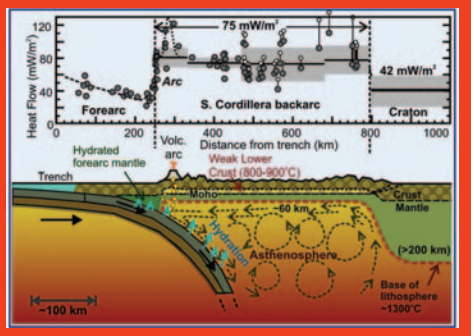

Cover: The North America Cordillera mobile belt illustrating the high elevation and complex tectonics characteristic of hot, thin backarc lithospheres. Backarcs remain weak enough to be deformed by plate margin forces for long geological periods. **Right:** Heat flow and thermal-tectonic cross section for N. Cascadia backarc illustrating uniform high heat flow and inferred shallow asthenosphere convection. See "Subduction zone backarcs, mobile belts, and orogenic heat," by R.D. Hyndman et al., p. 4–10.

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SCIENCE ARTICLE

Subduction zone backarcs, mobile belts, and orogenic heat

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ABSTRACT

Two important problems of continental tectonics may be resolved by recognizing that most subduction zone backarcs have hot, thin, and weak lithospheres over considerable widths. These are (1) the origin of long-lived active "mobile belts" contrasted to the stability of cratons and platforms, and (2) the origin of the heat of continental collision orogeny. At many continental margin plate boundaries, there are broad belts with a long history of distributed deformation. These regions are mobile because the lithosphere is sufficiently weak to be deformed by the forces developed at plate boundaries. We conclude that mobile belts are weak because they are hot, and they are hot as a consequence of their position in present or recent backarcs. Most continental backarcs have thin and hot lithospheres, not just those with active extension or rifting. Moho temperatures are 800–900 °C and lithosphere thicknesses are 50–60 km, compared to 400–500 °C and 150–300 km for cratons and other regions with a thermotectonic age greater than ca. 300 Ma. The temperature differences result in backarc lithospheres that are weaker than cratons by more than a factor of 10. Backarcs may be hot because shallow asthenosphere convection results from the reduction in viscosity due to water rising from the underlying subducting plate. Hot, weak, former backarcs are expected to be the locus of most deformation during continent or terrane collision orogeny. The heat indicated by orogenic plutonism, high grade metamorphism, and ductile deformation may come from the preexisting hot backarc lithosphere, not from the orogenic deformation process itself.

INTRODUCTION

The model of plate tectonics with narrow plate boundaries provides an excellent first-order description of global tectonics. Plate tectonics also provides an elegant explanation for orogenic crustal shortening and thickening in terms of continental or terrane collision. However, a number of large-scale tectonic problems are not explained by the simple rigid plate and continental collision models. In this article, we present explanations for two such tectonic problems: the origin of long-lived active "mobile belts" that lie along a number of continental margin plate boundaries, contrasted to the stability of cratons and platforms, and the origin of the heat of continental collision orogeny. Current mobile belts are up to 1000 km wide and cover nearly a quarter of the continents (e.g., Stein and Freymueller, 2002; Thatcher, 2003). For example, the North American Cordillera has been tectonically active for >180 m.y., with evidence for older tectonic events extending this history to >350 m.y. (e.g., Burchfiel et al., 1992) (Fig. 1). Rates of deformation in current mobile belts are commonly 5–15 mm/yr; i.e., 10%–20% of the main plate boundary rates as indicated by distributed seismicity, precision global positioning system (GPS) measurements, and geological studies.

The long geological histories of deformation suggest that these mobile belts exhibit long-term lithosphere weakness compared to cratons. In contrast, the Precambrian cratons and stable platforms have exhibited little internal deformation over long geological periods. They have some characteristic that allows them to maintain an especially thick, strong lithosphere, such as a more refractory mantle composition (Jordan, 1978; Forte and Perry, 2000). The reason for the long histories of tectonic activity in the mobile belts has not been clear. Also, most continental mobile belts have high elevation; they are mountain belts. Surprisingly, however, there is commonly no crustal thickening. In this article, we emphasize the important distinction between long-lived mobile mountain belts where the elevation is mainly thermally supported and short-lived continent or terrane collision orogenies where there is major crustal shortening and thickening.

Plate tectonics provides an elegant explanation for orogenic crustal shortening and thickening in terms of continental or terrane collision when an ocean closes. However, an important question remains unresolved that we attempt to address: What is the origin of the heat of orogeny? Significant heat from frictional deformation processes has been discounted through studies by a number of authors, and most other orogenic processes should absorb rather than generate heat.

Figure 1. The North America Cordillera mobile belt. The high elevation and complex current tectonics illustrate the hot, weak, backarc lithosphere deformed by variable margin forces.

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In this study, we examine the hypotheses that (1) most mobile belts are located in backarcs or recent backarcs that are characterized by hot, thin, and weak lithospheres; and (2) most continent or terrane collision orogenic belts involve shortening of former hot backarc mobile belts. We do not discuss less common weakening mechanisms that subsequently may be reactivated in collision, such as localized extension and hotspots.

BACKARC THERMAL STRUCTURE

Why are mobile belt regions so weak and why are cratons so strong for long geological periods? The primary reason appears to be that the mobile belts are hot, whereas cratons are cold (e.g., Vitorello and Pollack, 1980; Chapman and Furlong, 1992), and, below the upper crust brittle zone, there is a strong decrease in strength with increasing temperature. The systematic decrease in heat flow with age, or time since the last "thermotectonic event," has been well recognized. The greatest difference is between the currently active mobile belts (70–90 mW/m^2) compared to the cratons (~40 mW/m^2) (e.g., Chapman and Furlong, 1992; Vitorello and Pollack, 1980). Temperatures at the base of the crust are ~400 °C lower for cold cratons compared to young, hot mobile belts (i.e., 400–500 °C vs. 800–900 °C, respectively). Although only the coolest case of cratons is discussed here, Paleozoic stable areas are only slightly warmer than Archean cratons and are estimated to be almost as strong. As an example, Figure 2 shows temperature estimates for the Canadian Cordillera mobile belt compared to the adjacent Canadian Shield (Hyndman and Lewis, 1999; Lewis et al., 2003). With these thermal estimates, the base of the mobile belt lithosphere (hot enough for vigorous convection, close to the solidus) is at a depth of only 50–60 km. The mobile belt high temperatures and thin lithospheres also are inferred from many other deep temperature indicators, including temperature-dependent uppermost mantle seismic properties (Moho refraction velocity, Pn, tomography compression and shear wave velocities, V_p and V_s, and attenuation, Q), effective elastic thickness, Te, thermally supported high elevations, seismic estimates of lithosphere thickness, and upper mantle xenoliths. The high temperatures of current mobile belts are also indicated by widespread sporadic Cenozoic basaltic volcanism, in contrast to the almost complete absence of recent volcanism in cratons and stable platforms. The same indicators of temperature show the lithospheres of cratons to be cold and >200 km thick.

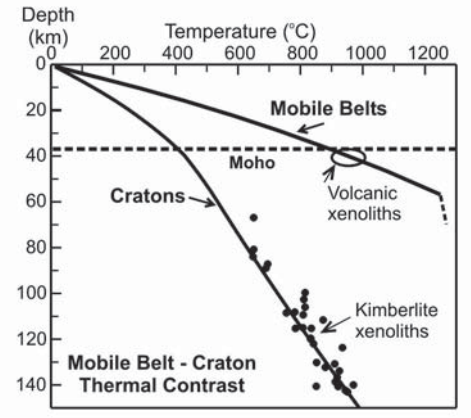

Figure 2. Temperature vs. depth for the Cascadia backarc and adjacent craton (from Hyndman and Lewis, 1999).

We have carried out a global survey of continental backarcs, and, in all cases where there is sufficient data, we have found surprisingly high and uniform temperatures across wide zones, indicated by heat flow and other deep temperature constraints (also see Currie, 2004). It is well recognized that extensional backarcs are hot (e.g., Wiens and Smith, 2003), including the Basin and Range and extensional west Pacific backarc basins. In these regions, rifting and spreading are obvious sources of heat. We therefore focus on nine backarcs where we conclude that there is no current or recent thermally significant extension in the region, as indicated by GPS, seismicity, or geological studies (Fig. 3). Our areas are all more than 100 km from such extension; Morgan (1983) showed that the thermal effects of rifts extend only a short distance. The thermal effect of extension decays with a time constant of ~50 m.y., so we have also excluded areas with significant mid-late Cenozoic extension.

We summarize the two principal indicators of high temperatures in Figure 4 (for details and references, see the GSA Data Repository[1]): (1) surface heat flow greater than ~70 mW/m^2 (for normal upper crust heat generation of 1.0–1.5 μW/m^3) (e.g., Lewis et al., 2003; Chapman and Furlong, 1992); and (2) low seismic velocities in the upper mantle (i.e., Pn velocities <7.9 km/s compared to ~8.2 km/s for cratons) (e.g., Black and Braile, 1982; Lewis et al., 2003) or seismic tomography velocities lower than the global average by at least 2% for P-waves or 4% for S-waves (~4% and ~7% slower relative to cratons) (e.g., Goes et al., 2000; Goes and van

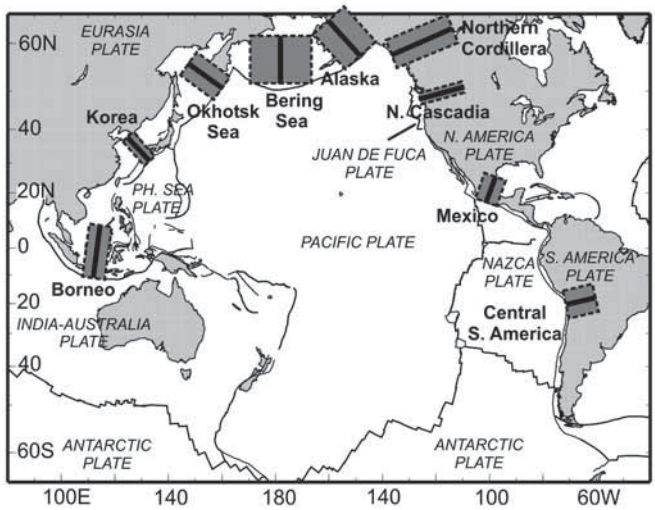

Figure 3. Examples of nonextensional backarcs with high heat flow and other high temperature indicators.

[1]GSA Data Repository item 2005030, Table DR1, notes, and references for Figure 4, is available on request from Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA, editing@geosociety.org, or at www.geosociety.org/pubs/ft2005.htm.

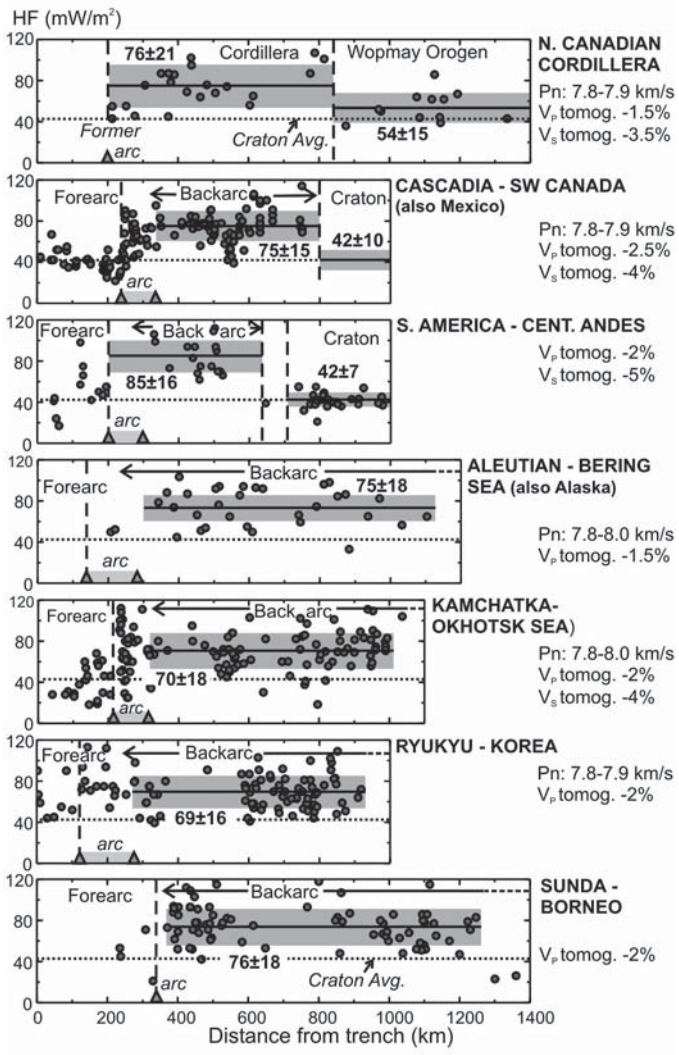

Figure 4. Heat flow (HF) data and other indicators of high temperatures across backarcs. References are given in the GSA Data Repository (see footnote 1). Pn—refraction uppermost mantle velocity; V_p—tomography compressional velocity; V_s—shear velocity.

der Lee, 2002). Temperature appears to be the dominant control of mantle velocity; the effects of composition, partial melt, anisotropy, etc., usually are much smaller (e.g., Goes et al., 2000; Wiens and Smith, 2003).

We include one oceanic backarc (Bering Sea) and one former continental backarc (the northern Canadian Cordillera that was cut off by transform faulting in the Eocene) that give very similar thermal results to the current continental backarcs. The heat flow averages range from 70 to 85 mW/m^2; Pn velocities are low, 7.8–7.9 km/s, and seismic tomography velocities are low, consistent with high lithosphere temperatures (i.e., ~800 °C at the Moho). There are also only small variations in heat flow and in the other indicators of deep temperatures across the backarcs. All of the other backarcs we have examined show evidence that they are hot, although they provide less information. It is well recognized that an active volcanic arc requires high temperatures (~1200 °C) in the underlying mantle wedge at a depth of ~100 km; however, we find that the high lithosphere temperatures extend across the whole backarc, even where there is no extension.

ELEVATION OF MOBILE BELTS

An important attribute of most continental mobile belts that indicates they are hot is high elevation. They are mountain belts. This elevation is usually in spite of relatively thin crust. For example, very little of the North America Cordillera has a crustal thickness greater than ~35 km (Mooney et al. 1998; Perry et al., 2002), but elevations are commonly ~1500 m. In contrast, cratons have elevations usually near sea level and average crustal thicknesses of ~40 km. Only in a few mountain belt regions of unusually high elevation and tectonic crustal thickening, such as Tibet, the central part of the Andes, and part of the Alps, is there thick crust. We argue that high elevations therefore provide a simple first order mapping association for hot, thin lithosphere.

Mobile belts are inferred to be in isostatic balance, in spite of the combination of high elevation and thin crust, because there is thermal expansion and density reduction to a depth of several hundred km relative to stable cratonic and platform areas. The effect of crust and upper mantle temperature on elevation has been discussed in detail by Lachenbruch and Morgan (1990). In a simple approximation, the density change due to a 200 °C average temperature difference to a depth of 150 km and a coefficient of thermal expansion of 3.5×10^{-5} per °C will approximately balance an elevation difference of 1 km or a crustal thickness difference of ~7 km (e.g., Lachenbruch and Morgan, 1990; Hyndman and Lewis, 1999).

CONVECTION MODEL FOR BACKARCS AND THE ROLE OF WATER

An explanation for why most mobile belts are hot is that they are all in backarcs or recent backarcs, and all backarcs are hot, as discussed above. The high temperatures are likely due to rapid upward convective heat transfer beneath thin lithospheres (e.g., Hasebe et al., 1970). We show a schematic convection model in Figure 5, along with the heat flow across the southern Canadian Cordillera from the trench to the craton. Most models of backarc convection have assumed that the circulation is driven by the traction and thermal effects of the downgoing oceanic plate. However, it has proved difficult

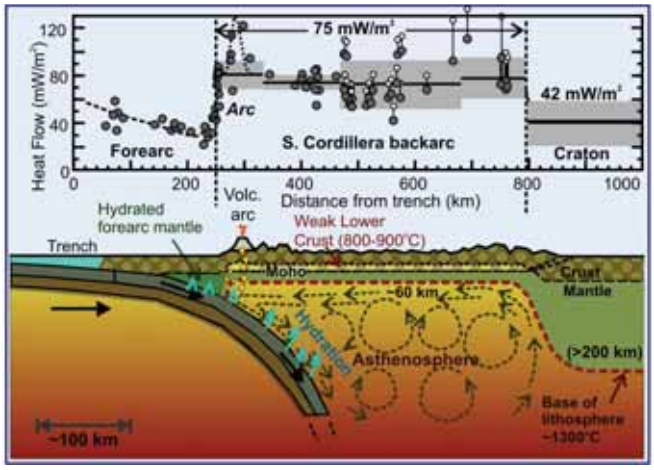

Figure 5. Heat flow across the N. Cascadia backarc and thermal-tectonic model. Solid points are corrected, open points uncorrected, for crustal heat generation, following Hyndman and Lewis (1999).

to produce uniform high heat flow across the backarc with such models, and regional small-scale convection seems to be required (Currie et al., 2004; see also Nyblade and Pollack, 1993). To maintain the high backarc heat flow, convection must be vigorous, with flow rates faster than relative plate rates (e.g., Currie et al., 2004).

In a few continental areas such as the Basin and Range, present or recent crustal extension has an additional thermal effect (e.g., Lachenbruch and Sass, 1977). Similarly, in the areas of oceanic backarcs where extension is occurring, it is difficult to separate the thermal effect of extension from that of convective heat transport in the underlying shallow asthenosphere. However, Watanabe et al. (1977) suggested that even in these basins, small-scale convection is needed to explain the thin lithospheres and the high heat flow asymptote for long times after the basins opened.

An explanation for shallow vigorous convection beneath backarc lithospheres is that, in addition to high temperatures, the mantle viscosity is lowered by incorporation of water expelled from the underlying subducting oceanic plate (e.g., Dixon et al., 2004; Honda and Saito, 2003). The amount of water supplied is estimated to be very large (e.g., Peacock, 1993). The backarc convection system is poorly understood, but vigorous convection may mix the water throughout the whole wedge. Mantle rocks containing small amounts of water in the mineral structure (>50 ppm) have a substantially lower effective viscosity than dry mantle rocks (e.g., Karato and Wu, 1993). Dixon et al. (2004) summarized the evidence for very low mantle viscosity beneath the Cordillera (former backarc) of the western United States and concluded that such low viscosities require significant water in the upper mantle, as well as high temperatures that are close to the solidus. They also argue that the observed very low shear-wave velocities in the upper mantle from seismic tomography require water as well as high temperatures.

In areas where the landward boundary of the backarc is a craton or old platform, the asthenosphere convection may be limited by thick, refractory craton lithosphere. However, the original craton rifting and associated asthenosphere upwelling may have extended and heated a considerable width of the margin of the craton or platform. This would have allowed subsequent backarc thermal convection to continue beneath the thinned region to the edge of the unextended craton lithosphere. The backarc also may be widened by the addition of accreted terranes, such as in western North America.

LITHOSPHERE STRENGTH OF BACKARC MOBILE BELTS

Lithosphere strength is expected to be the primary control on the nature of deformation processes. Lithosphere strength increases with depth in the shallow frictional regime, but at greater depths where there is ductile deformation, temperature and composition (especially crust vs. mantle) are the most important controls (e.g., Ranalli, 1995), so strength decreases with depth. A representative example of the strength of the lithosphere as a function of depth in a high temperature mobile belt and low temperature craton is shown in Figure 6 (top) for the Canadian Cordillera and adjacent Canadian Shield (see Flück et al., 2003; Lewis et al., 2003). In this simple model, the upper crust follows the Byerlee's Law criteria for brittle failure (e.g., Ranalli, 1995) with hydrostatic pore pressure (e.g., Townend and Zoback, 2000), and deformation at greater depths follows power law creep (Karato and Wu, 1993) at a common plate boundary deformation rate of ~$10^{-15}s^{-1}$. The upper crust has the rheology of granite, the lower crust of diabase, and the mantle of olivine (e.g., Ranalli, 1995). The much thinner and weaker lithosphere predicted for backarcs compared to cratons is clear.

The total strength of the lithosphere may be estimated by integrating the strength over depth (Fig. 6, bottom). Wet and dry refer to the laboratory rheologies that may apply to backarc mobile belts and cratons, respectively. The combined crustal and mantle lithosphere strength for backarc mobile belts is at least a factor of 10 less than for cold cratons. The mobile belt lithosphere strengths of $<5 \times 10^{12}$ N/m are within the range suggested for plate tectonic forces and the gravitational potential of mountain belts of $1–10 \times 10^{12}$ N/m (Lynch and Morgan, 1987; Whittakaer et al., 1992; Zoback et al., 2002). In contrast, craton lithospheres are too strong to be readily deformed. Alternatively, if one fixes the plate boundary forces at the estimated values, the calculated strain rates for backarc mobile belts are in the range observed for plate boundaries and are very small for stable cratons and platforms (Zoback et al., 2002). This large difference in lithosphere strength between hot backarcs and cold cratons

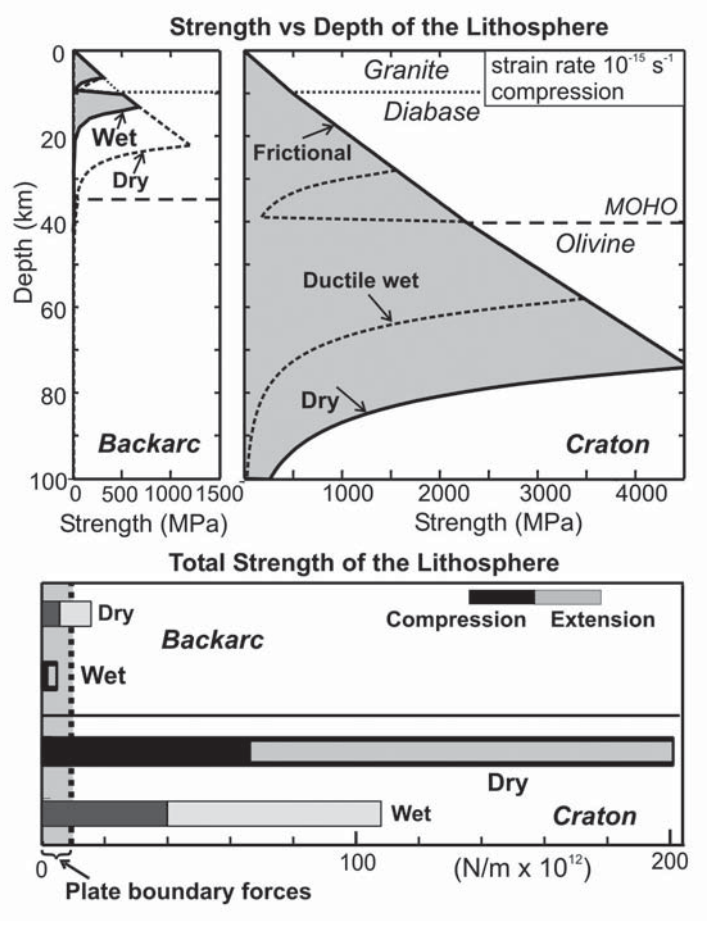

Figure 6. Top: strength vs. depth. Bottom: total lithosphere strength for hot backarc mobile belts and cold cratons.

should play a major role in subsequent orogenic deformation. Also, most backarc mobile belts are hot enough for the lower crust to be very weak and to allow lower crust detachment (Fig. 6, top).

DURATION OF HIGH TEMPERATURES IN MOBILE BELTS

There must be a finite life to the high temperatures in backarc mobile belts after the source of heat is removed, since most past mobile belts active in the Paleozoic or earlier no longer exhibit the characteristic high lithosphere temperatures. In the backarc convection model, the vigorous free convection should decline rapidly following the termination of subduction and the loss of water as a flux for convection. Although the processes involved are undoubtedly complex, lithosphere cooling and thickening are probably conductive following the increase in upper mantle viscosity due to water loss through partitioning into arc and backarc melt fractions and through upward diffusion.

The cooling time constant may be estimated from compilations of heat flow (and inferred lithosphere temperatures) versus age of the last thermotectonic event (e.g., Chapman and Furlong, 1992; Pollack et al., 1993; Chapman and Pollack, 1975; Pavlenkova, 1996; Artemieva and Mooney, 2001) (Fig. 7). The thermotectonic age is assumed to correspond approximately to the time since termination of subduction and therefore of water input. Most of the rapid decrease in heat flow appears to be in the several hundred m.y. following the last thermotectonic event. A similar cooling and lithosphere thickening time is suggested by several examples. The Appalachian mobile belt, with its last significant deformation ca. 300 Ma, is now cool and stable. Although heat flow and other thermal data suggest that it is still somewhat warmer than the cratons (e.g., Pollack et al., 1993), the difference may be primarily due to greater upper crust heat generation (Mareschal and Jaupart, 2004). In contrast, the northern Canadian Cordillera, where margin subduction was cut off by the Queen Charlotte transform fault in the Eocene, has high heat flow and inferred deep temperatures (Lewis et al., 2003), similar to currently active backarcs (Fig. 4).

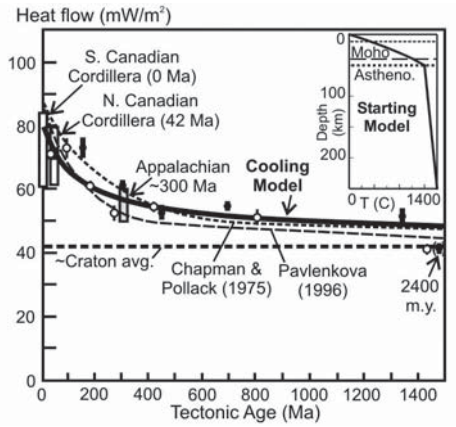

Figure 7. Heat flow vs. thermotectonic age. The zero time is interpreted to mark the termination of backarc convection (data references in text).

To illustrate the cooling, we have used a simple conductive model with an initial ~50-km-thick backarc lithosphere and an underlying adiabatic asthenosphere (Currie, 2004) (Fig. 7). This model is the limiting case of abrupt termination of convection to a depth of 250 km (approximate thickness of craton lithosphere) at the time of termination of subduction. Variations with depth of thermal properties and heat generation are included (e.g., Lewis et al., 2003). The addition of the effect of erosion of the high-radioactivity upper crust would give a somewhat lower heat flow at long times (Fig. 7). We also recognize that the thermotectonic age used in the heat flow data plot (peak regional metamorphism, major orogenic plutonism, etc.) is not precisely the same as the age of termination of subduction. However, the heat flow as a function of age predicted by the model is in good agreement with that observed (Fig. 7), which suggests that the termination of free convection occurs less than a few tens of millions of years after subduction stops.

CONTINENTAL COLLISION AND OROGENIC HEAT

Recognizing that most continental or terrane collisions inherit preexisting hot, weak backarcs may provide a resolution to the long-standing problem of the origin of the heat of orogeny (e.g., Loosveld and Etheridge, 1990; Jamieson et al., 1998; Thompson et al., 2001; Vanderhaeghe and Teyssier, 2001; Collins, 2002). High temperatures are a defining feature of orogenic belts, as inferred from widespread granitic plutonism, high temperature regional metamorphism, and ductile deformation at mid-crustal depths. Often, the heat and high temperatures are simply ascribed to "orogenic heating" without reference to the mechanism. In fact, most orogenic processes should absorb heat.

We discuss only continent or terrane collision orogeny where the backarc is continental. Some backarcs are primarily oceanic and may be largely consumed by subduction during closure. Two main sources of heat have been previously proposed. The first ascribes high temperatures to backarc extension prior to collision. This explanation has the problem that the extension must occur less than 50 m.y. before the collision orogeny for the heat not to have decayed. Also, Thompson et al. (2001) argue that there must be thinning of the mantle lithosphere with little thinning of the crust to explain the inferred crustal thicknesses following collision. The second proposed heat source is high radioactive heat generation rocks emplaced in the lower crust during the shortening.

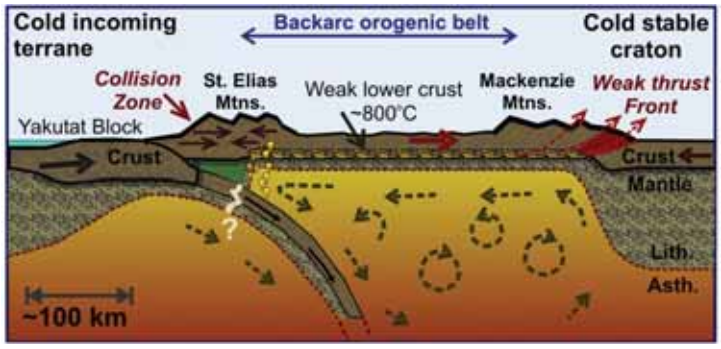

Figure 8. Model for initial collision of a weak backarc mobile belt–the northern Canadian Cordillera example.

This explanation has the problem that it results in maximum temperatures 50–100 m.y. after collision, whereas peak metamorphic assemblages are commonly argued to be synchronous with thickening (e.g., Thompson et al., 2001; Collins, 2002). This delayed heating also does not explain how shortening and thickening can be initiated in cold, strong lithosphere prior to the heating. We suggest that hot and thin former backarc lithosphere is commonly the primary locus of shortening (i.e., the vise or inherited weakness model; Ellis et al., 1998; Thompson et al., 2001; Collins, 2002). The orogenic heat comes from the preexisting hot backarc, not from the orogenic process itself.

The high temperature backarc thermal regime and inferred lithosphere strength model also provide insight into the initial development of backarc shortening in continental collision. Initial shortening and crustal thickening appear to be concentrated at the leading and trailing edges of the mobile belt. In the example of the collision of the Yakutat terrane in the Gulf of Alaska ca. 5 Ma, there has been strong shortening in the coastal collision zone and again in the Mackenzie Mountains of the eastern Cordillera. There has been little shortening in the intervening central Cordillera, and the crust remains thin (32–35 km thick) (e.g., Mazzotti and Hyndman, 2002) (Fig. 8). The backarc lower crust detachment must be sufficiently weak to transfer the collision stress to the weak foreland fold and thrust belt, even though the Cordilleran lithosphere is very thin. In contractional orogens, it has been argued that a through-going basal detachment in the lower crust separates the entire crustal section from the underlying lithosphere (Oldow et al., 1990). If this is correct for backarc mobile belts, thrust faults, transcurrent faults, and extension normal faulting are restricted to the overlying detached crustal section. Lower crust detachments seem necessary to explain the common characteristics of foreland fold and thrust belts where the upper mobile belt crust is thrust over the stable craton or platform (e.g., the northern Canadian Cordillera; Mazzotti and Hyndman, 2002) and the Andes of central South America (Hindle et al., 2002). With further shortening, the high temperatures allow the crust of the whole backarc to be thickened to >50 km, such as for the Altiplano of the South America Cordillera, for Tibet, and perhaps for the Laramide orogeny of western North America. This thickening may be associated with lower crust ductile thickening and extrusion (e.g., Bird, 1991; Meissner and Mooney, 1998).

CONCLUSIONS

The main conclusions of this work are (1) Continental mobile mountain belts exhibit long-term weakness compared to cratons and stable platforms. Mobile belts deform readily because they are hot and weak enough to be deformed by forces of the magnitude transmitted from plate boundaries. (2) Most mobile belts are hot and weak because they are, or recently were, located in backarcs. They may be hot because of shallow asthenosphere convection, facilitated by water from the underlying subducting slab. (3) Continental collision orogenic shortening is expected to be concentrated in former backarc mobile belts that are much weaker than the adjacent stable areas. The preexisting or inherited high temperatures provide an explanation for widespread orogenic plutonism, high temperature regional metamorphism, and ductile crustal deformation. Backarc and subsequent orogenic belt temperatures may be high enough for lower crust detachment that decouples complex surface tectonics from the uppermost mantle and for lower crustal flow.

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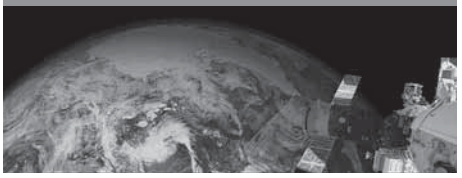

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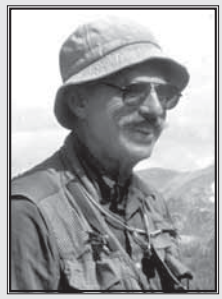

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ENVIRONMENT

Minnesota is called "the land of 10,000 lakes," a distinction that is rooted in the geologic history of the state. Not only does Minnesota boast an unusually long and diverse geologic record, but its natural resources are incorporated into many aspects of the culture that has developed here.

The modern cities of Minneapolis and St. Paul began on the banks of the Mississippi River in the middle of the nineteenth century. Many signs of days past still exist in Minneapolis, especially in the Riverfront District, where one can still visit century-old mills. With nearly two dozen lakes, the Mississippi River, parks, golf courses, and miles of trails, Minneapolis is truly an outdoor enthusiast's dream. Please be aware that cool temperatures are possible in May.

The Twin Cities are easily accessible by air. The Minneapolis–St. Paul International airport is a hub for Northwest Airlines and has non-stop flights from all major points of departure.

CALL FOR PAPERS

Abstract Deadline: February 22, 2005

Papers are invited for a variety of technical sessions (oral and poster). Authors interested in volunteering papers for symposia should contact the appropriate convener prior to submitting an abstract. Oral presentations in most technical sessions will be 15 minutes long, with 5 minutes for questions. Some sessions may be organized with a longer format (contact session chairs for details). All oral sessions will utilize a single digital projector and PowerPoint software. Use of overhead projectors and 35 mm slides is discouraged and will only be accommodated by special arrangement with the session chair. Poster space will be 4' × 8', and authors must be present at their poster for at least two hours.

REGISTRATION

Standard registration deadline: April 18, 2005
Cancellation deadline: April 25, 2005

Registration Fees

	Standard	On-site
Professional Member	$135	$155
Professional Nonmember	$170	$190
Student Member	$35	$50
Student Nonmember	$50	$60
K–12 Professional	$30	$30
Guest	$30	$30

GSA Headquarters will handle meeting registration. Please register online at www.geosociety.org. On-site registration will be available during the meeting at the Radisson Hotel Metrodome on the University of Minnesota campus. Register in advance to qualify for lower fees.

On-Site Registration Schedule

Wednesday, May 18	4:30–8 p.m.
Thursday, May 19	7:30 a.m.–4:30 p.m.
Friday, May 20	7:30 a.m.–noon

ACCESSIBILITY

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

FIELD TRIPS

All field trips will depart from and return to the lobby of the Radisson Hotel. The field trip coordinator is Jim Miller, Minnesota Geological Survey, mille06t@umn.edu, but for detailed information, please contact individual field trip leaders. Fees include transportation, accommodations, lunch, and field trip guidebook. Details can be found at www.geosociety.org/sectdiv/Northc/05ncmtg.htm.

PREMEETING

1. **The Geology of the Mississippi River Valley—Twin Cities Region: Using an Urban River for Inquiry-Based Earth Science Education.** Sat., May 14. Kent Kirkby, University of Minnesota, kirkby@tc.umn.edu; Karen Campbell, National Center for Earth Surface Dynamics. Explore some of the Twin Cities' urban outcrops to learn about the retreat of St. Anthony Falls, discover the origin of the Mississippi River system's only gorge, and investigate the complex interactions between the river valley's geologic processes and human communities. This field trip will showcase ways to use your own community's rivers as resources for inquiry-based science instruction. Cost: $75.
2. **Classic Precambrian Geology of Northern Minnesota.** Tues., May 17–Wed., May 18. Mark Jirsa, Minnesota Geological Survey, jirsa001@umn.edu; Jim Miller, Minnesota Geological Survey. This "best of" field trip will visit some of the famous outcrops that exemplify the Precambrian geology of Minnesota and that

should be on everyone's list of "must-see" outcrops when running a field trip to the area. Classic exposures of the Keweenawan Duluth Complex and North Shore Volcanic Group, the Paleoproterozoic Thomson and Virginia Formations and Biwabik Iron Formation, and the Archean Wawa and Quetico subprovinces will be visited on this trip. Cost: $175.

3. **Deposits and Landforms in the Region Glaciated by the St. Louis Sublobe.** Tues., May 17–Wed., May 18. Al Knaeble, Minnesota Geological Survey, knaeb001@umn.edu; Gary Meyer, Minnesota Geological Survey; Howard Mooers, University of Minnesota–Duluth; Phil Larson, University of Minnesota–Duluth; Lisa Marlow, University of Minnesota–Duluth. Geomorphic features, material properties, and the glacial history related to the St. Louis sublobe, the Rainy lobe, the Superior lobe (Mille Lacs moraine phase), glacial Lake Brainerd, and glacial Lake Aitkin II in the western St. Louis sublobe region will be investigated the first day. Stratigraphic and geomorphic relationships that constrain the timing of the advance of the St. Louis sublobe in its eastern extent relative to the retreating Rainy and Superior lobes, the history of glacial Lakes Aitkin and Upham I and II, and a newly defined lake that formed in the wake of the wasting St. Louis sublobe, Lake Sucre, will be examined the second day. Cost: $175.
4. **Granites of the East-Central Minnesota Batholith.** Wed., May 18. Terry Boerboom, Minnesota Geological Survey, boerb001@umn.edu; Daniel Holm, Kent State University; Randy Van Schmus, University of Kansas. This trip will examine several different post-Penokean Paleoproterozoic granitic intrusions of the east-central Minnesota batholith, post-batholith dikes, and weathering processes. We will discuss recently acquired geochronological data from these intrusions in relation to the waning stages of the Paleoproterozoic Penokean Orogen. The trip will include several stops at active and inactive quarries. Cost: $65.
5. **Sinkhole Anatomy 101—Karst Geology of Southern Minnesota.** Wed., May 18. Bob Tipping, Minnesota Geological Survey, tippi001@umn.edu; Calvin Alexander, University of Minnesota; Tony Runkel, Minnesota Geological Survey; Howard Hobbs, Minnesota Geological Survey. Join us on the backhoe excavation of a karst sinkhole on the Cave Farm near Spring Valley, Minnesota. Our host is the owner of the Spring Valley Caverns Karst preserve, John Ackerman. This field trip will feature the excavation of a sinkhole. Our goal will be to prepare cross sections of the sinkhole, to document and characterize whatever materials we find, and to prepare a short report on our findings. This trip will be limited to 20 participants. Applicants will be selected based on their ability and willingness to contribute skills, sample characterization, and mapping techniques to the overall excavation. We will also tour part of Spring Valley Caverns and other surface karst features on the Cave Farm. Cost: $65.
6. **Late Ordovician Stratigraphy and Paleontology of the Twin Cities Basin.** Wed., May 18. Robert Sloan, University of Minnesota, ssloan@winona.edu; Mike Middleton, University of Wisconsin–River Falls; Gerry Webers, Macalester College. This field trip will include fossil collecting and examination of the St. Peter Sandstone and stratigraphy of the Shadow Falls section of the Glenwood Formation, Platteville Formation, and the richly fossiliferous Lilydale Park (former Twin City Brick Company yard) section of the Decorah Shale (at 92 feet thick, it's the thickest known section, only 42 miles from the Transcontinental Arch). Cost: $65.

Postmeeting

7. **Late Ordovician Lithology and Biostratigraphy of the Southern Margin of the Twin Cities Basin.** Sat., May 21. Robert Sloan, University of Minnesota, ssloan@winona.edu; Mike Middleton, University of Wisconsin–River Falls; Gerry Webers, Macalester College. This field trip will include fossil collecting and examination of facies changes in the St. Peter Sandstone through Prosser Limestone of the southern margin of the Twin Cities basin. We will visit the thickest Minnesota section of the Glenwood Formation, the thinnest Minnesota section of the Platteville Formation, a section of the Decorah Shale at Zumbrota, and a catastrophic burial layer in the Prosser Limestone. Cost: $65.
8. **Pre-Cretaceous Weathering Profile and Cretaceous Geology of the Minnesota River Valley Area.** Sat., May 21. Larry Zanko, Natural Resources Research Institute, zanko@nrri.umn.edu; Dale Setterholm, Minnesota Geological Survey; John Heine, Natural Resources Research Institute. Exposures associated with the Minnesota River Valley and mining in that area provide opportunities to view products of the intense Pre-Cretaceous chemical weathering episode and the Late Cretaceous sediments that immediately overlie them. The weathered materials vary in character with the degree of weathering and the composition of the parent rock. The Cretaceous strata represent interdistributary, distributary, and lacustrine brackish and freshwater environments of a fluvially dominated delta plain and contain many rock and fossil types in a small area. The weathering products and the sedimentary rocks are mined for use in brick-making and cement. Cost: $75.
9. **Architecture of an Archean Greenstone Belt: Stratigraphy, Structure, and Mineralization.** Sat., May 21–Sun., May 22. Dean Peterson, Natural Resources Research Institute, dpeters1@nrri.umn.edu; Mark Jirsa, Minnesota Geological Survey; George Hudak, University of Wisconsin–Oshkosh. Archean greenstone belts are one of the world's premier geologic settings for hosting a variety of economically important mineral deposit types. These deposits include high-grade iron ore, lode-gold, volcanogenic massive sulfide, and komatiite-associated nickel, magnesite, and a number of others. The origin of these deposits is intrinsically linked to the architecture of the greenstone belt, namely the interrelationships between stratigraphy, structural setting, and hydrothermal fluids. The Vermilion district of northeastern Minnesota is a well exposed greenstone belt that displays a number of classic features of this geologic setting. Cost: $180.

10. **The Western Margin of the Keweenawan Midcontinent Rift System: Geologic Highlights of Archean, Paleoproterozoic, Keweenawan, and Paleozoic Bedrock in Eastern Minnesota and Northwestern Wisconsin.** Sat., May 21–Sun., May 22. Terry Boerboom, Minnesota Geological Survey, boerb001@umn.edu; Daniel Holm, Kent State University; Karl Wirth, Macalester College; Karen Halvholm, University of Wisconsin–Eau Claire; Bill Cannon, U.S. Geological Survey; Laurel Woodruff, U.S. Geological Survey. This trip will start in Archean rocks and end in Paleozoic rocks. Stops in between will examine Paleoproterozoic, Keweenawan, and Paleozoic unconformities, stratigraphy, and the structural-metamorphic history of Paleoproterozoic sedimentary and volcanic rocks, and structural and volcanic features, intrusive relationships, and alteration-mineralization of Keweenawan volcanic, intrusive, and sedimentary rocks. Cost: $185.
11. **Geology and Sedimentology of the Paleoproterozoic Animikie Group: Pokegama Formation, Biwabik Iron Formation, and Virginia Formation, Eastern Mesabi Range, and the Thomson Formation near Duluth.** Sat., May 21–Sun., May 22. Richard Ojakangas, University of Minnesota–Duluth, rojakang@d.umn.edu; Mark Severson, Natural Resources Research Institute; G.B. Morey, Minnesota Geological Survey; Peter Jongewaard, United Taconite; John Arola, Ispat Inland Mining; Joel Evers, Cliffs Mining; Doug Halvorson, Northshore Mining; T.B. Holst, University of Minnesota–Duluth. This trip will allow participants to study the formations of the Animikie Group on the Mesabi Iron Range: the basal siliciclastic Pokegama Formation, the overlying (1878 Ma) Biwabik Iron Formation, and the upper unit, the Virginia Formation. Evidence suggesting a tidally influenced environment of deposition for the Pokegama Formation and the Biwabik Iron Formation, including possible bimodal-bipolar cross bedding and stromatolites, will be observed. Significant members of both formations will be visited, generally in stratigraphic sequence. The lowest part of the turbiditic Virginia Formation, the equivalent Thomson Formation, and twice-folded older pre-Animikie rocks will be the final stops. Cost: $185.
12. **Pre-Wisconsinan and Wisconsinan Glacial Stratigraphy, History, and Landscape Evolution, Western Wisconsin.** Sat., May 21–Sun., May 22. Kent Syverson, University of Wisconsin–Eau Claire, syverskm@uwec.edu; Robert Baker, University of Wisconsin–River Falls; Steve Kostka, University of Wisconsin–Madison; Mark Johnson, University of Göteborg, Sweden. This trip will focus on pre-Wisconsinan and Wisconsinan glacial stratigraphic units in western Wisconsin and will introduce some new ideas about Quaternary stratigraphy, chronology, and landform development. This two-day trip will begin in the late Wisconsinan St. Croix moraine in western St. Croix County and will work down-section in subsequent stops in the eastern portion of the county as well as Dunn and Chippewa Counties. The trip will culminate with stops in the Chippewa moraine. Cost: $165.

ABSTRACTS

Abstract Deadline: February 22, 2005

Abstracts for all sessions should be submitted online at www.geosociety.org/sectdiv/Northc/05ncmtg.htm. An abstract submission fee of $10 will be charged. If you cannot submit your abstract electronically, contact Nancy Carlson, (303) 357-1061, ncarlson@geosociety.org.

TECHNICAL SESSIONS

Symposia

1. **Continental Tectonics of Shield Regions.** Daniel Holm, Kent State University, dholm@kent.edu; David Schneider, Ohio University, schneidd@ohio.edu.
2. **Deep Earth Science: Prospects for a Deep Underground National Laboratory.** John Goodge, University of Minnesota–Duluth, jgoodge@d.umn.edu; Dean Peterson, Natural Resources Research Institute, dpeters1@nrri.umn.edu.
3. **Groundwater Sustainability.** *Cosponsored by the Minnesota Ground Water Association.* Laurel Reeves, Minnesota Dept. of Natural Resources, laurel.reeves@dnr.state.mn.us; Harvey Thorleifson, Minnesota Geological Survey, thorleif@umn.edu; Martin Saar, University of Minnesota, saar@umn.edu.
4. **Lakes—Glacial Lakes, Large Lakes, Small Lakes, Groundwater Interaction.** *Cosponsored by GSA Limnogeology Division and GSA Sedimentary Geology Division.* Emi Ito, University of Minnesota, eito@umn.edu; Steven Colman, University of Minnesota, scolman@d.umn.edu.
5. **The Midcontinent Rift in the Lake Superior Region: A Modern Integration of a Century of Studies.** *Cosponsored by GSA Sedimentary Geology Division.* Jim Miller, Minnesota Geological Survey, mille066@umn.edu; Bill Cannon, U.S. Geological Survey, wcannon@usgs.gov; Mike Easton, Ontario Geological Survey, mike.easton@ndm.gov.on.ca.

Theme Sessions

1. **Arsenic in Drinking Water.** Randal Barnes, University of Minnesota, barne003@umn.edu; Mindy Erickson, University of Minnesota, eric0984@umn.edu.
2. **Developing Approaches to Terrestrial Paleoclimatology.** *Cosponsored by GSA Sedimentary Geology Division and the Great Lakes Section of the Society for Sedimentary Geology.* Greg Ludvigson, Iowa Geological Survey, gludvigson@igsb.uiowa.edu; Jeff Dorale, University of Iowa, jeffrey-dorale@uiowa.edu.
3. **Evolution of Crustal Melts.** Jim Stout, University of Minnesota, jstout@umn.edu; Jim Grant, University of Minnesota–Duluth, jgrant@d.umn.edu.
4. **Forensics in Environmental Geology.** Keith Rapp, Unisys Corporate Environmental Affairs, keith.rapp@unisys.com; Carolyn Boben, Xcel Energy, carolyn.l.boben@xcelenergy.com.
5. **Geologic Development of Midwestern Fluvial & Glaciofluvial Systems.** *Cosponsored by GSA Sedimentary Geology Division.* Curtis Hudak, Foth & Van Dyke and

Associates, Inc., CHudak@foth.com; Ed Hajic, Illinois State Museum, erhajic@mac.com.

6. **Geologic Development of the Mississippi River.** *Cosponsored by GSA Sedimentary Geology Division.* Howard Hobbs, Minnesota Geological Survey, hobbs001@umn.edu; Tammy Rittenour, Lund University, Tammy.Rittenour@geol.lu.se.
7. **Issues in Undergraduate Geoscience Education: Geology and Citizenship, Developing Quantitative Skills, Preparing Teachers to Teach Earth Science, Bringing Research on Learning to the Geosciences.** Mary Savina, Carleton College, msavina@carleton.edu; Cathy Manduca, Carleton College, cmanduca@carleton.edu.
8. **Innovations in Paleontological Methods: Geochemistry in Paleobiology: New Systems, New Substrates, New Techniques; Novel Insights into Terrestrial and Marine Depositional Systems through Taphonomy and Ichnology.** *Cosponsored by GSA Sedimentary Geology Division and the Great Lakes Section of the Society for Sedimentary Geology.* David Fox, University of Minnesota, dlfox@umn.edu; Tim Demko, University of Minnesota, tdemko@umn.edu; Ray Rogers, Macalester College, rogers@macalester.edu.
9. **Inquiry-Based, Hands-on, Classroom Exercises, Lab Demonstrations, and Field Investigations in Geoscience Education.** *Cosponsored by the Central Section of the National Association of Geoscience Teachers.* Kate Pound, St. Cloud State University, kspound@stcloudstate.edu; Megan Jones, North Hennepin Community College, Mjones@nhcc.edu; Lee Schmitt, Hamline University, lschmitt@hamline.edu. Special requirements: Each presenter must be able to show a classroom activity, demonstration, or investigation Friday afternoon in a "hands-on" area that will be tied to this session and to a workshop on hands-on activities and demonstrations for K–12 educators. Presenters should also submit a brief summary of their activity or demonstration for publication on the Web.

2005 GSA Section Meetings

NORTHEASTERN SECTION
March 14–16, 2005
Prime Hotel and Conference Center, Saratoga Springs, New York
Information: Kurt Hollocher, Union College, Department of Geology, Olin Building, Nott Street, Schenectady, NY 12308-3107, (518) 388-6518, hollochk@union.edu

SOUTHEASTERN SECTION
March 17–18, 2005
Grand Casino Biloxi, Biloxi, Mississippi
Information: Gail Russell, University of Southern Mississippi, Department of Geology, Box 5044, Hattiesburg, MS 39406-2000, (601) 266-4077, Gail.Russell@usm.edu

SOUTH-CENTRAL SECTION
April 1–2, 2005
Trinity University, San Antonio, Texas
Information: Diane Smith, Trinity University, Department of Geosciences, #45, One Trinity Place, San Antonio, TX 78212-4674, (210) 999-7656, dsmith@trinity.edu

CORDILLERAN SECTION
(*Joint meeting with American Association of Petroleum Geologists*)
April 29–May 1, 2005
Fairmont Hotel, San José, California
Information: Jonathan Miller, San José State University, Department of Geology, 1 Washington Square, San José, CA 95192-0102, (408) 924-5015, jsmiller@email.sjsu.edu

NORTH-CENTRAL SECTION
May 19–20, 2005
University of Minnesota, Minneapolis, Minnesota
Abstract Deadline: February 22, 2005
Information: Carrie Jennings Patterson, University of Minnesota, Minnesota Geological Survey, 2642 University Ave. W., St. Paul, MN 55114-1032, (612) 627-4780, ext. 220, carrie@umn.edu, or Barbara Lusardi, University of Minnesota, Minnesota Geological Survey, 2642 University Ave. W., St. Paul, MN 55114-1032, (612) 627-4780, ext. 212, lusar001@umn.edu

ROCKY MOUNTAIN SECTION
May 23–25, 2005
Mesa State College, Grand Junction, Colorado
Abstract Deadline: February 22, 2005
Information: Rex Cole, Mesa State College, Department of Physical & Environmental Science, 1100 North Ave., Grand Junction, CO 81501-3122, (970) 248-1599, rcole@mesastate.edu

www.geosociety.org/sectdiv/sections.htm

10. **Integrating Real and Virtual Field Trips in K–16 Geoscience Education.** *Cosponsored by the Central Section of the National Association of Geoscience Teachers.* Cinzia Cervato, Iowa State University, cinzia@iastate.edu; Rusty Low, University of Minnesota, rlow@cce.umn.edu.
11. **Landscape Development.** Lesley Perg, University of Minnesota, lperg@umn.edu; Kelly MacGregor, Macalester College, macgregor@macalester.edu.
12. **Mid-Continental Quaternary History in a Global Context.** Greg Balco, University of Washington, balcs@u.washington.edu; Carrie Jennings, Minnesota Geological Survey, carrie@umn.edu.
13. **New Geoscience Applications for Advanced Visualization Methods, 3-D, Web-Access, and Large Databases.** Paul Morin, University of Minnesota, lpaul@umn.edu; Emi Ito, University of Minnesota, eito@umn.edu; Harvey Thorleifson, Minnesota Geological Survey, thorleif@umn.edu.
14. **Precious Metals: PGE & Au in Precambrian Terranes of the Lake Superior Region.** Jim Miller, Minnesota Geological Survey, mille066@umn.edu; Dean Peterson, Natural Resources Research Institute, dpeters1@nrri.umn.edu.
15. **Soils as Keys to Quaternary Geology and Landscapes.** Randall Schaetzl, Michigan State University, soils@msu.edu; Joe Mason, University of Wisconsin, mason@geography.wisc.edu.
16. **Unconventional Natural Gas Resources Associated with Glacial Deposits—Shallow Bedrock Gas and Drift Gas.** George Shurr, GeoShurr Resources, geoshurr@frontiernet.net; Derric Iles, South Dakota Geological Survey, diles@usd.edu.
17. **Undergraduate Research in the Geosciences (Poster Session).** *Sponsored by the Council on Undergraduate Research.* Robert Shuster, University of Nebraska–Omaha, rshuster@mail.unomaha.edu; Karen Fryer, Ohio Wesleyan University, khfryer@owu.edu; David Matty, Central Michigan University, matty1dj@cmich.edu.

Workshops

1. **Magnetic Techniques in Environmental Reconstruction.** Wed., May 18, 1–5 p.m., Institute for Rock Magnetism, 291 Shepphard Labs, Univ. of Minnesota. Subir Banerjee, University of Minnesota, banerjee@umn.edu; Mike Jackson, University of Minnesota, jacks057@umn.edu. Max: 12. Cost: $20.
2. **Workshop for Teachers: Inquiry-based, Hands-on, Classroom Exercises, Lab Demonstrations, and Field Investigations in Geoscience Education.** *Cosponsored by the Central Section of the National Association of Geoscience Teachers.* Fri., May 20, 8 a.m.–5 p.m. Kate Pound, St. Cloud State University, kspound@stcloudstate.edu; Megan Jones, North Hennepin Community College, Mjones@nhcc.edu; Lee Schmitt, Hamline University, lschmitt@hamline.edu. Cost: $25.
3. **Description and Characterization of Lake Sediment Cores: A Hands-on Workshop.** Wed., May 18, 1–5 p.m. Amy Myrbo, University of Minnesota, amyrbo@umn.edu; Emi Ito, University of Minnesota, eito@umn.edu. LRC Core Facility, 672 Civil Engineering, University of Minnesota. Max.: 12. Cost: $20.
4. **Roy J. Shlemon Mentor Program in Applied Geoscience.** *Sponsored by GSA Foundation.* Thurs., May 19, and Fri., May 20, 11:30 a.m.–1 p.m.; location available at GSA's registration desk. Karlon Blythe, kblythe@geosociety.org. Lunch provided. This interactive and informative program for undergraduate and graduate students, led by professional geoscientists, will cover real life issues including professional opportunities and challenges that await students after graduation. Plan to attend both free luncheons to hear different presenters each day. Students will receive FREE LUNCH tickets in their registration packet to attend both Shlemon Programs. However, space is limited. First come, first served.
5. **The John Mann Mentors in Applied Hydrogeology Program.** *Sponsored by GSA Foundation.* Thurs., May 19, 5–6:30 p.m. Meeting location information available at GSA's registration desk. Karlon Blythe, kblythe@geosociety.org. Refreshments provided. This early evening event presents mentoring opportunities for undergraduate and graduate students and recent graduates with declared interest in applied hydrogeology as a career to interact and network with practicing hydrogeology professionals. This program is a focused, small-scale event that features FREE FOOD for participants. Participant eligibility is limited to those students who have declared their career interest to be hydrology or hydrogeology on their GSA membership applications and who have registered online for this section meeting. An e-mail invitation will then be sent to those qualified students. Keep in mind that only a quick response to the invitation will secure you a seat, as attendance at this Mann Mentors event is limited!

SPECIAL EVENTS

- **Welcome Reception.** Wed., May 18, 7–9 p.m., Hubert H. Humphrey Room.
- **North Central GSA Management Board Breakfast and Business Meeting.** Thurs., May 19, 7–9 a.m. Invitation only.
- **Central Section National Association for Geoscience Teachers (NAGT) Luncheon and Business Meeting.** Thurs., May 19, noon–1 p.m. Cost: $16.50.
- **National Association for Geoscience Teachers Bash and Business Meeting.** Entertainment and dinner fare provided. Thurs., May 19, 7–9 p.m. Reservation required. Cost: Professional, $15; Student, $5.
- **Opportunities in Earth Science for All Americans.** *Sponsored by the Association for Women Geoscientists.* Invited speaker Marilyn Suiter. Fri., May 20, noon–1 p.m. No cost, but reservations required.

GUEST ACTIVITIES

The Twin Cities offer a variety of activities including museums, theaters, shops, parks, gardens, and riverboat tours. The local planning committee has compiled a list of activities and attractions. For information on these and other activities, visit http://talc.geo.umn.edu/conference/.

STUDENT TRAVEL

The North-Central Section and the GSA Foundation have made travel grants available for students who are presenting oral or poster papers. Students must be currently enrolled and must be members of the relevant section to apply for support. For more information, contact R.F. Diffendal, Jr., executive secretary, North-Central Section, rdiffend@unlnotes.unl.edu.

STUDENT AWARDS

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

EXHIBITS

Booths and table space will be available in the Hubert H. Humphrey Room near the poster sessions. Contact Peter McSwiggen, McSwiggen and Associates, (612) 781-2282, PMcS@McSwiggenAssoc.com.

ACCOMMODATIONS

The Radisson Hotel Metrodome provides an ideal venue for the 2005 GSA North-Central Section meeting. With over 20,000 square feet of meeting space, all of the GSA technical sessions, exhibits, posters, and functions will be centrally located. Situated on the University of Minnesota East Bank campus, the hotel is conveniently close to the University of Minnesota facilities and to both the downtown Minneapolis and St. Paul shopping, entertainment, and business districts. GSA participants are strongly encouraged to stay at the conference headquarters for easy access to all GSA activities. Reserve through www.radisson.com/gsa to receive the special GSA rate of $105 for single/double occupancy ($15 extra per additional adult).

ADDITIONAL INFORMATION

Requests for additional information should be addressed to the general chairs, Carrie Jennings, carrie@umn.edu, or Barbara Lusardi, lusar001@umn.edu, (612) 627-4780, Minnesota Geological Survey, 2642 University Avenue, St. Paul, MN 55114, USA.

STUDENTS—Mark Your Calendars!

Students: Plan now to attend a Shlemon Mentor Program and/or a Mann Mentor Program in Applied Hydrogeology at your 2005 Section Meeting to chat one-on-one with practicing geoscientists. These volunteers will answer your questions and share insights on how to get a job after graduation. When programs are scheduled for multiple days, each day's program will offer a different set of mentors.

FREE LUNCHES will be served (students only) at the Shlemon Mentor Programs. Students will receive a **FREE LUNCH** ticket, along with their registration badge, to attend each Shlemon Program. However, space is limited. First come, first served.

And, it gets better: **FREE light suppers** will be served (students only) at the Mann Mentor Programs. The **Mann Programs** are specific to careers in hydrogeology; if you're interested in receiving an invitation to attend the Mann Program for a **FREE light supper** after the tech sessions end, contact Karlon Blythe, kblythe@geosociety.org. Be sure to indicate which Section Meeting you plan to attend.

Mentor Programs for 2005 Section Meetings

FOR LOCATIONS OF PROGRAMS, ASK AT THE GSA REGISTRATION DESK.

NORTHEASTERN SECTION MEETING

Saratoga Springs, New York
SHLEMON MENTOR LUNCHEON PROGRAMS:
Mon. and Tues., March 14–15, 11:30 a.m.–1 p.m.

MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM:
(by invitation; contact kblythe@geosociety.org)
Mon., March 14, 5–6:30 p.m.

SOUTHEASTERN SECTION MEETING

Biloxi, Mississippi
SHLEMON MENTOR LUNCHEON PROGRAMS:
Thurs. and Fri., March 17–18, 11:30 a.m.–1 p.m.

MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM:
(by invitation; contact kblythe@geosociety.org)
Thurs., March 17, 5–6:30 p.m.

SOUTH-CENTRAL SECTION MEETING

San Antonio, Texas
SHLEMON MENTOR LUNCHEON PROGRAM:
Fri., April 1, 11:30 a.m.–1 p.m.

MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM:
(by invitation; contact kblythe@geosociety.org)
Fri., April 1, 5–6:30 p.m.

CORDILLERAN SECTION MEETING

San José, California
SHLEMON MENTOR LUNCHEON PROGRAMS:
Fri. and Sat., April 29–30, 11:30 a.m.–1 p.m.

MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM:
(by invitation; contact kblythe@geosociety.org)
Fri., April 29, 5–6:30 p.m.

NORTH-CENTRAL SECTION MEETING

Minneapolis, Minnesota
SHLEMON MENTOR LUNCHEON PROGRAMS:
Thurs. and Fri., May 19–20, 11:30 a.m.–1 p.m.

MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM:
(by invitation; contact kblythe@geosociety.org)
Thurs., May 19, 5–6:30 p.m.

ROCKY MOUNTAIN SECTION MEETING

Grand Junction, Colorado
SHLEMON MENTOR LUNCHEON PROGRAMS:
Mon. and Tues., May 23–24, 11:30 a.m.–1 p.m.

MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM:
(by invitation; contact kblythe@geosociety.org)
Mon., May 23, 5–6:30 p.m.

For more information contact kblythe@geosociety.org

THE GEOLOGICAL SOCIETY OF AMERICA

ROCKY MOUNTAIN

57th Annual Meeting
Rocky Mountain Section, GSA
Mesa State College, Grand Junction, Colorado

May 23–25, 2005

www.geosociety.org/sectdiv/rockymtn/05rmmtg.htm

The 57th Annual Meeting of the Rocky Mountain Section will be hosted by the geology program within the Department of Physical and Environmental Sciences, Mesa State College. The meeting will be held on the campus of Mesa State College.

ENVIRONMENT

Located in Grand Junction, Colorado, Mesa State College is a medium-sized (6000 students) liberal arts college. Grand Junction (area population of 116,000) is the largest city in western Colorado, located roughly halfway between Denver and Salt Lake City. The high desert climate (elevation 4600 feet) is typically mild and sunny during May, perfect for the scheduled field trips. Local geological attractions include Colorado National Monument, the Book Cliffs, Unaweep Canyon, Dinosaur Journey Museum, Riggs Hill and Dinosaur Hill Outdoor Museums, Rabbit Valley Dinosaur Quarry, and the Museum of Western Colorado. Within a two-hour drive are Arches National Park, Canyonlands National Park, the Black Canyon of the Gunnison National Park, and Dinosaur National Monument.

GETTING THERE

Grand Junction is an easy destination. Major highways passing through the city include Interstate 70 and U.S. Highway 50. Driving time from Denver is about four hours (250 miles), and from Salt Lake City, it is about 4.5 hours (275 miles). Commuter airline service is available from America West Express via Phoenix, SkyWest from Salt Lake City, and Frontier Airlines, Great Lakes Airlines, and United Express/SkyWest from Denver. For more information regarding air service, see www.walkerfield.com. Greyhound Lines and Amtrak also serve Grand Junction.

Most hotels and motels are located on Horizon Drive, which is about 2.3 miles from Mesa State College. Public transportation (Grand Valley Transit) is available. Contact www.grandvalleytransit.com for more information.

A map of Grand Junction can be downloaded from www.visitgrandjunction.com, and maps of Mesa State College and surrounding areas can be downloaded from www.mesastate.edu/main/maps/.

ABSTRACTS

Abstract Deadline: February 22, 2005

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

REGISTRATION

Standard Registration Deadline: April 18, 2005
Cancellation Deadline: April 25, 2005

GSA Headquarters will handle registration. Registration details are available on the Web at www.geosociety.org. To obtain lower registration fees and to assist planning by the local committee, please register online at www.geosociety.org/sectdiv/rockymtn/05rmmtg.htm, or download the PDF registration form. If you are unable to preregister this way, contact GSA Sales and Service, (303) 357-1000 option 3, 1-888-443-4472, or gsaservice@geosociety.org.

All requests for registration changes or cancellations must be made in writing and received by April 25, 2005. No refunds will be made after this date.

On-site registration will be in the W.W. Campbell College Center:

Sunday, May 22	3–8 p.m.
Monday, May 23	7:30 a.m.–4 p.m.
Tuesday, May 24	7:30 a.m.–4 p.m.
Wednesday, May 25	7:30–10 a.m.

Registration Fees

	Standard		On-site	
	Full meeting	One day	Full meeting	One day
Professional Member	$125	$85	$135	$95
Professional Member (70 and older)	$95	$55	$105	$65
Professional Nonmember	$135	$95	$145	$105
Student or Associate Member	$75	$65	$80	$70
Student Nonmember	$85	$75	$90	$80
K–12 Professional	$40	$30	$45	$35
Guest or Spouse	$25	$15	$30	$20
Field Trip/Workshop only	$25	$25	$25	$25

ACCESSIBILITY

GSA is committed to making its meetings accessible to all people interested in attending. Indicate special requirements (wheelchair accessibility, etc.) on the registration form. Mesa State College is ADA compliant.

FIELD TRIPS

For additional information regarding field trips, please contact either the trip leader or the field trip chair, Gigi Richard, (970) 248-1689, grichard@mesastate.edu. Complete descriptions are posted at www.geosociety.org/sectdiv/rockymtn/05rmmtg.htm. A compilation of field trip handouts will be available for purchase at the time of the meeting.

Premeeting

1. **Geological History of the Uncompahgre Plateau and Unaweep Canyon: From Penn-Permian Glaciers to Plio-Pleistocene Neotectonics.** Two days, Sat. and Sun., May 21–22. Andres Aslan, Mesa State College, (970) 248-1614, aaslan@mesastate.edu; William Hood, Mesa State College; Lynn Soreghan, University of Oklahoma; Michael Blum, Louisiana State University;

Rick Livaccari, Mesa State College. Max.: 23; min.: 15. Cost: Professionals, $140; students $35 (maximum of 10). Includes guidebook, two box lunches, and transportation in vans. *Note*: Lodging not included. This field trip will involve some hiking and climbing.

Since the early surveys of the western United States, geologists have puzzled over enigmatic Unaweep Canyon. This two-day field trip will discuss possible origins of the canyon ranging from Cenozoic incision by the Colorado and Gunnison Rivers to late Paleozoic glaciation. Day 1 will emphasize late Cenozoic fluvial incision, formation of the Cactus Park Lake, stream piracy, and possible late Quaternary deformation. Day 2 will focus on emerging evidence for a late Paleozoic glacial origin for Unaweep's inner gorge and new interpretations for the proximal Cutler Formation facies exposed at the canyon's western end.

2. **Dinosaur Quarries of Western Colorado and Eastern Utah.** Two days, Sat. and Sun., May 21–22. John Foster, Museum of Western Colorado, (970) 858-7282, jfoster@westcomuseum.org; Rod Scheetz, Brigham Young University; James Kirkland, Utah Geological Survey. Max.: 20; min.: 13. Cost: $170, includes guidebook, one night accommodation (double occupancy) in Moab, Utah, two box lunches, and transportation in vans. Hiking and moderate climbing can be expected.

   Tour of dinosaur localities in the Upper Jurassic Morrison Formation and the Lower Cretaceous Cedar Mountain Formation of western Colorado and eastern Utah. Stops Saturday will include the Fruita Paleontological Area, one of the most important Jurassic microvertebrate localities in the world; the Mygatt-Moore Quarry, type locality of both *Mymoorapelta*, the first Jurassic ankylosaur found in North America, and the palaeoniscoid fish *Morrolepis*; and the Fisher Mesa trackside, a locality with dozens of deep, large theropod tracks in the Entrada Sandstone. After a night in Moab, Sunday's stops will be the Dalton Wells Quarry, a site at the base of the Cedar Mountain Formation and one of the most productive quarries in the formation, and the Gaston Quarry, a site that produced the ankylosaur *Gastonia* and the type specimen of *Utahraptor*.

3. **Colorado River Raft Trip, Grand Junction to Westwater.** Three days, Fri.–Sun., May 20–22. John Pitlick, University of Colorado, Boulder, (303) 492-5906, pitlick@colorado.edu. Max.: 18; min.: 12. Cost: $345, includes guidebook, raft guides and equipment, three lunches, two dinners, two breakfasts, and transportation in vans. *Note*: This trip involves overnight camping in a remote canyon and rafting through class III and possibly class IV rapids depending on water levels. Hiking and moderate climbing can also be expected.

4. **Laramide Strike-Slip Faulting along the Cactus Park–Bridgeport Fault of the Uncompahgre Plateau.** One day, Fri., May 20. Rick Livaccari, Mesa State College, (970) 248-1081, rlivacca@mesastate.edu; John Hodge, Mesa State College. Max.: 13; min.: 8. Cost: Professionals, $75; students $25 (maximum of 5). Includes map, one box lunch, and transportation (van). This field trip will involve hiking and climbing.

   A prominent, Laramide-age strike-slip structure, called the Cactus Park–Bridgeport fault, has recently been identified and mapped in the northern Uncompahgre Plateau. The Cactus Park–Bridgeport fault is a continuous, subvertical, oblique-slip fault with a predominance of left-lateral strike-slip and lesser amounts of reverse dip-slip. This field trip will focus on field assessment of the kinematic nature of the Cactus Park–Bridgeport fault. Spectacular outcrops will be visited.

Concurrent

5. **Viniculture Geology and Biology of the Grand Valley, Colorado.** Half-day, Mon. afternoon, May 23. Harold (Skip) Hase, Mesa State College, (970) 248-1161, shase@mesastate.edu; Larry Madsen, Mesa State College; Rick Ballard, Mesa State College. Max.: 20; min.: 13. Cost: $35, includes guidebook, wine tasting, and transportation in vans. This trip involves a moderate amount of walking.

   This is a half-day field trip focused on the wine industry in the Grand Valley from Palisade to Fruita, Colorado. The trip will look at vineyards and growing conditions through the valley and look at the wine making process from harvesting to crushing to fermentation and aging, with a complete tour through a winery from start to finish (tasting is part of the process). In Colorado, you must be 21 years of age to consume alcohol.

6. **Geology of Colorado National Monument.** Half-day, Tues. afternoon, May 24. William Hood, Mesa State College, (970) 241-8020, WHood@compuserve.net. Max.: 20; min.: 13. Cost: $30, includes geologic map, light refreshments, and transportation in vans. Hiking and moderate climbing can also be expected.

   Colorado National Monument, located on the outskirts of Grand Junction, is a truly memorable locale for Colorado Plateau geology. This nontechnical half-day trip will explore the geology, history, and scenery of the monument from a variety of perspectives. This is an ideal trip for spouses, guests, and K–12 educators. Bring your camera and plenty of film (memory).

7. **The DeBeque Canyon Landslide, Interstate 70, Milepost 51.** Half-day, Wed. afternoon, May 25. Jonathan L. White, Colorado Geological Survey, Denver, (303) 866-3551, jonathan.white@state.co.us. Max.: 20; min.: 13. Cost: $40, includes guidebook, refreshments, and transportation in vans. *Note*: In the event of wet conditions, a short, strenuous hike will be necessary.

   The landslide of DeBeque Canyon is about 20 miles (32 km) east of Grand Junction, near milepost 51 of Interstate 70. The active landslide complex, on the south wall of a 500-ft-deep (152 m) canyon cut into the Cretaceous Williams Fork Formation, has several failure mechanisms, including near-horizontal block gliding, both translational and rotational shear modes, and toppling rockfall. Striking features of this slide are a rubble zone of house-sized sandstone blocks and deep fissures above the canyon rim. The landslide has a history of recent movements (e.g., 1998) that have diverted the

Colorado River channel and impacted the highway and railway corridors on the valley floor. This field trip will visit the landslide from the plateau above, so no strenuous hiking is needed. At several vantage points along the fissures and looking down on the rubble and canyon floor, we will discuss the history and age of the landslide, the ongoing monitoring program and current rates of movement, failure mechanisms, and the water-diversion construction project completed in 2003.

Postmeeting

8. **The Uravan Mineral Belt.** One day, Thurs., May 26. William Chenoweth, retired U.S. Department of Energy Geologist, Grand Junction, (970) 242-9062, cheno@earthlink.net; Craig S. Goodknight, S.M. Stoller Corp., Grand Junction; Edward T. Cotter, S.M. Stoller Corp., Grand Junction; Richard D. Dayvault, S.M. Stoller Corp., Grand Junction. Max.: 20; min.: 13. Cost: $60, includes guidebook, box lunch, and transportation in vans. This trip involves a moderate amount of hiking and climbing.

   Since the beginning of the twentieth century, the uranium-vanadium deposits in the Salt Wash Member of the Morrison Formation in southwestern Colorado have been mined for radium, vanadium, and uranium. The area is considered the birthplace of the Atomic Age. This trip will examine mining areas in the Uravan and Paradox Valley areas, reclaimed millsites, and disposal cells.
9. **Canyons of the Eastern Uinta Mountains, Dinosaur National Monument, Raft Trip, Green River.** Four days, Thurs.–Sun., May 26–29. Jack Schmidt, Utah State University, (435) 797-1791, jack.schmidt@usu.edu. Max.: 18; min.: 12. Cost: $550, includes guidebook, raft guides and equipment, four lunches, three dinners, three breakfasts, and transportation in vans. *Note*: This trip involves overnight camping in a remote canyon and rafting through class III and possibly class IV rapids depending on water levels. Hiking and moderate climbing can also be expected.
10. **Upheaval Dome, Impact Crater (?), San Rafael Swell, and White Canyon Areas, Utah: Evidence Supporting a Major Bolide Impact Event Horizon near the Permian-Triassic Boundary.** Two days, Thurs. and Fri., May 26–27. Joe Fandrich, Mesa State College, (970) 256-9029, joefandrich@hotmail.com; Jared Morrow, University of Northern Colorado. Max.: 20; min.: 13. Cost: $210, includes guidebook, one night lodging (single occupancy) in Hanksville, Utah, two box lunches, and transportation in vans. This trip involves a moderate amount of hiking and climbing.

    Day 1 includes travel to Upheaval Dome, an eroded impact crater (?), and the San Rafael Swell. We will visit impact-generated (?) seismite/tsunamites in a breccia at the base of the Black Dragon Shale and sedimentary dikes and convoluted beds in the lower Entrada Sandstone, which are attributed to the Upheaval Dome impact. Day 2 will involve travel to the White Canyon area to visit impact-generated seismite/megatsunamites in the upper Hoskinnini Member of the Moenkopi Formation.
11. **Stratigraphy, Sedimentology, and Energy Resources of Cretaceous Rocks in the Book Cliffs Area, Western Colorado and Eastern Utah.** Two days, Thurs. and Fri., May 26–27. Rex Cole, Mesa State College, (970) 248-1599, rcole@mesastate.edu; Mark Kirschbaum, U.S. Geological Survey, Denver; Robert G. Young, consulting geologist. Max.: 23; min.: 15. Cost: $190, includes guidebook, two box lunches, and transportation in 4 × 4 vehicles. *Note*: Lodging not included. This trip involves a significant amount of hiking and climbing over uneven ground.

    This two-day field trip will provide a general overview of Upper Cretaceous marine, marginal-marine, coastal-plain, and alluvial-plain strata exposed in the Book Cliffs of eastern Utah and western Colorado, including the Castlegate Sandstone, Sego Sandstone, Neslen Formation, Farrer Formation, Tuscher Formation, Iles (Mount Garfield) Formation, and Williams Fork (Hunter Canyon) Formation. During the field stops, emphasis will be on lithostratigraphic characteristics, sequence-stratigraphic relationships, depositional facies, and energy resources (coal and natural gas).

TECHNICAL PROGRAM

Technical sessions will generally be 12 minutes long with three minutes for questions. Some sessions may use a longer format. Only digital media presentations (PowerPoint) will be allowed (sorry, no slides or overheads). Because a centralized computer system (PC based) will be used, speakers will not be allowed to use their own laptops. Poster sessions will be held in Liff Auditorium (W.W. Campbell College Center). Poster space will be 4' × 8'. A limited number of tables will also be available upon request. Authors are required to be present for at least two hours during the day.

Complete descriptions of the symposia and theme sessions are posted at www.geosociety.org. For additional information, contact technical program co-chairs Andres Aslan, (970) 248-1614, aaslan@mesastate.edu, or Rick Livaccari, (970) 248-1081, rlivacca@mesastate.edu.

SYMPOSIA

1. **Water Resources in the Colorado River Basin and the Western U.S.** Robert Ward, Colorado State University, (970) 491-6308, Robert.Ward@colostate.edu; Gigi Richard, Mesa State College, (970) 248-1689, grichard@mesastate.edu.
2. **Selenium-Sodium-Salinity-Sediment in the Upper Colorado River Basin: Origins and Impacts.** Richard Grauch, U.S. Geological Survey, Denver, (303) 236-5551, rgrauch@usgs.gov; Paul von Guerard, U.S. Geological Survey, Grand Junction, (970) 245-5257, pbvongue@usgs.gov.
3. **Buried Riches to Hazardous Wastes—Western Colorado's Uranium Legacy.** Bill Chenoweth, retired, U.S. Dept. of Energy, (970) 242-9062, cheno@earthlink.net; Craig Goodknight, S.M. Stoller Corp., (970) 248-6550, cgoodknight@gjo.doe.gov.
4. **Bolide Impact Characteristics, Event Horizons, and Impact Structures in Western North America and Beyond.** Joe Fandrich, Mesa State College, (970) 256-9029, joefandrich@hotmail.edu; Jared Morrow,

University of Northern Colorado, (970) 351-2483, jared.morrow@unco.edu.

5. **Mudslide Mania—Characteristics and Geologic Investigations of Debris Flows and Alluvial Fans in the Rocky Mountain Region.** David Noe, Colorado Geological Survey, (303) 866-2432, dave.noe@state.co.us; Paul Santi, Colorado School of Mines, (303) 273-3108, psanti@mines.edu.

THEME SESSIONS

1. **Sustainability of Groundwater Resources of the Colorado Plateau.** Kenneth Kolm, Blasland, Bouck & Lee, (303) 231-9115, kkolm@bbl-inc.com.
2. **The Colorado River System: Hydrology and Fluvial Processes.** Gigi Richard, Mesa State College, (970) 248-1689, grichard@mesastate.edu; John Pitlick, University of Colorado, Boulder, (303) 492-5906, pitlick@spot.colorado.edu.
3. **Selenium-Sodium-Salinity-Sediment in the Upper Colorado River Basin: Origins and Impacts.** Richard Grauch, U.S. Geological Survey, Denver, (303) 236-5551, rgrauch@usgs.gov, Paul von Guerard, U.S. Geological Survey, Grand Junction, (970) 245-5257, pbvongue@usgs.gov.
4. **Late Cenozoic Evolution of the Rocky Mountains and Colorado Plateau.** Eric Leonard, Colorado College, (719) 389-6513, eleonard@coloradocollege.edu; Andres Aslan, Mesa State College, (970) 248-1614, aaslan@mesastate.edu; Karl Karlstrom, University of New Mexico, (505) 277-4346, kek1@unm.edu.
5. **Precambrian Geology of Western Colorado.** Karl Karlstrom, University of New Mexico, (505) 277-4346, kek1@unm.edu.
6. **Sedimentology, Stratigraphy, and Energy Resources of Cretaceous Rocks in the Book Cliffs area, Western Colorado and Eastern Utah.** Rex Cole, Mesa State College, (970) 248-1599, rcole@mesastate.edu; Robert Young, consulting geologist.
7. **Paleoenvironments and Paleoecology of the Upper Jurassic Morrison Formation of the Western U.S.** John Foster, Museum of Western Colorado, (970) 242-0971, jfoster@westcomuseum.org; Steve Hasiotis, University of Kansas, (785) 864-4941, hasiotis@ku.edu.
8. **Current Topics on Regional Vertebrate Tracks in the Modern Western Interior of the U.S.** Debra Mickelson, University of Colorado, Boulder, (303) 722-9995, Debra.Mickelson@colorado.edu; Martin Lockley, University of Colorado, Denver, mlockley@carbon.cudenver.edu.
9. **Quaternary Tectonics and Earthquake Hazards in the Rocky Mountain Region.** Vince Matthews, Colorado Geological Survey, (303) 866-3028, vince.mattews@state.co.us; Verner Johnson, Mesa State College, (970) 248-1672, vjohnson@mesastate.edu.
10. **Terrestrial Planetary Geology in North America.** Joe Fandrich, Mesa State College, (970) 256-9029, joefandrich@hotmail.edu; Jared Morrow, University of Northern Colorado, (970) 351-2483, jared.morrow@unco.edu.
11. **Council on Undergraduate Research—Undergraduate Research Poster Session.** Kim Hannula, Ft. Lewis College, (970) 247-7463, hannula_k@fortlewis.edu.
12. **Late Paleozoic Geology of Western Pangaea: The Greater Ancestral Rocky Mountains.** Chuck Kluth, Colorado School of Mines, (303) 904-3889, kluths@comcast.net; Lynn Soreghan, University of Oklahoma, (405) 325-4482, lsoreg@ou.edu.
13. **Incorporating Undergraduate Research into the Curriculum.** C. Frederick Lohrengel II, Southern Utah University, (435) 586-7941, lohrengel@suu.edu; Robert L. Eves, Southern Utah University, (435) 586-1934, eves@suu.edu; Mark R. Colberg, Southern Utah University, (435) 586-8331, colberg@suu.edu.

WORKSHOPS

Introduction to Geographic Information Systems (GIS) and Global Positional Systems (GPS). Two days, Sat. and Sun., May 21–22. Ann B. Johnson, Environmental Systems Research Institute (ESRI), ajohnson@esri.com; Dave Fosdek, ESRI; Verner Johnson, Mesa State College. This course will introduce the use of GIS in geology-related applications using ArcGIS, ArcMap, ArcCatalog, and Spatial and 3D Analyst extensions. Experience with ArcGIS is not necessary, but familiarity with Windows OS would be beneficial. Focus will be hands-on use of ArcGIS, including ModelBuilder, data access and analysis, Geoprocessing with ArcTools, and the Geodatabase. Max.: 20; min.: 10. Cost: Professionals, $125; students $80. Includes instructional materials and refreshments.

Roy J. Shlemon Mentor Program in Applied Geology. *Sponsored by GSA Foundation.* Mon., May 23, and Tues., May 24, from 11:30 a.m.–1 p.m. Location available at GSA's registration desk. Karlon Blythe, kblythe@geosociety.org. This interactive and informative program for undergraduate and graduate students, led by professional geoscientists, will cover real life issues, including professional opportunities and challenges that await students after graduation. Plan to attend both free luncheons to hear different presenters each day. Students will receive FREE LUNCH tickets in their registration packet to attend both Shlemon Programs. However, space is limited: first come, first served.

The John Mann Mentors in Applied Hydrogeology Program. *Sponsored by GSA Foundation.* Mon., May 23, 5–6:30 p.m. Location available at GSA's registration desk. Karlon Blythe, kblythe@geosociety.org. This event presents mentoring opportunities for undergraduate and graduate students and recent graduates with declared interest in hydrogeology as a career to interact and network with practicing hydrogeology professionals. The focused, small-scale program features FREE FOOD for participants. Participant eligibility is limited to those students who have declared their career interest to be hydrology or hydrogeology on their GSA membership applications and who have registered online for this Section meeting. An e-mail invitation will be sent to those qualified students. Only a quick response to the invitation will secure you a seat, as attendance is limited.

SPECIAL EVENTS

- **Ice Breaker.** Sun., May 22, 5 p.m., W.W. Campbell College Center, Mesa State College.
- **Annual Banquet and Business Meeting.** Mon., May 23; location and time TBA.
- **Rocky Mountain Section Board Meeting.** Tues., May 24; location and time TBA.

SPOUSE AND GUEST ACTIVITIES

Grand Junction has numerous facilities and opportunities for guests and spouses. The area is rapidly gaining recognition for its high quality vineyards, championship golf courses, restaurants, museums, and shopping venues. Within minutes of campus are many areas for mountain biking, rafting, hiking, rock and fossil collecting, and photography. For additional general information, contact the Grand Junction Visitor and Convention Bureau (800-962-2547; www.visitgrandjunction.com).

STUDENT TRAVEL

The Rocky Mountain Section and the GSA Foundation have made travel grants available for students who are presenting oral or poster papers. Students must be currently enrolled and must be Rocky Mountain GSA members. Students should contact Kenneth Kolm at (303) 231-9115 or kkolm@bbl-inc.com.

STUDENT AWARDS

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

EXHIBITS

A limited amount of exhibit space may be available at $250 per booth for commercial organizations and $100 per booth for nonprofits. Contact Rex Cole at (970) 248-1599 or rcole@mesastate.edu.

ACCOMMODATIONS

An excellent selection of hotels and motels are available within several miles of the Mesa State campus on Horizon Drive. GSA has arranged special rates at the following hotels. Please contact the hotels directly for reservations. Be sure to mention that you would like a Rocky Mountain GSA rate. Because Grand Junction is a popular tourist destination, it is recommended that you make your reservations early. For all but the Ramada Inn, the group code is *Geological Society of America*; attendees will need to use this code to receive the discount.

Ramada Inn. (970) 243-5150—Discounted rate of $50.
Best Western Sandman Motel. (970) 243-4140—Discounted rate of $55.
Best Western Horizon Inn. (970) 245-1410—Discounted rate of $59 with continental breakfast.
LaQuinta Inn and Suites. (970) 241-2929—Discounted rate of $65.
Holiday Inn. (970) 243-6790—Discounted rate of $69.
Nearby (5–15 miles) camping facilities are also available in Colorado National Monument (www.nps.gov/colm/pphtml/camping.html), Colorado River State Park–Fruita, and Colorado River State Park–Island Acres (www.parks.state.co.us).

ADDITIONAL INFORMATION

For additional information, contact general chair Rex Cole (970) 248-1599, rcole@mesastate.edu; vice chair Andres Aslan (970) 248-1614, aaslan@mesastate.edu; technical co-chairs Andres Aslan (970) 248-1614, aaslan@mesastate.edu, and Rick Livaccari (970) 248-1081, rlivacca@mesastate.edu; or the field trip chair, Gigi Richard, (970) 248-1689, grichard@mesastate.edu.

UPCOMING AWARD DEADLINES

Funds supporting all but the national awards are administered by the GSA Foundation.

APPLICATIONS DUE

Feb. 15, 2005: **Antoinette Lierman Medlin Scholarship in Coal Geology.** Coal Geology Division. Please send applications to: Dr. Romeo Flores, U.S. Geological Survey, Box 25046, MS 939, Denver Federal Center, Denver, CO 80225, USA; fax: 303-236-0459; rflores@dncrds0.cr.usgs.gov. For details, see the December 2004 issue of *GSA Today* or visit www.geosociety.org/grants/medlin.htm.

NOMINATIONS DUE

Feb. 20, 2005: **Laurence L. Sloss Award for Sedimentary Geology.**** Sedimentary Geology Division: Nominations due to Paul Link, treasurer, Sedimentary Geology, via e-mail (with attachments) to linkpaul@isu.edu.

Feb. 28, 2005: **Gilbert H. Cady Award.**** Coal Geology Division: Nominations to R. Marc Bustin, The University of British Columbia, Vancouver, BC V6T1Z4, Canada, mbustin@eos.ubc.ca.

Mar. 31, 2005: **John C. Frye Environmental Geology Award.***

Apr. 1, 2005: **Don J. Easterbrook Distinguished Scientist Award.**** Quaternary Geology and Geomorphology Division: Nominations due to John E. Costa, U.S. Geological Survey, 10615 S.E. Cherry Blossom Dr., Portland, OR 97216, jecosta@usg.gov.

Apr. 1, 2005: **Farouk El-Baz Award for Desert Research.**** Quaternary Geology and Geomorphology Division: Nominations due to Alan R. Gillespie, Quaternary Research Center, P.O. Box 351310, University of Washington, Seattle, WA 98195-1360, alan@rad.ess.washington.edu.

Apr. 30, 2005: **National Awards.*** (William T. Pecora Award, National Medal of Science, Vannevar Bush Award, and Alan T. Waterman Award.)

*Details and nomination procedures for these awards are posted at www.geosociety.org/aboutus/awards/. You may also contact Diane Lorenz, (303) 357-1028, awards@geosociety.org, Grants, Awards, and Recognition, P.O. Box 9140, Boulder, CO 80301-9140, USA.

**For details on these awards, see the January 2005 issue of *GSA Today* or visit www.geosociety.org/sectdiv/divisions.htm.

GeoVentures™ 2005

Want to find out about all our latest GeoVentures™ trips? Join our GeoVentures™ E-News list! See our Web page, www.geosociety.org/geoventures.

GeoTrip Eastern Australia—Fossils, Intrusions, Caves, and Coasts

June 16–June 27, 2005
Departs from Sydney, Australia
(10 days, 11 nights)

Trip Leaders: Gary Lewis, Director, GSA Education and Outreach Department. Gary, a geologist and educator, has been leading trips in Australia since 1989. Prior to his work as director of Education and Outreach at GSA, he worked for the Australian Geological Survey for 9 years and at CSIRO (Commonwealth Scientific & Industrial Research Organisation). Gary studied at Sydney University. **Greg McNamara,** paleontologist and geoscience educator. Greg studied at Monash University in Melbourne and has worked at James Cook University in Far North Queensland. He has been the manager of education programs at the Australian Geological Survey, as well as at museums and other institutions.

Description

This special trip for students has been designed to increase your field knowledge of a range of sedimentary and igneous terrains. Come "downunder" and spend time examining huge sedimentary basins, mapping intrusions, identifying fossil assemblages, and visiting caves. For almost half of this trip you will be housed less than 100 yards from a pristine beach and estuary. As well as having great geological experiences, you will also have time to visit famous landmarks in Sydney and the Australian National Capital, Canberra. While this trip is held in Australia's winter, temperatures are mild and weather is normally dry. All accommodations are in dorms or cabins, and participants will need to supply their own sleeping bags. Once in Australia, you might like to visit some of the other famous places, such as the Great Barrier Reef or Uluru (Ayers Rock) before or after the GeoTrip. Optional extras include a kayaking experience along a section of rugged coastline or into a pristine lake.

Fees and Payment: $1,525 for GSA student members, $1,625 for nonmembers. A $200 deposit is due with your reservation and is refundable (less $75) through May 1. Balance is due May 1. Min.: 12 (*firm*); max.: 20. **Included:** Ground transportation within Australia, all accommodations, all park entry fees, field guides, all breakfasts, most lunches, four dinners. **Not included:** Airfare to and from Sydney, optional side excursions (caves and kayaks), alcoholic beverages, personal expenditures, and any other expenses not specifically included in the itinerary.

To register for this GeoTrip, please fill out and return the registration form below.

REGISTER TODAY!

Send a deposit to hold your reservation; please pay by check or credit card. You will receive further information soon.

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

E-mail

GSA Member #

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GeoTrip The Geology of Middle Earth——A GeoTrip through New Zealand

May 1–14, 2005, Auckland, New Zealand

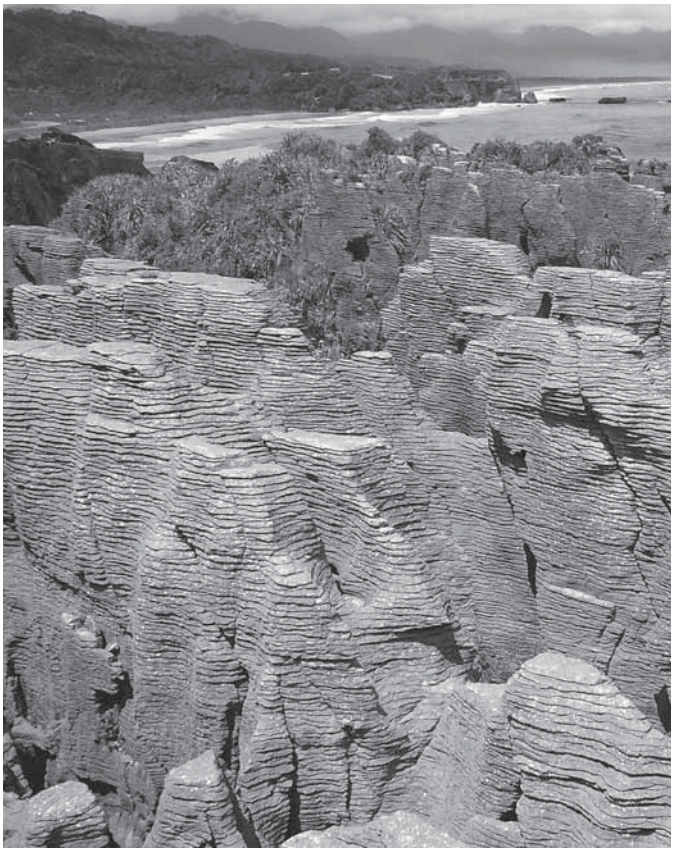
Scientific Leaders: Hamish Campbell, Cliff Atkins, and **Craig Jones** are professional New Zealand geologists who have extensive experience working in New Zealand geology and can also offer local knowledge on history, flora and fauna, and more.

Description

New Zealand straddles the boundary between the Pacific and Australian tectonic plates and yields a rich geological history that reveals everything from sections of ancient Gondwana to active volcanoes and glaciated Alps. This dynamic environment created the wild and spectacular landscapes that provide many of the backdrops seen in the "Lord of the Rings" (LOTR) movie trilogy. This ready-made "Middle Earth" owes much of its stunning scenery to its geological past. Join this GeoTrip on an excursion along the length of New Zealand, highlighting geology that made this location the ideal setting for LOTR. The trip will appeal to both hardened geologists, who revel in diverse rocky environments, and nongeologists, who wish to experience breathtaking natural scenery while discovering New Zealand's rich character and culture. Whether you are a geologist, LOTR fan, tourist, or all three, this trip is bound to please!

Depending on arrival times, participants can include some sightseeing around the Quaternary basaltic volcanic center of Auckland city. This may include a short ferry ride out to Rangitoto Island, which is the largest and youngest of the New Zealand volcanoes and formed some 600 years ago.

Punakaiki, New Zealand.



Fees and Payment: $4,375 for GSA members, $4,375 for spouses, $4,775 for nonmembers. A $200 deposit is due with your reservation and is refundable through March 1, less a $75 processing fee. Total balance is due March 1, 2005. (Single room supplement is $800.) Min.: 12; max.: 20. **Included:** Ground transportation within New Zealand, lodging, meals, field guides, and entry fees. **Not included:** Airfare to Auckland and from Christchurch, optional side excursions, alcoholic beverages, personal expenditures, and any other expenses not specifically included.

To register for this GeoTrip, please fill out and return the registration form on page 29.

GeoClass Geology of Golden, Colorado, and the Surrounding Area

June 17–20, 2005, Table Mountain Inn, Golden, Colorado

Scientific Leader: Gregory S. Holden, Colorado School of Mines, Golden. A professor at the Colorado School of Mines for 27 years, Greg has lead field trips in the Golden area for thousands of students, teachers, and professionals, geologists and nongeologists alike. He looks forward to showing off Golden, his favorite geological laboratory, and the surrounding area.

Description

Golden, Colorado, a small, historic town at the western foot of the southern Rocky Mountains, is separated from the Denver Metro area by lava-capped North and South Table Mountains. Outcrops and geologic features around Golden illustrate the full geologic history of the southern Rockies and have served as a natural laboratory for generations of geologists at the Colorado School of Mines. This GeoClass will examine the rock record of the Golden area, from the Precambrian basement to Quaternary pediment gravels. We will see and assess the evidence for original Proterozoic crust formation, the Ancestral Rocky Mountains, the Laramide Orogeny and current Neogene regional uplift. We will see how rock type and processes have shaped the Golden valley and affected land use and infrastructure in the town. The trip format will be van trips to local geologic features and outcrops and short hikes along Front Range trails where, if it is a good season, the spring wildflowers should be at their peak. We will take van trips to Red Rocks Park, North Table Mountain, White Ranch Park, and Golden Gate State Park, all within a 20-minute drive from our hotel in Golden.

Photo courtesy City of Golden.

Fees and Payment: $725 for GSA members, $775 for spouses, $825 for nonmembers. A $200 deposit is due with your reservation and is refundable through May 1, less a $20 processing fee. Total balance is due May 1, 2005. Min.: 12; max.: 22. **Included:** Classroom programs and materials, field trip transportation, lodging for three nights (single occupancy or doubles for couples), breakfast on Saturday, Sunday, and Monday, boxed lunch on Saturday and Sunday, and welcoming and farewell events. **Not included:** Transportation to and from Golden, Colorado, transportation during hours outside field trips, alcoholic beverages, and other expenses not specifically included.

To register for this GeoClass, please fill out and return the registration form on page 29.

GeoHostel Geologic Excursions in South-Central Montana

July 9–14, 2005
Best Western Yellowstone Inn
Livingston, Montana

Scientific Leaders: Robert C. Thomas and **Sheila M. Roberts**, University of Montana–Western. **Rob Thomas** is a professor of geology in the Department of Environmental Sciences at Western, where he teaches his courses in the natural lab that is southwest Montana. Western is the experiential learning campus of the University of Montana, and is the first public university in the United States to offer semester courses one at a time. Rob utilizes these field-based courses to incorporate undergraduate students as partners in his research. For example, he and his students have worked on sedimentary basins along the northern margin of the Yellowstone hot spot for the last ten years. In addition, he and his students have worked on Cambrian mass extinctions, the processes that form mixed carbonate-siliciclastic systems, and applied fluvial geomorphology. Rob has partnered for years with Sheila Roberts on the geology of the Lewis and Clark Trail, and together they have pursued innovation in geoscience education. His passion is to make geology accessible to the public. **Sheila Roberts** has been a professor of geology and chemistry in the Department of Environmental Sciences at Western for nine years. By utilizing the department's field-based program, Sheila has incorporated all levels of undergraduate students in her research. Her Master's thesis was on Permian rocks in SW Montana (University of Montana–Missoula). She teaches regional geology at Western and has edited many publications about western Montana, including the 2000 Rocky Mountain Regional GSA guidebook. Sheila's current research is extremely diverse and includes aspects of Pleistocene climate change in SW Montana, the geology of the Lewis and Clark Trail in Montana, weathering rates of marble tombstones regionally, and the chemistry of natural waters in Beaverhead County.

Description

The geology of south-central Montana is some of the most varied and interesting in the United States. From Archean basement to Quaternary glacial deposits, this area exposes enough geology to meet the needs of even the most discerning geologist. We will base our geological explorations in the vibrant, small town of Livingston, Montana. This artsy town is located along the banks of the Yellowstone River and provides an ideal location to explore the geology of the region. The trips will focus on the geology of two distinct geologic regions: (1) the frontal edge of the Cordilleran fold and thrust belt and associated igneous rocks north of Livingston, and (2) Archean to Quaternary geology north of the Yellowstone caldera in the Paradise Valley and surrounding mountain ranges. We will also take a trip into Yellowstone National Park to see the travertine deposits of Mammoth Hot Springs and tour the geology of the Lamar River Valley. In addition, we will visit the world-famous dinosaur exhibits located at the Museum of the Rockies in Bozeman, Montana.

Fees and Payment: $1,350 for GSA members, $1,400 for spouses, $1,450 for nonmembers. A $200 deposit is due with your reservation and is refundable through June 1, less a $20 processing fee. Total balance is due June 1, 2005. Min.: 25; max.: 36. **Included:** Classroom programs and materials, field trip transportation, lodging for six nights (single occupancy or double for couples), breakfast and lunch daily, and welcoming and farewell events. **Not included:** Transportation to and from Livingston, Montana, transportation during hours outside field trips, alcoholic beverages, and other expenses not specifically included.

To register for this trip, please fill out and return the registration form on page 29.

Photo courtesy Donnie Sexton, Travel Montana.

2005 GeoVentures™

For complete details on GeoVentures™ or for full itineraries, contact Edna Collis, program officer, 1-800-472-1988, ext. 1034, fax 303-357-1072, ecollis@geosociety.org, or contact geoventures@geosociety.org. Participants must be 18 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 or contact Edna Collis.

New Officers for the Foundation's Board

At its November meeting, the GSA Foundation Board of Trustees appointed Robert D. Hatcher, Jr., as Chair, and David E. Dunn as Vice Chair. Susan M. Landon will continue as Treasurer of the Foundation.

Current Board of Trustees

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Most memorable early geologic experience:

University of Colorado field camp 1948, when my beautiful plane table topographic/geologic map of Bedrock Peak got only a *B*! My legend labeled a small patch of soil *dirt*! (And that material is still *dirt* to me!)

John R. Rand

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ANNOUNCEMENTS

MEETINGS CALENDAR

2005

March 1–3	APPEX—AAPG Prospect & Property Expo, London, England; www.aapg.org.
March 12	American Society of Civil Engineers, Seattle Section, 22nd Annual Spring Seminar, "Tunneling in the Pacific Northwest," Seattle, Washington, USA. **Information:** Mark Rohrbach, mrohrbach@geoengineers.com, (253) 383-4940.
April 5–7	Return to Rifts?—The Next Wave. Burlington House, London, The Geological Society. **Information:** Lydia Dumont, The Geological Society, Burlington House, Piccadilly, London W1J OBG, UK, +44 (0)20 7434 9944, fax +44 (0)20 7494 0579, lydia.dumont@geolsoc.org.uk.
May 24–28	The 51st Annual Meeting of the ILSG, Nipigon, Ontario. **Information:** www.lakesuperiorgeology.org/nipigon2005; contact e-mail: Nipigon2005@Lakeheadu.ca.
August 8–11	Earth System Processes 2 (ESP2). Ancient earth systems, modern earth system processes, and earth system futures. Cosponsored by GSA and the Geological Society of Canada. Westin Hotel, Calgary, Alberta, Canada. **Information:** www.geosociety.org/meetings/esp2/ or contact Deborah Nelson, dnelson@geosociety.org, +1.303.357.1014.
August 9–12	9th International Conference on Diffuse Pollution, Johannesburg, South Africa. Abstracts due February 28, 2005. **Information:** www.iwa-wisa-2005.com/ or contact Dr. Ralph Heath at ralphh@phd.co.za.

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

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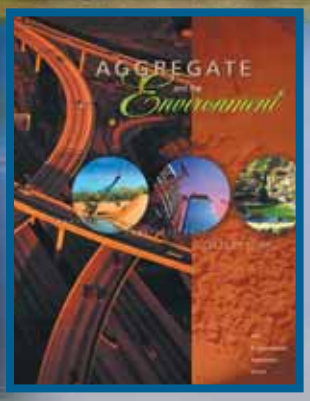


Aggregate and the Environment

William H. Langer, Lawrence J. Drew, Janet S. Sachs
ISBN 0-922152-71-3. Item #631601

Aggregate resources are vital to our way of life because they are the major raw materials used in construction of roads, rail lines, bridges, hospitals, schools, airports, factories, and homes, but the mining and processing of natural resources such as aggregate commonly raises concerns about potential environmental impacts. This book is designed to help you understand our aggregate resources and our living planet.

Petroleum and the Environment

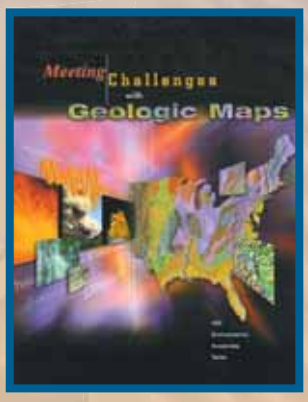
William E. Harrison and Stephen M. Testa
ISBN 0-922152-68-3. Item #605002

Concerned citizens recognize the need to manage both our petroleum resources and natural environments wisely. This publication provides an introduction to the major environmental concerns and solutions associated with petroleum exploration, production, transportation, and use.

Meeting Challenges with Geologic Maps

William A. Thomas
ISBN 0-922152-70-5. item #634601

Geologic maps are our most important and complete compilation of information about the solid Earth we live on, and we cannot understand the Earth without them. *Meeting Challenges with Geologic Maps* presents 16 examples that show how geologic maps are helping to delineate fragile habitat and ecosystems, protect against natural hazards, and find needed resources.



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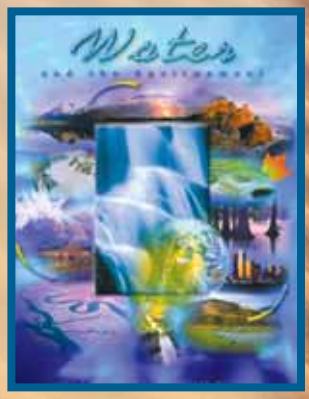

Water – not oil or minerals – is the most controlling resource on Earth. Its distribution, quantity, availability, and quality are the controls for the development of agriculture, industry, rural, urban, and municipal use. *Water and the Environment* provides information about water and its importance; where water comes from; water-related environmental concerns; water protection, policies and regulations; and our future needs for water.

Water and the Environment

Stephen J. Vandas, Thomas C. Winter, and William A. Battaglin
ISBN 0-922152-63-2. Item #633001

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Positions Open

FACULTY POSITION IN GEOPHYSICS
UNIVERSITY OF WISCONSIN–MADISON

The Department of Geology and Geophysics invites applications for a tenure-track assistant professor position in geophysics beginning August 2005. The evaluation of candidates will focus primarily on their potential for innovative scientific research and teaching. We invite applications from outstanding candidates across the spectrum of geophysical research, and particularly encourage candidates who would interact with our existing programs in geodynamics, seismology, structural geology, and tectonophysics. Teaching responsibilities are at both the graduate and undergraduate level. Applicants should submit a resume, statement of research interests, and names of three or more references by March 1, 2005, to: Geophysics Search Committee Chair, Department of Geology and Geophysics, University of Wisconsin–Madison, 1215 W. Dayton St., Madison, WI 53706

The University of Wisconsin–Madison is an equal-opportunity/affirmative action employer and encourages applications from women and minorities.

STRUCTURAL GEOLOGY/BATES COLLEGE

The **Bates College Department of Geology** invites applications for a **one-year sabbatical leave replacement** in the general area of **tectonics** and **structural geology** beginning in **Fall 2005**.

Bates College is a highly selective liberal arts college of approximately 2,000 students, located in Maine, 1 hour north of Portland and 2.5 hours north of Boston. Bedrock outcrops along the Maine coast and the White Mountains, which the department uses for labs, fieldtrips, and research, expose world-class structures produced by Acadian and Alleghenian collisions and Mesozoic rifting.

Teaching responsibilities include an introductory tectonics course with multiple lab sections, a sophomore-level structural geology course with a lab, and an advanced junior/senior-level geology course on a topic of the candidates choosing. The replacement is also expected to advise one to three senior theses during the year as part of the department's required senior thesis program. A Ph.D. is preferred, but consideration will be given to applicants who have not yet completed their Ph.D.

Review of applications begins April 1, 2005, and will continue until the position is filled. Please mail a letter of application, curriculum vitae, transcripts, three complete letters of recommendation and sample syllabi for one or more of the courses above to: **Geology Search Committee (#R2354), c/o Bates College Academic Services, 2 Andrews Road, 7 Lane Hall, Lewiston, ME 04240.**

For more information, please contact Prof. Dykstra Eusden, Chair, at deusden@bates.edu, www.bates.edu.

Bates College values a diverse college community and seeks to assure equal opportunity through a continuing and effective Affirmative Action program.

PLANETARY SCIENCE/REMOTE SENSING
UNIVERSITY OF NORTH DAKOTA

The Department of Space Studies at the University of North Dakota seeks a Planetary Scientist with strong remote sensing training to begin their appointment Fall Semester 2005. Appointment will be at the assistant professor rank on the tenure-track. Exceptional candidates may be considered at the associate professor rank. A Ph.D. in Planetary or Earth Science or appropriate field with a remote sensing specialty is required. A strong interest in developing collaborative research projects with existing interests in volcanology, planetary surface processes, characterization of planetary surfaces, and planetary analog studies is expected. Significant and ongoing involvement with space missions and the space community will be an advantage. Duties will include teaching graduate courses in the areas of Planetary Science, and Applications of Remote Sensing, on campus and through distance learning technologies; research; advising students; and providing service to the University and the community.

Space Studies is an interdisciplinary program featuring an M.S. degree and an undergraduate minor. This new faculty position will enhance and complement the department's current emphasis in space policy, space history, space systems engineering, space life sciences, planetary science, remote sensing, and Earth system science. An interdisciplinary appreciation of space exploration will be expected. A Ph.D. is planned for the near future and the new hire is expected to play an important role in developing a research focus in the area of planetary science. The department is the lead institution in North Dakota's NASA Space Grant Consortium and the ND NASA EPSCoR Program. Additional information about the department is at http://www.space.edu.

Salary will be competitive and commensurate with qualifications and experience. Send a letter of application, CV, teaching and research statements, names and contact information for three references to: Dr. Shan de Silva, Chair, Dept. of Space Studies, University of North Dakota, PO Box 9008, Grand Forks, ND 58202-9008. Email: desilva@space.edu. UND is an equal opportunity, affirmative action employer.

PERMANENT FULL-TIME INSTRUCTOR POSITION
WASHINGTON STATE UNIVERSITY

The Department of Geology, Washington State University, seeks to fill a full-time, permanent instructor position for our popular introductory Physical Geology course to begin Fall semester 2005. The successful candidate must have earned a Ph.D. in the geosciences or geoscience education, and demonstrate a commitment to excellence in geoscience teaching. The candidate will be expected to teach multiple sections of the introductory course each semester and oversee the integration of its laboratory into the curriculum. See http://www.wsu.geology/ for more details on the position, the introductory course and its role in our department's curriculum.

Applications should include a full curriculum vitae, a statement of teaching philosophy, and the names, addresses and email addresses of 3 referees. Screening of applicants will begin February 15, 2005. Applications for the position should be addressed to Dr. Michael Pope, Chair, Geoscience Instructor Search Committee, Department of Geology, Washington State University, Pullman, WA 99164, USA.

Washington State University employs only U.S. citizens and lawfully authorized non-U.S. citizens. All new employees must show employment eligibility verification as required by the U.S. Immigration and Naturalization Service. WASHINGTON STATE UNIVERSITY IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EDUCATOR AND EMPLOYER. Members of ethnic minorities, women, Vietnam era or disabled veterans, persons of disability and/or persons the ages of 40 and over are encouraged to apply.

SURFICIAL PROCESSES/HYDROLOGY
COLLEGE OF WILLIAM & MARY

The Geology Department at the College of William & Mary is seeking applicants for a full-time, one-year, leave-replacement position for the academic year 2005–2006 pending budgetary approval. The successful applicant will teach undergraduate courses including surface processes, hydrology, environmental geology, and introductory geology. We seek a colleague eager to interact with undergraduates in an environment where teaching and research are emphasized. The department has five full-time faculty and a laboratory coordinator. We prefer candidates who will have Ph.D. in hand at the time of appointment, but will consider those nearing completion of the Ph.D. Applicants should send a letter of application, current c.v., statement of teaching interests, and three letters of reference to: Greg Hancock, Department of Geology, College of William & Mary, PO Box 8795,

TEXAS A&M UNIVERSITY
Department of Geology & Geophysics

M.T. Halbouty '30 Visiting Chair

The Department of Geology & Geophysics, Texas A&M University, invites applications for the Michel T. Halbouty '30 Visiting Chair position. We particularly encourage applications from established researchers in any field seeking a sabbatical location or extended stay to develop or continue collaboration with faculty in the Department.

While there are no application deadlines, we will begin selecting a short list in March, 2005. Once selected, start time may be immediate. Compensation is negotiable but may include salary for up to one year.

Send letter of interest and resume to Dr. David V. Wiltschko, Chair, Halbouty Chair Search Committee, Department of Geology & Geophysics, 3115 Texas A&M University, College Station, TX, 77843-3115; d.wiltschko@tamu.edu.

Texas A&M is an equal opportunity employer that encourages applications from minority group members and women.

CLASSIFIED ADVERTISING

Williamsburg, VA 23187-8795. E-mail: gshanc@wm.edu. Review begins February 21, 2005, and will continue until the position is filled. The College of William & Mary is an EEO/AA university.

LECTURER, DEPARTMENT OF GEOLOGY
UNIVERSITY OF TORONTO

We invite applications for a full-time teaching-stream appointment at the rank of Lecturer. The primary responsibilities will be to teach and provide innovative support for undergraduate courses in geology. In addition, the Lecturer will assist with field courses and provide support for laboratory classes. Important secondary responsibilities are to take a leadership role in geoscience awareness activities, and to engage in university outreach programs, including participation in departmental promotional events and presentations at schools and other public organizations. There is no requirement as Lecturer to do research but the individual selected is not discouraged from this. A Ph.D. in Geology or a related area is required, together with evidence of excellence in teaching at the university level.

The appointment is available from July 1, 2005. It is initially for a term of one year and, following a successful review, will be renewed. Lecturer positions at the University of Toronto are renewable annually and assessment for promotion to a continuing Senior Lecturer rank may take place in the fifth year.

Applicants should send their curriculum vitae with a statement of their teaching philosophy and materials relevant to teaching experience. They should also ask three referees to send letters directly to the search committee. Applications and letters of reference should be sent to: Chair, Lecturer Search, Department of Geology, University of Toronto, 22 Russell Street, Toronto, Ontario, Canada M5S 3B1.

E-mailed applications and letters of reference will not be accepted nor will letters of reference submitted with the application package. The application deadline is February 14, 2005. Applications received after this date will be considered until the position has been filled.

The University of Toronto is strongly committed to diversity within its community and especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, members of sexual minority groups and others who may contribute to the further diversification of ideas.

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

TENURE-TRACK ASSISTANT PROFESSORSHIP PALEOCEANOGRAPHY, UNIVERSITY OF TORONTO

The University of Toronto is further expanding its research in the area of climate change and, to that end, the Department of Geology is seeking an outstanding individual for an appointment on its St. George (downtown) campus at the level of assistant professor in paleoceanography. We encourage applications from candidates in all specialties within this broad field. Applicants must demonstrate their academic excellence, their ability of independent research and a potential for collaboration with existing research programs in the University. In addition to establishing an internationally recognized independent research program, the successful candidate must have a strong commitment to teaching. He/she will be expected to teach graduate and upper level undergraduate courses in fields related to their specialization as well as general introductory courses. The position is available from July 1, 2005.

Applicants should provide their curriculum vitae, including a list of publications, a brief statement describing their research program and teaching philosophy. They should also ask three referees to send letters directly to the search committee. Applications and letters of reference should be sent to: Chair, Paleoceanography Search, Department of Geology, University of Toronto, 22 Russell Street, Toronto, Ontario, Canada M5S 3B1.

E-mailed applications and letters of reference will not be accepted nor will letters of reference submitted with the application package. The application deadline is February 14, 2005. Applications received after this date will be considered if the position has not been filled.

The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, members of sexual minority groups, and others who may add to the diversity of ideas. Information about the department is on our web site at www.geology.utoronto.ca. Enquiries about the application should be sent to geol_sec@geology.utoronto.ca.

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

THREE TENURE TRACK POSITIONS UNC–CHAPEL HILL IN GEOLOGICAL OCEANOGRAPHY AND/OR SEDIMENT DYNAMICS

The Marine Sciences Program of the University of North Carolina at Chapel Hill seeks to fill three (3) tenure track faculty positions spanning the areas of Geological Oceanography, Marine Geology and Sediment Dynamics. Two positions will be at the Institute of Marine Sciences (IMS) on the coast in Morehead City, and one will be in the Department of Marine Sciences (MASC) in Chapel Hill.

Department of Marine Sciences Position: All aspects of geological oceanography will be considered. We encourage applicants whose research complements existing strengths and/or cuts across traditional disciplinary boundaries (see www.marine.unc.edu/MASC.html for further information). The candidate filling the MASC position will be expected to teach one course per semester.

Institute of Marine Sciences Positions: Estuarine, coastal and continental shelf processes are focal areas at IMS, and interest in observational studies is desirable (see www.marine.unc.edu/IMS.html for more information). The IMS positions carry no formal teaching requirement, although undergraduate and graduate teaching opportunities exist.

The selected individuals will be expected to develop vigorous, externally funded research programs, publish in peer-reviewed journals, and direct graduate students. Qualifications include a Ph.D. in Geological Oceanography, Marine Geology, Engineering or a related field. Post-doctoral experience is preferred. We anticipate that these positions will be filled at the Assistant Professor level; one position at IMS might be filled at the Associate Professor level. Nine months' salary support is provided for each position.

Applicants should submit a CV and statements of research and (for MASC) teaching interests. Also arrange for four letters of reference to be sent to the Chair, Geological Oceanography Search Committee, UNC–Chapel Hill, Dept. of Marine Sciences, Venable Hall CB#3300, Chapel Hill, NC 27599. Please indicate whether you would like to locate at IMS or MASC. Applications will be considered beginning March 1, 2005. The University of North Carolina at Chapel Hill is an equal opportunity employer.

ASSISTANT PROFESSOR, GEOPHYSICS
UTAH STATE UNIVERSITY

The Geology Department at Utah State University seeks candidates for a tenure-track position at the assistant professor rank in geophysics to start in August 2005. A Ph.D. in geophysics or a closely related field is required for the position, and candidates should have demonstrated research excellence and a commitment to teaching. Successful candidates will be expected to develop an independent research program, to teach graduate and undergraduate courses in geophysics, and to integrate with existing strengths in the department. We encourage geophysicists with expertise in (but not limited to) seismology, exploration geophysics, geodesy, potential fields, geodynamics, and paleomagnetism and who examine processes within the continental crust/lithosphere to apply. Further information is available at http://www.usu.edu/geoldept/. Applicants should send a detailed CV, statements of teaching and research interests, and names and addresses of at least three references to: Prof. James P. Evans, Chair, Search Comm., Dept. of Geology, Utah State University, Logan, UT 84322-4505. Review of applications will begin Feb. 1, 2005. USU is an AA/EO employer with an NSF Advance Grant to promote opportunities for minorities and women in the sciences and engineering.

MINERALOGY/PETROLOGY/STRUCTURAL GEOLOGY
UNIVERSITY OF PITTSBURGH AT JOHNSTOWN

The University of Pittsburgh at Johnstown, a four-year, degree-granting institution invites applications for a tenure-track position at the Assistant Professor level in the Department of Geology & Planetary Science beginning in the 2005 fall term. Primary instructional responsibilities will include Mineralogy, Igneous and Metamorphic Petrology, and Structural Geology courses (including labs), as well as non-lab introductory courses. Requirements include: Ph.D. in geology at time of appointment; teaching and research experience appropriate to the position; strong commitment to undergraduate education including field-oriented undergraduate research; and excellent communication skills. An interest in Appalachian geology is also desirable. To apply, send a letter of interest (including a statement of teaching and research goals); a statement of eligibility to work in the U.S.; curriculum vita; transcripts for all degrees (copies acceptable initially); and names and contact information for at least three references to Dr. Jack D. Beuthin, Geology Search Committee Chair, Department of Geology & Planetary Science, University of Pittsburgh at Johnstown, Johnstown, PA, 15904. Review of applications will begin on February 1, 2005, and will continue until the position is filled. Email correspondence can be sent to beuthin@pitt.edu. The University of Pittsburgh is an Equal Opportunity, Affirmative Action employer. Women and members of minority groups underrepresented in academia are especially encouraged to apply.

STABLE ISOTOPE GEOCHEMISTRY
SOUTHERN ILLINOIS UNIVERSITY CARBONDALE

The Department of Geology at Southern Illinois University Carbondale invites applications for a tenure-track position in stable isotope geochemistry at the assistant professor level with a start date of Aug. 16, 2005. Post-doctoral experience is preferred. The applicant should demonstrate the existence of, or potential for developing, an internationally recognized, externally funded research program. We prefer a stable isotope geochemist who can contribute to our existing strengths in energy and environmental geology with the potential to collaborate with faculty in other departments, such as an ecologist currently being sought by the Department of Zoology, or with the Coal Research Center or the Mining and Mineral Resources Program. The successful applicant is expected to teach courses in introductory geology and undergraduate and graduate courses in their area of expertise. Normal teaching load is three to four courses per academic year. Applicants must hold a Ph.D. or show that they will complete all degree requirements by the time of appointment.

Review of applications will begin February 15, 2005, and continue until the position is filled. Applicants should submit a curriculum vitae, a statement of teaching and research interests, and the names and addresses of at least three referees to: Dr. Scott Ishman, Search Committee Chair, Department of Geology, Mailcode 4324, Southern Illinois University Carbondale, Carbondale, IL 62901-4324. Fax: (618) 453-7393. E-mail: sishman@geo.siu.edu.

Southern Illinois University Carbondale is a large, research-oriented institution situated in a pleasant small-town setting southeast of St. Louis. SIUC is seeking to enhance interdisciplinary research as it strives to be a top 75 public research university (http://news.siu.edu/s150/). The Geology Department has a full-time faculty of 10 with about 40 undergraduate and 30 graduate students and offers Bachelor and Master degree programs in geology and participates in the Interdisciplinary Environmental Resources and Policy Ph.D. program.

For further information, please visit our comprehensive website www.science.siu.edu/geology. SIUC is an affirmative action/equal opportunity employer that strives to enhance its ability to develop a diverse faculty and staff and to increase its potential to serve a diverse student population. All applications are welcomed and encouraged and will receive consideration.

Opportunities for Students

Three Applied Geohydrology Summer Research Assistantships. Kansas Geological Survey, University of Kansas. These are 12-week summer positions open to students at any university. $5,880 for 12 weeks. Required: Relevant coursework in earth sciences or engineering and interest in hydrogeology. Initial review date: March 1, 2005. For more information go to http://www.kgs.ku.edu/General/jobs/geohydro_applied.html; to apply go to http://jobs.ku.edu (search by Research Assistant title). EO/AA Employer.

Opportunities for Graduate Study in Geology at Kent State University. The Department of Geology at Kent State University, composed of sixteen full-time faculty, seeks motivated students for graduate study in Geology in the general areas of: Earth Evolution, Earth Surface Processes, Engineering Geology, or Tectonics. Interdisciplinary research opportunities are also available through the Kent State University Water Resources Research Institute (http://dept.kent.edu/wrri/). Graduate stipends are awarded on a competitive basis with rolling admission. While applications are evaluated continuously, to receive full consideration for financial support, they must be received by February 15 for August admission. Applications may be submitted to Kent State University online at: http://dept.kent.edu/geology/graduate/gradapp.html.

For complete information regarding faculty research interests and the graduate program, please see our website (http://dept.kent.edu/geology/) or contact the graduate coordinator, Dr. Rodney Feldmann. The

Department of Geology offers a comprehensive course of study leading to the M.S. or Ph.D. degree. Emphasis is placed on research designed not only to advance the understanding of the geological sciences, but also to solve societal problems.

Students wanted for asteroid spectroscopic research. The Department of Space Studies at the University of North Dakota in Grand Forks is seeking prospective Master's and Doctoral students who wish to pursue careers in asteroid research. Specifically, we are looking for students with geological backgrounds (BS or MS degree) who are interested in asteroid mineralogical studies via the application of near-infrared spectroscopic techniques using large astronomical observatories. This research aims to identify asteroid major mineralogies, redox states, and the relationships between asteroids and meteorites. Both main-belt and near-Earth asteroids are presently areas of focus. Knowledge obtained is used to constrain early solar system physical conditions and to determine hazard mitigation techniques for potentially hazardous asteroids. Contact Dr. Paul Hardersen at (701) 777-4896 or via email at Hardersen@volcano.space.edu for more information.

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YOUNGSTOWN STATE UNIVERSITY

SEDIMENTARY GEOLOGY

THE DEPARTMENT OF GEOLOGICAL & ENVIRONMENTAL SCIENCES at YOUNGSTOWN STATE UNIVERSITY invites applications for a tenure-track faculty position available Fall 2005. Ph.D. in a geoscience area required. Seeking individual committed to excellence in teaching and research in Sedimentology/Stratigraphy. Preference will be given to candidates with interests in science education, paleontology, geomorphology and/or GIS applications.

Review of application will begin February 15, 2005.

Submit letter of application, current vita, official transcripts of all degrees, and three references to: **Dr. Charles Singler, Chairperson, Geological & Environmental Sciences, Youngstown State University, One University Plaza, Youngstown OH 44555.**

Website: **www.ysu.edu**

For additional information regarding YSU hiring procedures visit us at **www.cc.ysu.edu/hr**

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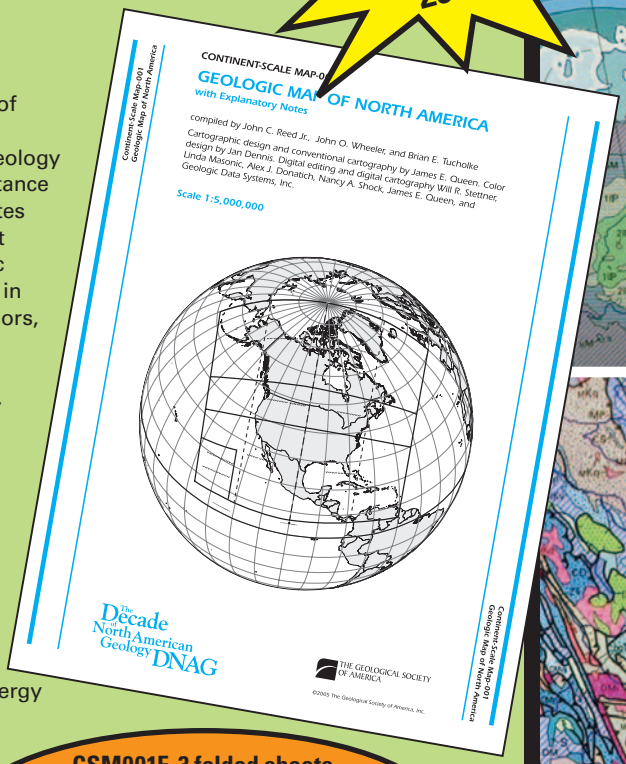

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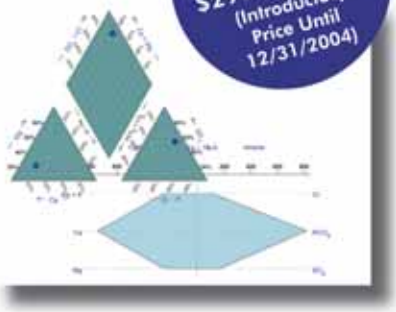

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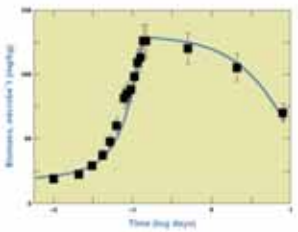

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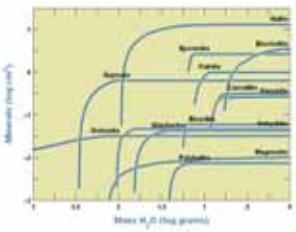

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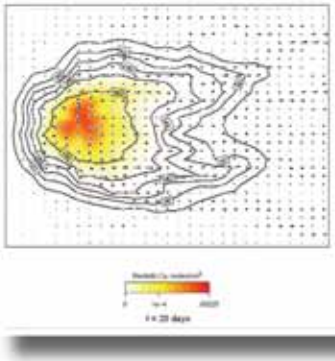

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