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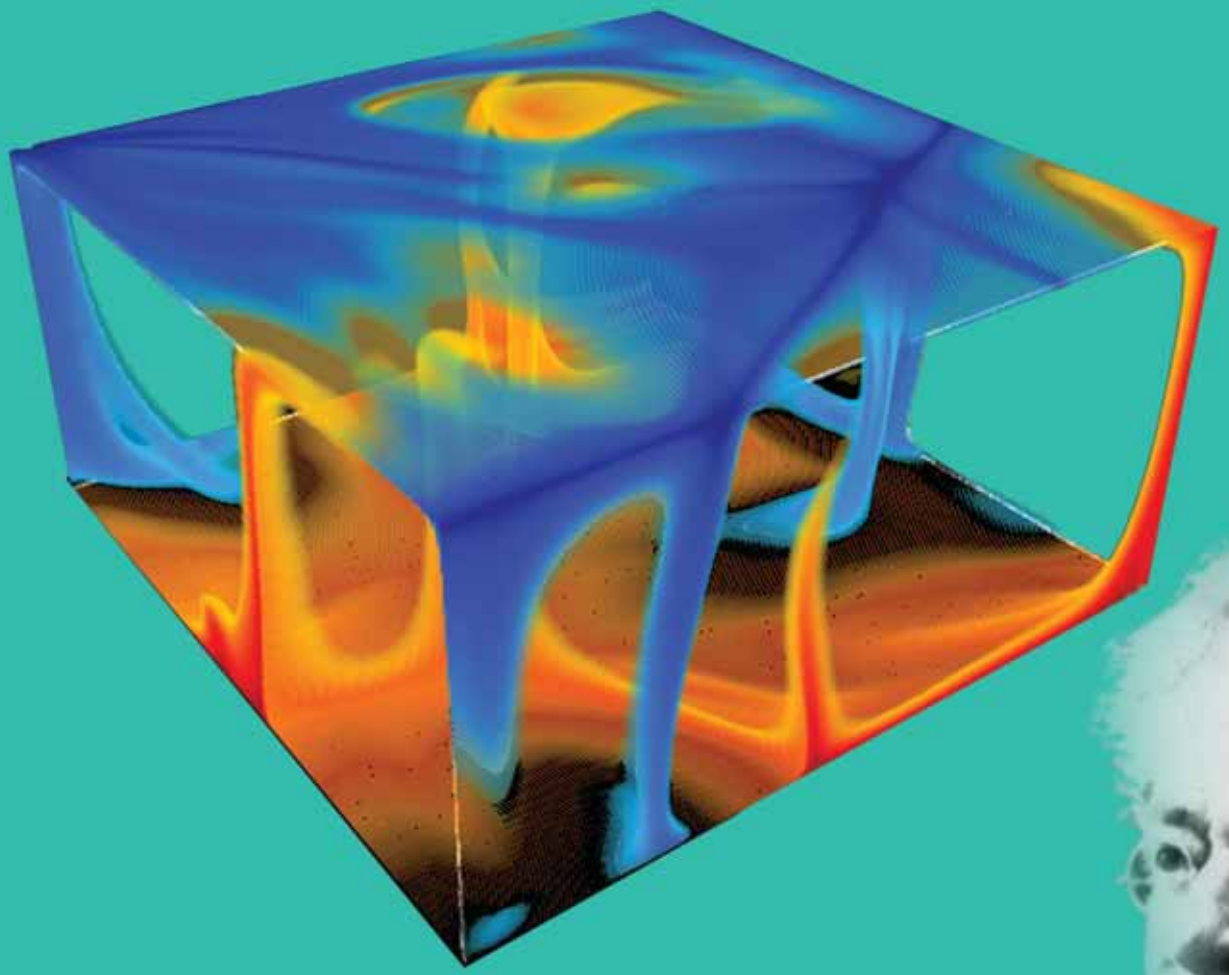

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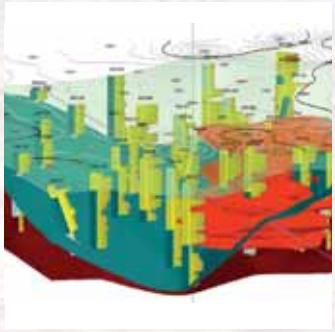

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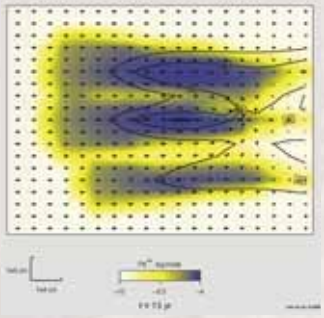

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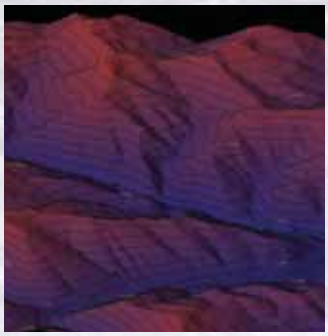

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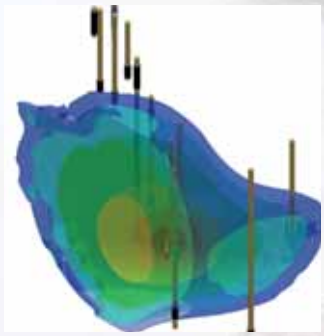

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Cover: John Perry suggested, in 1895, that convection in the Earth might allow a much greater age for the Earth than was suggested by Lord Kelvin's calculation, which was based on conduction. Photograph of John Perry published with kind permission of the Department of Mathematics, Imperial College London. Image of convection simulation by G. Houseman using visualization software provided by J. Schmalzl. See "John Perry's neglected critique of Kelvin's age for the Earth: A missed opportunity in geodynamics" by England et al., p. 4–9.

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ADVERTISING:
Classifieds & Display: Ann Crawford, +1.800.472.1988, ext. 1053, +1.303.357.1053, Fax +1.303.357.1070; acrawford@geosociety.org

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SCIENCE ARTICLE

John Perry's neglected critique of Kelvin's age for the Earth: A missed opportunity in geodynamics

Philip England, *Department of Earth Sciences, Oxford University, Parks Road, Oxford OX1 3PR, UK;* ***Peter Molnar,*** *Department of Geological Sciences and Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado 80309, USA;* ***Frank Richter,*** *Department of the Geophysical Sciences, 5734 S. Ellis Ave. Chicago, Illinois 60637, USA*

ABSTRACT

Many readers know the tale of how William Thomson (later Lord Kelvin) calculated the age of the Earth from physical principles and adhered for over 50 years to an estimate that was far younger than geologists' estimates, despite the virtually unanimous opposition of the geological community of the time. The prevalent version of this tale alleges that the discovery of radioactivity simultaneously provided the demonstration (through radiometric dating) that Kelvin had greatly underestimated the age of the Earth and the explanation of why he was wrong (radioactivity being a source of heat that invalidated Kelvin's calculation). We show this popular story to be incorrect; introducing the known distribution of radioactivity into Kelvin's calculation does not invalidate its conclusion. In 1895, before the discovery of radioactivity, John Perry showed that convection in the Earth's interior would invalidate Kelvin's estimate for the age of the Earth, but Perry's analysis was neglected or forgotten, with the consequence that a powerful argument in favor of mobilism was overlooked during the first few decades of debate about continental drift.

INTRODUCTION

The story of Kelvin and the age of the Earth is often told as a David-and-Goliath struggle, with the geologists in the role of the underdog armed only with the slender sword of geological reasoning, while Lord Kelvin bludgeoned them with the full force and prestige of mathematical physics. Kelvin's comeuppance is often taken as evidence that simple physics ought not to be applied to geological problems, but there have been numerous occasions when simple physical models have had great explanatory power in geology. Perry's critique of Kelvin's calculation reminds us that even well-posed physical models can sometimes be misleading, but recognition of their flaws may lead to major advances.

KELVIN'S CALCULATION OF THE AGE OF THE EARTH

We cannot, in this short space, approach a full description of Kelvin's arguments about the age of the Earth. The reader is referred to Burchfield (1975) for a detailed account of the controversy, to Lindley (2004) for a very readable biography, with an insightful account of the debate on the age of the Earth in the context of Kelvin's other work, and to Richter (1986) and Stacey (2000) for other geophysical perspectives on Kelvin's calculations.

Fourier laid the groundwork for the mathematical analysis of the flow of heat in his treatise *Théorie Analytique de la Chaleur* (Fourier, 1822), and he made arguments that the Earth must be cooling (Fourier, 1827), with which Lyell was certainly familiar (Lyell, 1830, p. 140–141). Kelvin first wrote on heat when he was 16, clarifying some of Fourier's mathematics, and he first addressed the age of the Earth in 1844 when he showed that, if one were to assume that the Earth is a solid body cooling from an initially high temperature, measurement of the rate of heat loss from its surface would place bounds on its age.

Kelvin imagined the Earth to have solidified from an originally molten state, such that its initial condition was of uniform temperature, T_0, with its surface maintained at a constant temperature for all time. Under these assumptions, temperature depends upon depth, z, below the Earth's surface, and upon time, t, since the initial state. Fourier had shown that the diffusion of heat in a solid is described (in one spatial dimension and in the absence of heat sources) by

$$\frac{\partial T}{\partial t} = \kappa \frac{\partial^2 T}{\partial z^2}, \tag{1}$$

where T is temperature, and κ is the thermal diffusivity (Table 1).

We take the surface of the Earth ($z = 0$) to be at a temperature of 0 °C; given that any plausible estimate for T_0 is several thousand such degrees, the small deviations of the Earth's surface temperature from 0 °C may be neglected. With the stated initial and surface conditions, and with the condition that the temperature tends to T_0 at infinite depth, the solution to Equation 1 is

$$T(x,t) = T_0 \mathrm{erf}\left(\frac{z}{2\sqrt{\kappa t}}\right), \tag{2}$$

where erf(x) is the error function (e.g., Carslaw and Jaeger, 1959). The temperature gradient at the Earth's surface is

$$G = \left.\frac{\partial T}{\partial z}\right|_{z=0} = \frac{T_0}{\sqrt{\pi \kappa t}} \tag{3}$$

(Fourier, 1822; Kelvin, 1863a). An excellent introduction to thermal diffusion is given by Carslaw and Jaeger (1959), and all solutions to the diffusion problems we discuss can be found there.

The expressions of Equations 2 and 3 are familiar to many as the solution for the cooling of the oceanic lithosphere when it is treated as a half-space (Turcotte and Oxburgh, 1967; Parsons and Sclater, 1977; see also Turcotte and Schubert, 2002, p. 157). This problem is mathematically identical to Kelvin's problem, though the age involved is that of the ocean floor, rather than of the Earth.

Equations 2 and 3 express the fact that, in a given time, t, the average distance that heat can diffuse is approximately $\sqrt{\pi \kappa t}$

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and, in consequence, at any time, t, material at a depth greater than $\sqrt{\pi\kappa t}$ is still at its original temperature and, to a good approximation, the temperature gradient between the surface and the depth is $T_0/\sqrt{\pi\kappa t}$.

The key point of Kelvin's model is that Equation 3 may be inverted to give t, the age of the Earth, in terms of the geothermal gradient, G, or the heat flux, Q, observed at the Earth's surface now:

$$t = \frac{\left(T_0/G\right)^2}{\pi\kappa} = \frac{\left(KT_0/Q\right)^2}{\pi\kappa}. \quad (4)$$

When Kelvin first made these arguments in 1844 and 1846, geothermal data were not available to him. By the time he returned to the problem 15 years later, geothermal gradients had been measured in several parts of the world. Kelvin (1863a) quoted measurements of between 1/110 °F and 1/15 °F of temperature increase per foot of depth and chose as a mean gradient for his calculation 1/50 °F per foot (or ~36 °C/km). With an assumption of the initial temperature, T_0, based on melting experiments on rocks (7000 °F, ~3900 °C) and with an estimate, based on laboratory measurements, of $\kappa \approx 1.2 \times 10^{-6}$ $m^2\ s^{-1}$, this gradient yields an age of 96 Ma; Kelvin (1863a) gave bounds of 24 Ma and 400 Ma on the age to take account of uncertainties in thermal gradient and thermal conductivity.

For the rest of our discussion, we shall use heat flux, rather than thermal gradient, because it is the more fundamental unit, in part because it is unaffected by near-surface contrasts in conductivity. The Earth's average surface heat flux is 80mW m^{-2}; the average for the continents is ~60mW m^{-2} and, except in the shields, the background heat flux in the continents (after the contribution from near-surface radioactivity has been stripped out) is ~40mW m^{-2} (Sclater et al., 1981). We therefore take the range of surface heat flux that has to be matched by any proposed thermal history of the Earth to be 40–80mW m^{-2}. Using this range, and the values of other quantities given in Table 1, the modern equivalent of Kelvin's estimate is 24–96 Ma.

Scientists derive an extra measure of confidence in a conclusion if they can arrive at it by more than one independent route, and this was no doubt true in Kelvin's case. He had shown that, given what was known at the time, the only plausible source for the energy radiated by the sun was internal energy derived from gravitational potential energy release during its accretion. He had calculated the amount of this energy and concluded that it could sustain the present rate of radiation from the sun for no more than 100 m.y. (Stacey, 2000). The agreement between these two apparently independent estimates strengthened Kelvin's conviction in his calculation of the age of the Earth.

TABLE 1. NOTATION FOR, AND ASSUMED VALUES AND UNITS OF, RELEVANT PHYSICAL QUANTITIES

A	Heat production		$\mu W\ m^{-3}$
c	Specific heat	10^3	$J\ kg^{-1}\ K^{-1}$
G	Geothermal gradient at the Earth's surface		°C/km
K	Thermal conductivity	3	$W\ m^{-1}\ K^{-1}$
κ	Thermal diffusivity ($= K/\rho c$)	10^{-6}	$m^2\ s^{-1}$
L	Conducting lid to the Earth		m
Q	Surface heat flux	40–80	$mW\ m^{-2}$
R	Radius of the Earth	6.4×10^6	m
ρ	Density	3300	$kg\ m^{-3}$
t	Time		s
T	Temperature		°C
T_0	Initial temperature of the Earth	1300	°C
T_i	Interior temperature of the Earth (Equation 5)		°C
z	Depth		m

KELVIN AND THE GEOLOGISTS

The early nineteenth-century formulation of Uniformitarianism was commonly expressed through Hutton's aphorism, "No vestige of a beginning, no prospect of an end." The doctrine that the Earth was of unlimited age allowed geologists to explain any phenomenon not by the laws of physics, but by "reckless drafts on the bank of time" (Chamberlin, 1899). For Kelvin, this game without rules was simply not scientific; indeed, it was forbidden by the laws of thermodynamics, which he had played such a large part in developing.

In 1867, Kelvin had a conversation with the geologist Andrew Ramsay, "almost every word of which remains stamped on my mind to this day" (Kelvin, 1899; see also Lindley, 2004, p. 175–177). They had been listening to Archibald Geikie discussing the

> … geological history of the actions by which the existing scenery of Scotland was produced. I asked Ramsay how long a time he allowed for that history. He answered that he could suggest no limit to it. I said "You don't suppose geological history has run through 1,000,000,000 years?" "Certainly I do." "10,000,000,000 years?" "Yes." "The sun is a finite body. You can tell how many tons it is. Do you think it has been shining for a million million years? " "I am as incapable of estimating and understanding the reasons which you physicists have for limiting geological time as you are incapable of understanding the geological reasons for our unlimited estimates." I answered, "You can understand the physicists' reasoning perfectly if you give your mind to it."

It is easy to overlook the enormous gains to geology that came simply from having to fight the battle with Kelvin about the age of the Earth. By the end of the nineteenth century, the doctrine of a steady-state Earth of indefinite age had been replaced by the understanding that present geological processes provide guides to, and constraints upon, past geological events: "No vestige of a beginning, no prospect of an end" had been replaced by "The present is the key to the past" (Chamberlin, 1899; Burchfield, 1975). Even before radioactivity was discovered, geologists had come to accept that the age of the Earth was finite and that estimating the age by quantitative reasoning was a crucial part of geological endeavor.

What nobody did until 1895, however, was to put their mind, as Kelvin had suggested, to the physicists' reasoning, and discover the flaw in it.

KELVIN'S ASSUMPTIONS

A single principle underlies all Kelvin's arguments about the age of the Earth: that energy is conserved. To carry out his analyses, Kelvin added three assumptions. Two assumptions applied only to his arguments about the Earth: that the Earth

was rigid and that its physical properties were homogeneous. The third assumption, that there was no undiscovered source of energy, applied both to the Earth and to the sun.

The conventional story alleges that his third assumption was Kelvin's undoing, but as we shall show below, this story, while correct for the age of the sun, is incorrect for the age of the Earth. The real flaw in Kelvin's argument about the Earth was pointed out by one of his former assistants, John Perry, in 1895—a year before radioactivity was discovered and eight years before it became recognized as a source of heat.

Perry (1895a) wrote: "I have sometimes been asked by friends interested in geology to criticise Lord Kelvin's calculation of the probable age of the Earth. I have usually said that it is hopeless to expect that Lord Kelvin should have made an error in calculation." Instead of focusing on Kelvin's calculations, Perry suggested, one should examine his assumptions. In Kelvin's model, the present supply of heat to the Earth's surface is derived from the cooling of a shallow outer layer of thickness, $\sqrt{\pi\kappa t}$ (Equation 3). If, however, the thermal conductivity inside the Earth were much higher than at the surface, then the deep interior would also cool, providing a large store of energy to maintain the surface heat flux. In that case, Kelvin's estimate of the age of the Earth would be too low, potentially by a large multiple.

Perry had two reasons for postulating a higher conductivity in the interior. First, experimental evidence showed an increase, if modest, in conductivity of rocks with temperature; in addition, the Earth's increase in density with depth implies a greater proportion of iron and other materials that conduct heat better than do silicates. More radically, he argued (Perry, 1895a) that convection in the fluid, or partly fluid, interior of the Earth would transfer heat much more effectively than would conduction: "… much internal fluidity would practically mean infinite conductivity for our purpose."

Unable to calculate the role of convection in a complete fashion, Perry proposed approximating its effect by a high "quasi-conductivity" in the interior of the Earth. He suggested a simple thought experiment to illustrate this point. Suppose that only a thin outer skin of the Earth, of thickness L, transfers heat by conduction, and that the rest of the Earth has effectively perfect thermal conductivity. The heat flux through the conducting lid at any time, t, will be KT_i/L, where T_i is the interior temperature; this flux, multiplied by the Earth's surface area, will equal the rate at which the interior is losing heat:

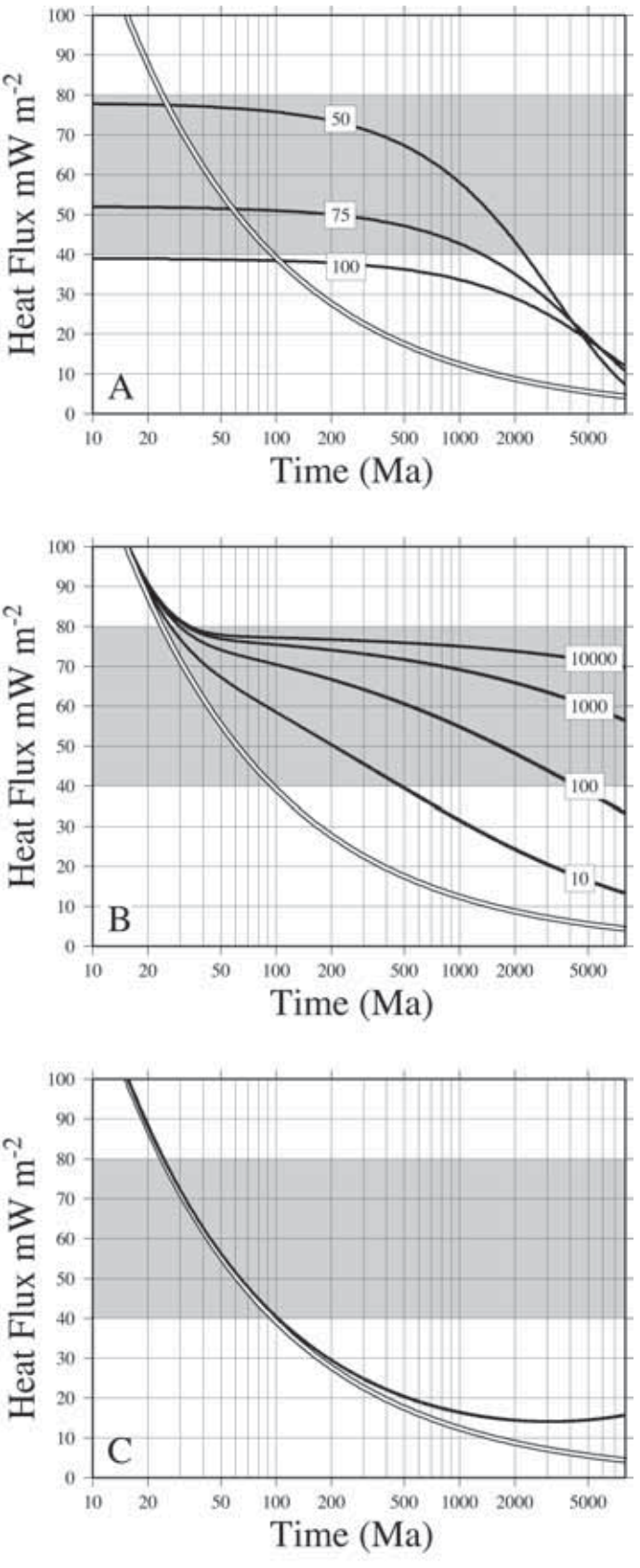
$$4\pi R^2 \frac{KT_i}{L} = \frac{4\pi R^3}{3}\rho c \frac{dT_i}{dt}. \quad (5)$$

The solution for T_i is

$$T_i = T_0 \exp\left(\frac{-3\kappa t}{RL}\right) \quad (6)$$

(Perry 1895a, p. 255, footnote 1). For a lid of thickness L = 100(50) km, the heat flux given by Equation 6 decays with a time constant ($RL/3\kappa$) of 6(3) Ga, and the Earth's measured heat flux is consistent with any age up to 2 Ga (Fig. 1A).

A less-than-perfect thermal conductivity for the interior of the Earth would cause it to cool down more slowly than is suggested by Equation 6. Perry and Heaviside modified Kelvin's calculation for the case of large, but finite, interior



conductivity (Perry, 1895b; Carslaw and Jaeger, 1959, p. 322) and showed that the Earth's present heat flux is consistent with an age of gigayears, provided that the conducting lid is a few tens of kilometers thick and the effective (or "quasi-") conductivity of the interior is ~100 times greater than that of the lid (Fig. 1B).

In modern parlance, Perry's "quasi-conductivity" for a convecting fluid would be expressed by the Nusselt number, which is the ratio of the heat flux out of a convecting layer to the heat that would be carried across the same layer by conduction alone. For the conditions appropriate to the Earth's mantle, this ratio is likely to be in the range of 30–100 (McKenzie et al., 1974; Turcotte and Oxburgh, 1967). In the past 30 years, numerous studies of the Earth's thermal history, using more rigorous parameterizations of convection than were available to Perry, have confirmed that the surface heat flux provides, at best, a weak constraint on the age of the Earth. Indeed, as Richter (1986) points out, the present challenge—given the age of the Earth—is to determine what physical conditions in its interior lead to the present value of the heat flux.

RADIOACTIVITY

Curie and Laborde (1903) demonstrated that radioactive decay releases heat, and several people soon argued that this source of heat was great enough to overturn Kelvin's conclusion about the age of the Earth. In 1904, Rutherford spoke on the matter at a meeting in the Royal Institution:

> I came into the room, which was half dark, and presently spotted Lord Kelvin in the audience and realized that I was in for trouble at the last part of the speech dealing with the age of the Earth, where my views conflicted with his. To my relief he fell fast asleep but as I came to the important point, I saw the old bird sit up, open an eye and cock a baleful glance at me! Then sudden inspiration came, and I said Lord Kelvin had limited the age of the Earth, *provided no new source of heat was discovered.* That prophetic utterance refers to what we are now considering tonight, radium! Behold! The old boy beamed at me. (Eve, 1939, p. 107).

Heat given out by radium obviously cannot be the missing energy, because the half-life of its dominant isotope is 1600 yr, but it soon was demonstrated (through assuming equilibrium in their decay series) that uranium and thorium provide heat sources with half-lives of gigayears. Within a few years, radiometric dating of rocks had stretched the age of the Earth to 2 Ga (Dalrymple, 1991, p. 69–78). Measurements of heat production in crustal rocks permitted the interpretation that all the Earth's surface heat flux could be explained by heat generated in a layer of granite a few tens of kilometers thick, but that interpretation was not subjected to anything like the rigorous scrutiny given to Kelvin's argument. Bailey Willis, recording these times forty years on, wrote: "Thanks to Madame Curie, the inexhaustible energies of the atom of the globe … are potentially available to geological speculation." (Willis, 1942; Oreskes, 1999, p. 48–51). In other words, Chamberlin's "reckless drafts" were now on the bank of heat, rather than on the bank of time.

We now know that the crust does not contain enough radioactive heat to explain the surface heat flux; nevertheless, it is still frequently stated that, because the discovery of radioactive heat undermined an assumption behind Kelvin's calculation, it also undermined his conclusion. This statement is logically incorrect; Kelvin's conclusion would be undermined by that discovery only if incorporation of the Earth's radioactive heat into his calculation produced a substantially different age for the Earth.

Modern estimates for the total present rate of radioactive heat generation within the Earth are ~2×10^{13} W, equivalent to a surface heat flux of 40mW m^{-2} (Sclater et al., 1981). It might, therefore, seem that the Earth's internal heat production can account for its surface heat flux, but we must recall that this heat production is distributed through the whole volume of the mantle, and diffusion of heat is slow. Kelvin's calculation (Equation 2) shows that only the outer ~100 km of the Earth will cool by conduction in 100 m.y., and we should correspondingly expect that, if Kelvin's calculation were re-run with the inclusion of radioactivity, only the heat generated in the outermost part of the Earth would contribute to the surface heat flux.

The heat flux at the surface of a half-space, whose temperature is zero at time $t = 0$ and that is thereafter heated internally at a rate A per unit volume is

$$Q = \frac{2A}{\sqrt{\pi}}\sqrt{\kappa t} \qquad (7)$$

(Carsaw and Jaeger, p. 79). This expression shows that only the heat generated within a distance ~$\sqrt{\kappa t}$ of the surface contributes to the surface heat flux at any time, t.

Kelvin's calculation can be adjusted to take into account internal heating by adding the heat flux from Equation 7 to that from Equation 3. If the total rate of radioactive heat generation (2×10^{13} W) is distributed evenly through the mantle, it is equivalent to a volumetric rate of $A = 0.02\mu$W m^{-3}. This level of heating raises the heat flux above that in Kelvin's calculation by

Figure 1. Calculations of the surface heat flux of the Earth according to the models discussed in the text. Shaded band in each panel of this figure shows the range of estimates for the mean surface heat flux at present day (see text). Double line shows the surface heat flux out of a semi-infinite medium of thermal diffusivity 10^{-6} m^2 s^{-1}, whose initial temperature is constant at 1300 °C (Kelvin's calculation: Equation 3, with the values of parameters given in Table 1). (A) The flux of heat through the surface of a sphere of radius 6400 km, whose outer 50 km, 75 km, or 100 km is a solid lid with thermal conductivity 3W m^{-1} K^{-1}, and whose interior is a well-stirred fluid (Equation 5). This is Perry's thought experiment for the cooling of a convecting planet (Equation 6). (B) The surface heat flux out of a layer that is 50 km thick, has a thermal diffusivity 10^{-6} m^2 s^{-1}, and thermal conductivity 3W m^{-1} K^{-1}. This layer is underlain by a half-space whose thermal conductivity is 10, 100, 1000, and 10000 times greater than that of the top layer, with its other properties the same. The medium has initial temperature T_0 = 1300 °C, and its surface is maintained at zero temperature (Carslaw and Jaeger, 1959, p. 322). This is the modification to the model illustrated in Figure 1A that was suggested by Perry and Heaviside (Perry, 1895b). (C) The surface heat flux from a semi-infinite medium that is heated internally (Carslaw and Jaeger, 1959, p. 79). The thermal diffusivity is 10^{-6} m^2 s^{-1}, the initial temperature of the medium is 1300 °C throughout, the surface is maintained at zero temperature for all time, $t > 0$, and the medium is heated internally at a rate A_0 = 0.02μW m^{-3}. This calculation shows the negligible influence of the Earth's radioactive heat production upon Kelvin's calculation.

a few mW m^{-2} the first g.y. of Earth's history (Fig. 1C); consequently—even if Kelvin had included radioactive heat in his calculation—his estimate of the age of the Earth would have been unaffected (Richter, 1986).

Thus, the discovery of radioactivity did not invalidate Kelvin's calculation for the age of the Earth. In a rigid Earth, with or without radioactivity, heat is delivered to the surface by conduction through a shallow layer, which can maintain a rate of heat loss comparable to today's for only a small fraction of what we now know to be the Earth's age.

WHY WERE PERRY'S ARGUMENTS FORGOTTEN, AND WHY WAS THE MYTH ACCEPTED?

Perry argued that Kelvin's estimate of the age of the Earth could be many times too low if its interior were fluid with a high "quasi-conductivity" due to its convection. The suggestion of a fluid mantle was not new; indeed, it was widely understood as the necessary condition for isostasy. Perry published his case (Perry, 1895a, 1895b, 1895c) in the pages of *Nature,* which, judging by the passion that authors of papers attached to their agendas, was as prominent an organ of scientific discourse in 1895 as it is today. It therefore seems probable that those concerned with the debate about the age of the Earth would have known of Perry's argument. So why was the argument not accepted in the decade before radioactive heat became established or, indeed, thereafter?

Part of the explanation may be that the debate often descended to the use of rhetoric in place of scientific argument. Kelvin (1899) cites many examples of rhetoric from his opponents and, while Kelvin himself was generally quite measured in his replies, P.G. Tait (in his self-appointed role as Kelvin's bulldog) did not hesitate to respond in kind (Lindley, 2004, p. 175–178) (see also letters from Tait, quoted in Perry, 1895a). Faced with all this hot air, Mark Twain (1903) concluded, "As Lord Kelvin is the highest authority in science now living, I think we must yield to him and accept his view." Perhaps a parallel sentiment led to Kelvin's view being supplanted by Rutherford's, after 1904.

It is also probable that Perry was not understood by most people who cared about the age of the Earth. A thread running through much of Kelvin's writing on this subject is that the geological community of his time shied away from mathematics (Lindley, 2004). Geologists may have regarded Perry's exchanges with Kelvin (Kelvin, 1895; Perry, 1895a, 1895b, 1895c) as nothing more than an incomprehensible tussle among physicists. Furthermore, that tussle may have seemed irrelevant. As suggested by Andrew Ramsay's tart conversation with Kelvin, many geologists felt that Kelvin was incapable of understanding geological reasoning, so some of the resistance to his arguments (and indifference to Perry's refutation) may have stemmed from the belief that geology is too complex to be encapsulated in a mathematical model.

Kelvin knew, however, that simple models are an indispensable tool in science, whose purpose is to allow analysis of the major features of phenomena, not slavishly to reproduce all their details. Many of the most useful models are underlain by a principle famously expressed by Einstein: "Everything should be made as simple as possible, but not simpler."

It is worth illustrating the explanatory power of simple models in geology by a relevant modern example. Suppose we wished to explain the flux of heat from the ocean floor. A model that accounted accurately only for major, obvious, geological variables (different thermal properties and thicknesses of sediments, crustal layers, and mantle; hydrothermal circulation; off-ridge volcanism, etc.) would still have at least a dozen parameters, many of them poorly known, and would require millions of calculations (probably numerical) simply to explore the parameter space; consequently, its results would be impossible to grasp. In contrast, treating the ocean floor as a homogeneous conducting medium yields a simple analytical solution (Equation 2) that captures the main features of the cooling of the seafloor as it moves away from the oceanic ridges and explains the surface elevations of half of the Earth's surface (Parsons and Sclater, 1977; Turcotte and Oxburgh, 1967).

What Kelvin did not allow for is that, to varying degrees, all simple models are bound to fail, and we may learn as much by their failure as by their successes. The cooling half-space model fails for young ocean floor because of the influence of hydrothermal circulation; however, the degree to which heat flux departs from the simple model allows us to estimate the amount of heat transferred by that circulation, and hence the flux of water through the oceanic ridges (Lister, 1972; Morton and Sleep, 1985). The model also fails for ocean floor older than ca. 80–90 Ma but, in failing, reveals a second scale of convection in the mantle and allows us to estimate the thickness of the plates (Crosby et al., 2006; Parsons and McKenzie, 1978; Parsons and Sclater, 1977).

Perry's analysis of the failure of Kelvin's model similarly carried the strong implication that the solid Earth can carry heat by convection. Kelvin felt that he was on firm ground in rejecting the notion of a fluid interior to the Earth: he knew from the study of Earth tides that at least the outer 1500 km of the mantle is as rigid as steel (Kelvin, 1863b). Perry (1895a) tried hard to change Kelvin's mind on this point, using language specifically addressed to Kelvin's way of thinking:

> … the real basis of your calculation is your assumption that the solid earth cannot alter its shape … even in 1000 million years, under the action of forces constantly tending to alter its shape, and yet we see the gradual closing up of passages in a mine, and we know that wrinkling and faults and other changes of shape are always going on in the earth under the action of long-continued forces. I know that solid rock is not like cobbler's wax, but 10^9 years is a long time, and the forces are great. (Perry, 1895a)

The reference to cobbler's wax is deliberate. Kelvin, like many others at the time, thought that light could not pass through a vacuum, but required a physical medium, the ether, for its propagation. That medium had to possess elastic properties at very short times, to allow light waves to propagate, but it needed to be weak at longer time scales, so that the Earth could move freely through it. Although he could not find a satisfactory mathematical formulation for the ether, Kelvin was fond of a physical demonstration that illustrated its required physical properties (Lindley, 2004, p. 247). He

placed water in a glass cylinder, floated a layer of cork on the water, covered that with a layer of Scottish shoemaker's wax, and finally placed bullets on the top. Over a short period of observation, nothing visible happened, but after six months the corks and the bullets were within the wax, and after a year, the corks were on the top and the bullets were on the bottom. The wax exhibited strength on the short time scale, but was weak on the long time scale. These, qualitatively, were the required properties of the ether and—Perry was implying—of the Earth's mantle. Kelvin completely missed the point and so, it seems, did everyone else.

If Perry's analysis had been absorbed by the scientific community of the day, then the first radiometric ages for the Earth would have come as confirmation of the convective explanation for the Earth's surface heat flux, and the "fixist" view of the Earth, which exerted such a brake on geological progress in the first half of the twentieth century, would have been difficult to sustain. As it was, however, proponents of continental drift and convection needed repeatedly to make arguments in favor of a fluid Earth, against considerable skepticism (e.g., Oreskes, 1999). As late as the 1960s, geophysical models were being constructed that tried to match the surface heat flux employing a solid Earth with elaborate distributions of thermal conductivity and heat generation.

We are left with the question as to why the myth persists that the discovery of radioactivity simultaneously proved Kelvin wrong and provided the explanation for his error. Part of the answer, perhaps, is that it makes a good story. Rutherford's biographer (Eve, 1939) reports that he repeated his tale of thinking on his feet in front of the "old bird" Kelvin on many occasions; it is entirely possible that the pleasing form of the anecdote, and the eminence of its author, led to the uncritical acceptance of the myth. As Stephen Gould (who himself propagated this myth) wrote: "The most erroneous stories are those we think we know best—and therefore never scrutinize or question" (1996). It is hard to dissuade aging scientists, as they slip into their anecdotage, from repeating stories that they find amusing, but their younger colleagues must not mistake such stories for the history of science.

ACKNOWLEDGMENTS

We are grateful to Richard O'Connell, who introduced P. England to Perry's papers in 1983, to Stephen Johnston, Russell Pysklywec, and Norman Sleep for helpful comments, and to Craig Jones for correcting an error in Figure 1.

REFERENCES CITED

Burchfield, J.D., 1975, Lord Kelvin and the Age of the Earth: New York, Science History Publications, 260 p.
Carslaw, H.S., and Jaeger, J.C., 1959, Conduction of Heat in Solids, second ed.: Oxford, Oxford University Press, 510 p.
Chamberlin, T.C., 1899, Lord Kelvin's address on the age of the earth as an abode fitted for life: Science, v. 9, p. 889–901, doi: 10.1126/science.9.235.889.
Crosby, A.G., McKenzie, D., and Sclater, J.G., 2006, The relationship between depth, age, and gravity in the oceans: Geophysical Journal International, v. 66, p. 553–573.
Curie, P., and Laborde, A., 1903, Sur la chaleur dégagée spontanément par les sels de radium: Comptes Rendus de l'Académie des Sciences, v. 136, p. 673–675.
Dalrymple, G.B., 1991, The Age of the Earth: Stanford, Stanford University Press, 474 p.
Eve, A.S., 1939, Rutherford: Being the Life and Letters of the Rt. Hon. Lord Rutherford, O.M.: New York, Macmillan, 451 p.
Fourier, J.B.J., 1822, Théorie analytique de la chaleur: Paris, Académie des Sciences, p. 3, 141.
Fourier, J.B.J., 1827, Mémoire sur les températures du globe terrestre et des espaces planétaires: Mémoires de l'Académie Royale des Sciences de l'Institute de France, v. 7, p. 570–604.
Kelvin, W.T., 1863a, On the secular cooling of the earth: Transactions of the Royal Society of Edinburgh, v. 23, p. 157–170.
Kelvin, W.T., 1863b, On the rigidity of the earth; shiftings of the earth's instantaneous axis of rotation; and irregularities of the earth as a timekeeper: Philosophical Transactions of the Royal Society of London, v. 153, p. 573–582.
Kelvin, W.T., 1895, On the age of the earth: Nature, v. 51, p. 438–440.
Kelvin, W.T., 1899, The age of the earth as an abode fitted for life: Journal of the Transactions of the Victoria Institute, v. 31, p. 11–35.
Lindley, D., 2004, Degrees Kelvin: Washington, D.C., Joseph Henry Press, 366 p.
Lister, C.R.B., 1972, On the thermal balance of a mid-ocean ridge: Geophysical Journal of the Royal Astronomical Society, v. 26, p. 515–535.
Lyell, C., 1830, Principles of Geology, vol. 1: London, John Murray, 511 p.
McKenzie, D.P., Roberts, J.M., and Weiss, N.O., 1974, Convection in the earth's mantle: Towards a numerical simulation: Journal of Fluid Mechanics, v. 62, p. 465–538, doi: 10.1017/S0022112074000784.
Morton, J.L., and Sleep, N.H., 1985, A mid-ocean ridge model: Constraints on the volume of axial hydrothermal flux: Journal of Geophysical Research, v. 90, p. 11,345–11,354.
Oreskes, N., 1999, The rejection of Continental Drift: London, Oxford University Press, 420 p.
Parsons, B., and McKenzie, D.P., 1978, Mantle convection and the thermal structure of the plates: Journal of Geophysical Research, v. 83, p. 4485–4496.
Parsons, B., and Sclater, J.G., 1977, An analysis of the variation of ocean floor bathymetry and heat flow with age: Journal of Geophysical Research, v. 82, p. 802–827.
Perry, J., 1895a, On the age of the earth: Nature, v. 51, p. 224–227.
Perry, J., 1895b, On the age of the earth: Nature, v. 51, p. 341–342.
Perry, J., 1895c, On the age of the earth: Nature, v. 51, p. 582–585.
Richter, F.M., 1986, Kelvin and the age of the earth: Journal of Geology, v. 94, p. 395–401.
Sclater, J.G., Parsons, B., and Jaupart, C., 1981, Oceans and continents: Similarities and differences in mechanisms of heat loss: Journal of Geophysical Research, v. 86, p. 11,535–11,552.
Stacey, F.D., 2000, Kelvin's age of the earth paradox revisited: Journal of Geophysical Research, v. 105, p. 13,155–13,158, doi: 10.1029/2000JB900028.
Turcotte, D.L., and Oxburgh, E.R., 1967, Finite amplitude convection cells and continental drift: Journal of Fluid Mechanics, v. 28, p. 29–42, doi: 10.1017/S0022112067001880.
Turcotte, D.L., and Schubert, G., 2002, Geodynamics: Cambridge, Cambridge University Press.
Willis, B., 1942, American geology 1850–1900: Science, v. 96, no. 2486, p. 167–172, doi: 10.1126/science.96.2486.167.

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Attention Voting Members:

GSA Elections Start 8 March 2007

The success of GSA depends on you, the Members, and on the work of the elected officers who serve on GSA's Executive Committee and Council. All GSA member types are eligible to vote. Please make your wishes for GSA known by voting for the nominees listed here.

In late February, you'll receive a postcard with instructions on how to access a secure Web site and your electronic ballot. Biographical information on each candidate will be available for review at www.geosociety.org beginning mid-February. Paper versions of the ballot and candidate information will be available for those unable to vote online.

JULY 2007 OFFICER AND COUNCILOR NOMINEES

PRESIDENT
(July 2007–June 2008)
John M. (Jack) Sharp Jr.
University of Texas at Austin
Austin, Tex., USA

VICE PRESIDENT
(July 2007–June 2008)
Judith Totman Parrish
University of Idaho
Moscow, Idaho, USA

TREASURER
(July 2007–June 2008)
Robbie R. Gries
Priority Oil and Gas LLC
Denver, Colo., USA

COUNCILOR Position 1
(July 2007–June 2011)

John J. Clague
Simon Fraser University
Burnaby, B.C., Canada

Jacqueline E. Huntoon
Michigan Technological University
Houghton, Mich., USA

COUNCILOR Position 2
(July 2007–June 2011)

G. Randy Keller
University of Oklahoma
Norman, Okla., USA

Allen J. Dennis
University of South Carolina
Aiken, S.C., USA

COUNCILOR Position 3
(July 2007–June 2011)

Yildirim Dilek
Miami University–Ohio
Oxford, Ohio, USA

Monica E. Gowan
University of Canterbury
Christchurch, New Zealand

Ballots must be submitted electronically or postmarked by 6 April 2007.

THE GEOLOGICAL SOCIETY OF AMERICA

UPCOMING APPLICATION & NOMINATION DEADLINES

Medals and Awards
Nominations Due: 1 February 2007

Candidate nominations are requested for the following medals and awards: Penrose Medal, Day Medal, Honorary Fellows, Young Scientist Award (Donath Medal), GSA Public Service Award, GSA Distinguished Service Award, and 2007 Subaru Outstanding Woman in Science Award. For details on the awards and nomination procedures, see the October 2006 issue of *GSA Today*. For the online nomination form, go to www.geosociety.org/aboutus/awards/ or call +1-303-357-1028. Materials and supporting information for any of the nominations may be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

GSA Fellows
Nominations Due: 1 February 2007

The Committee on Membership requests nominations of members to be elevated to GSA Fellow status. Any GSA Fellow may nominate a Member for this honor. Two supporting letters in addition to the online nomination form are needed. For details on nomination procedures, see the October 2006 issue of *GSA Today*, go to www.geosociety.org/members/fellow.htm, call +1-303-357-1028, or e-mail awards@geosociety.org.

John C. Frye Environmental Geology Award
Nominations Due: 31 March 2007

In cooperation with the Association of American State Geologists, GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. For details, see the October 2006 issue of *GSA Today*, go to www.geosociety.org/aboutus/awards/, or call +1-303-357-1028. Nominations must be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

Student Research Grants 2007

Apply online at www.geosociety.org/grants/gradgrants.htm. Application for a GSA student research grant is an **online-only** process. Submission must be completed by **Thurs., 1 February 2007, at 11:59 p.m. (MST).**

Students must be GSA members and may only receive a grant once at the master's level and once at the Ph.D. level. For more information on GSA's 2007 research grant program, go to www.geosociety.org/grants/gradgrants.htm, call +1-303-357-1028, or e-mail awards@geosociety.org.

THE GEOLOGICAL SOCIETY OF AMERICA

SCIENCE ▪ STEWARDSHIP ▪ SERVICE

National Awards
Nominations Due: 30 April 2007

Candidate nominations are needed for the following national awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, and Alan T. Waterman Award. For details, see the October 2006 issue of *GSA Today*. Nominations should be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

Research Awards in Geomorphology and Micropaleontology

Two of GSA's most prestigious research-support awards are made possible by the generosity of the late W. Storrs Cole.

Geomorphology

The **Gladys W. Cole Memorial Research Award** provides support for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico. GSA Members and Fellows between the ages of 30 and 65 who have published one or more significant papers on geomorphology are eligible for the award. The 2007 award is US$8700.

Micropaleontology

The **W. Storrs Cole Memorial Research Award** supports research in invertebrate micropaleontology. This award carries a stipend of US$7700 in 2007 and will go to a GSA Member or Fellow between the ages of 30 and 65 who has published one or more significant papers on micropaleontology.

Deadline for applications: 1 February 2007.

Online application forms are now accepted at www.geosociety.org/grants/postdoc.htm. Supplemental information may be e-mailed to awards@geosociety.org or sent to Grants, Awards and Recognition, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

The Gladys W. Cole and W. Storrs Cole award funds are managed by the GSA Foundation.

Final Announcement and Call for Papers

THE GEOLOGICAL SOCIETY OF AMERICA

JOINT MEETING

41st Annual Meeting, South-Central Section, GSA
41st Annual Meeting, North-Central Section, GSA
Lawrence, Kansas

11–13 April 2007

The Kansas Geological Survey and the University of Kansas departments of geology and geography will host the 2007 joint annual meetings of GSA's South-Central and North-Central Sections. The sections will meet Wed.–Fri., 11–13 April, at the Kansas Memorial Union on the University of Kansas campus, Lawrence, Kansas.

Lawrence has a population of 88,000, and is about 35 miles west of Kansas City, located in a terrane of gently westward-dipping Pennsylvanian strata. The intersection of the Oread Escarpment with the Kansas and Wakarusa River valleys at Lawrence highlights a cuesta landscape, featuring rolling hills and beautiful vistas. The University of Kansas (KU) central campus is on the dipslope rim of the Oread Escarpment, and can be seen for miles when approaching from the east or south. Mid-April is a delightful time to visit Lawrence and the KU campus. Beautiful and historic downtown Lawrence is located at the foot of the Oread Escarpment, just to the east of the KU campus. Lawrence has a vibrant arts community and a wonderful downtown shopping, dining, and bar district with commercial and public art galleries, the Watkins Museum, and a variety of live music venues. Other restaurants, bars, and shopping centers are spread throughout the city.

REGISTRATION

Early Registration Deadline: 12 March 2007
Cancellation Deadline: 19 March 2007

GSA Headquarters will handle meeting registration; please register online at www.geosociety.org/sectdiv/Northc/07nc-scmtg.htm. On-site registration will be at the Kansas Memorial Union on the KU campus during the meeting on the following dates and times:

Tues., 10 April	4:30–7:30 p.m.
Wed., 11 April	7:30 a.m.–4:30 p.m.
Thurs., 12 April	7:30 a.m.–4:30 p.m.
Fri., 13 April	7:30 a.m.–noon

Registration Fees	**Early**		**Standard**	
	Full meeting	One day	Full meeting	One day
Professional Member	US$150	US$95	US$170	US$110
Professional Nonmember	US$185	US$120	US$195	US$130
Student Member	US$50	US$35	US$65	US$45
Student Nonmember	US$65	US$45	US$75	US$50
K–12 Professional	US$40	US$30	US$40	US$30
Guest	US$40		US$40	

ACCOMMODATIONS

Blocks of rooms have been reserved at the Best Western Lawrence, +1-785-843-9100; Hampton Inn, +1-785-841-0265; Holiday Inn Holidome, +1-785-841-7077; Holiday Inn Express, +1-785-749-7555; and Eldridge Inn, +1-785-749-5011. For details see www.geosociety.org/sectdiv/Northc/07nc-scmtg.htm.

ACCESSIBILITY

GSA is committed to making its meetings accessible to all people interested in attending. Please indicate special requirements (wheelchair accessibility, etc.) on your registration form.

TRAVEL AND TRANSPORTATION

Lawrence is located along the Kansas Turnpike (I-70). Air travelers to Lawrence should use Kansas City International Airport (MCI) for air transportation and rental car services. Kansas City International Airport is only 49 miles from Lawrence. Airport shuttle service to Lawrence is provided by Kansas Transportation Service, +1-877-942-0544, and KCI Roadrunner, +1-800-826-8294. Contact these providers prior to traveling for times and pickup information. Amtrak offers two trains per day (one westbound and one eastbound) to Lawrence. Travelers by rail should plan ahead for taxi or other pickup at the Amtrak station, because no shuttle services are available at the station.

PARKING

As with many other universities, parking can be tight on the KU campus. Campus parking permits will be provided to meeting registrants who request them during registration. The parking areas for meeting registrants will be located at the Kansas Union parking ramp and an adjacent parking lot. Maps of the KU campus, the Kansas Union, parking areas, and local hotels are posted on the KU Web site, www.kgs.ku.edu/Conferences/GSA07/index.html.

STUDENT TRAVEL

Travel grants are available from the South-Central and North-Central Sections in cooperation with the GSA Foundation for students who are presenting oral or poster papers. To be eligible, students must be GSA Student Members. Students from the South-Central and North-Central Sections should apply to their respective sections. Students from other sections should apply to the section (South-Central or North-Central) that is geographically closer to your area. Complete the online **Travel Grant Application Form**, which will be available in mid-January 2007, by **15 March 2007.**

STUDENT AWARDS

Awards will be given for the best student oral and poster presentations. To be eligible, students must be lead authors and presenters, and they should be capable of answering detailed questions about their research.

ABSTRACTS

Abstract Deadline: 23 January 2007

Papers are invited from students and professionals for oral and poster presentations in general discipline sessions, topical

sessions, and symposia. An individual may present only one volunteered paper; however, a person may be co-author on other papers. Individuals invited to participate in symposia may present an additional volunteered paper. Submit abstracts using the GSA Abstracts Form at http://gsa.confex.com/gsa/2007SC/index.epl. An abstract submission fee of US$10 will be charged. If you cannot submit the abstract electronically, please contact Nancy Carlson, +1-303-357-1061, ncarlson@geosociety.org.

TECHNICAL SESSIONS

Symposia

1. **Pander Society Symposium—Mixed-Up Conodonts: Extracting Useful Information and Solving Geologic Puzzles Using Stratigraphic Leaks and Redeposited Faunas.** Cosponsored by *Pander Society; Paleontological Society*. James Miller, Missouri State University, jimmiller@missouristate.edu; Stephen Leslie, University of Arkansas at Little Rock, saleslie@ualr.edu. Oral and Poster.
2. **Roger L. Kaesler—Scientist and Editor: His Contributions to Paleontology through Research and the *Treatise on Invertebrate Paleontology*.** Cosponsored by *Paleontological Society*. Bruce S. Lieberman, University of Kansas, blieber@ku.edu. Oral only.

Theme Sessions

1. **Microbial Methane Energy Resources.** George W. Shurr, GeoShurr Resources, geoshurr@frontiernet.net; Fred J. Anderson, North Dakota Geological Survey, fjanderson@state.nd.us. Oral and Poster.
2. **Hydrothermal Processes in Midcontinent Sedimentary Rocks.** Cosponsored by *Great Lakes Section, Society for Sedimentary Geology (SEPM)*. John Luczaj, University of Wisconsin–Green Bay, luczajj@uwgb.edu; Robert H. Goldstein, University of Kansas, gold@ku.edu. Oral only.
3. **Applications of Stable Isotopes to Modern and Quaternary Environmental Issues.** William C. Johnson, University of Kansas, wcj@ku.edu; Luis Gonzalez, University of Kansas, lgonzlez@ku.edu. Oral and Poster.
4. **Identification of Environmental Processes Using Isotopic Tracers.** Margaret Townsend, Kansas Geological Survey, townsend@kgs.ku.edu; Roy Spalding, University of Nebraska–Lincoln, rspalding1@unl.edu. Oral and Poster.
5. **Groundwater Flow and Transport Processes in Carbonate Aquifers.** Martin Appold, University of Missouri–Columbia, appoldm@missouri.edu; Carol Wicks, University of Missouri–Columbia, wicksc@missouri.edu. Oral and Poster.
6. **Early Pleistocene Glaciation of the Central Plains.** Wakefield Dort, University of Kansas, yolanda@ku.edu. Oral and Poster.
7. **Loess and Paleoenvironments.** Randall Schaetzl, Michigan State University, soils@msu.edu. Oral and Poster.
8. **Geoarchaeological and Geomorphological Explorations in the Midcontinent: In Honor of Wakefield Dort Jr.** William I. Woods, University of Kansas, wwoods@ku.edu; Rolfe D. Mandel, Kansas Geological Survey, mandel@kgs.ku.edu; William C. Johnson, University of Kansas, wcj@ku.edu. Oral and Poster.
9. **Geophysics in the Midcontinent (Posters).** Kevin Mickus, Missouri State University, kevinmickus@missouristate.edu. Poster only.
10. **Community-Based Service Learning in the Geosciences.** Cosponsored by *Central Section, National Association of Geoscience Teachers*. Kathleen Bower, Eastern Illinois University, kmbower@eiu.edu. Oral only.
11. **Issues in Geoscience Education.** Cosponsored by *Central Section, National Association of Geoscience Teachers*. Annabelle Foos, University of Akron, afoos@uakron.edu. Oral and Poster.
12. **Strategies for Success in Bridging the Gap between Culture, Religion, and Science in the Geoscience Classroom.** Sadredin C. Moosavi, Walden University smoosavi@waldenu.edu; Elizabeth Heise, University of Texas at Brownsville, eheise@utb.edu. Oral only.
13. **Undergraduate Research (Posters).** Cosponsored by *Geoscience Education Division, Council on Undergraduate Research*. Robert Shuster, University of Nebraska–Omaha, robert_shuster@mail.unomaha.edu. Poster only.
14. **Medical Mineralogy Session and Panel Discussion.** A. Umran Dogan, Ankara University, Turkey, and University of Iowa, umran-dogan@uiowa.edu; Meral Dogan, Hacettepe University, Turkey, meralmdogan@hotmail.com. Oral and Poster.
15. **Traces of Life: Micro- to Macroscopic Evidence of Past and Present Biogenic Activity and Their Implications for Marine and Continental Settings.** Cosponsored by *Paleontological Society*. Stephen T. Hasiotis, University of Kansas, hasiotis@ku.edu; Jennifer A. Roberts, University of Kansas, jaroberts@ku.edu; David Fowle, University of Kansas, fowle@ku.edu. Oral and Poster.
16. **Fossils and Modern Analogs: Using Modern Organisms to Improve Paleontological Interpretations.** Cosponsored by *Paleontological Society*. Daniel I. Hembree, Ohio University, hembree@ohio.edu; Brian F. Platt, University of Kansas, bfplatt@ku.edu; Jon J. Smith, University of Kansas, jjsmith@ku.edu. Oral only.
17. **Paleontologic Deviates: Taphonomy and Pathology.** Cosponsored by *Paleontological Society*. Bruce Rothschild, Northeastern Ohio Universities College of Medicine, bmr@ku.edu; Larry Martin, University of Kansas, ldmartin@ku.edu. Oral only.
18. **Systematic Paleontology in the 21st Century: Analyzing Evolution, Diversity, and Beyond.** Cosponsored by *Paleontological Society*. Alycia L. Stigall, Ohio University, stigall@ohio.edu. Oral and Poster.
19. **Sequence Stratigraphy and Biostratigraphy of Pennsylvanian–Lower Permian Cyclothems in the North American Midcontinent.** Cosponsored by *Paleontological Society*. Gregory P. Wahlman, BP America, gregory.wahlman@bp.com; Philip H. Heckel, University of Iowa, philip-heckel@uiowa.edu. Oral only.

20. **The Legacy of Raymond Cecil Moore (1892–1974): The 20th Century's Paleontologist-Stratigrapher Laureate.** Daniel F. Merriam, University of Kansas, dmerriam@kgs.ku.edu; Paul Enos, University of Kansas, enos@ku.edu. Oral and Poster.
21. **Neogene Depositional Environments, Paleoclimatology, and Stratigraphic Architecture of the Succession Forming the High Plains Aquifer.** P. Allen Macfarlane, Kansas Geological Survey, dowser@kgs.ku.edu; Greg Ludvigson, Kansas Geological Survey, gludvigson@kgs.ku.edu; Marios Sophocleous, Kansas Geological Survey, marios@kgs.ku.edu. Oral and Poster.
22. **Upper Paleozoic Depositional Systems, Cyclo- and Sequence Stratigraphic Architecture, and Their Controls on Hydrocarbon Reservoirs in the U.S. Midcontinent.** Wan Yang, Wichita State University, wan.yang@wichita.edu; Salvatore J. Mazzullo, Wichita State University, salvatore.mazzullo@wichita.edu. Oral and Poster.
23. **Insights from Cretaceous-Paleogene Paleoenvironments and Deposition: Glimpses of the Greenhouse.** Brian J. Witzke, Iowa Geological Survey, bwitzke@igsb.uiowa.edu; Greg A. Ludvigson, Kansas Geological Survey, gludvigson@kgs.ku.edu. Oral and Poster.
24. **Geologic Framework of the U.S. Continental Interior.** Mary Hubbard, Kansas State University, mhub@ksu.edu; Daniel Holm, Kent State University, dholm@kent.edu; Stephen Marshak, University of Illinois, smarshak@uiuc.edu. Oral and Poster.
25. **Hydrologic Investigations in Floodplain Aquifers in the Midwestern United States.** Marcia K. Schulmeister, Emporia State University, mschulme@emporia.edu; Brian P. Kelly, U.S. Geological Survey, bkelly@usgs.gov. Oral and Poster.
26. **Establishing Teacher-Scientist Collaborations in K–12 Earth Science Education.** Charles Spencer, Central Missouri State University, spencer@cmsu1.cmsu.edu. Oral and Poster.
27. **Applied Hydrogeology and Geophysics: Innovative Approaches to Old Hydrogeological Challenges.** Amir Mokhtari Fard, Hydro Research, Täby, Sweden, amfard@hydroresearch.se. Oral and Poster.
28. **Geologic Hazards in Urban Areas and Transportation Corridors of the Midcontinent.** Gregory Ohlmacher, Kansas Geological Survey, ohlmac@kgs.ku.edu. Oral and Poster.

WORKSHOP

1. **Advancing Understanding of Groundwater Concepts Using Simulation and Role-Play in the Plume Busters Software.** Sat., 14 April, 8:30 a.m.–12:30 p.m. P. Allen Macfarlane, Kansas Geological Survey, dowser@kgs.ku.edu; Margaret Townsend, Kansas Geological Survey, townsend@kgs.edu; Geoff Bohling, Kansas Geological Survey, geoff@kgs.ku.edu. Max.: 15. Cost: US$10.

SHORT COURSE

1. **SEPM Short Course Number 51: Recognizing Continental Trace Fossils in Outcrop and Core.** Cosponsored by *Paleontological Society; Society for Sedimentary Geology (SEPM).* Sat., 14 April, 8:30 a.m.–5 p.m. Stephen T. Hasiotis, University of Kansas, hasiotis@ku.edu. Max.: 25. Cost: US$45.

FIELD TRIPS

For further information regarding field trips, please contact the field trip leader(s). All field trip fees include transportation. Other included features noted below.

Premeeting

1. **Sequence Stratigraphy, Biostratigraphy, and Chronostratigraphy of the Virgilian Stage, Northern Midcontinent.** Mon.–Tues., 9–10 April. Darwin Boardman, Oklahoma State University, +1-405-744-5315, darwin.boardman@okstate.edu. Max.: 40. Cost: US$250. Includes 1 night lodging, lunches, and guidebook.
2. **Fluvial-Estuarine Deposition in the Mid-Cretaceous Dakota Formation, Kansas and Nebraska.** Tues., 10 April. R. Matt Joeckel, University of Nebraska–Lincoln, +1-402-472-7520, rjoeckel@unlnotes.unl.edu; Greg Ludvigson, Kansas Geological Survey, +1-785-864-2734, gludvigson@kgs.ku.edu. Max.: 18. Cost: US$50. Includes lunch and guidebook.
3. **Geology and Industrial Use of the Lamproid Occurrences in Southeast Kansas.** Tues., 10 April. Pieter Berendsen, Kansas Geological Survey, +1-785-864-2141, pieterb@kgs.ku.edu. Max.: 18. Cost: US$50. Includes lunch and guidebook.

Postmeeting

4. **The Weaubleau and Decaturville Impact Structures in West-Central Missouri: Sorting Out Their Ages Using Redeposited Conodonts and Crinoids in Breccias.** Cosponsored by *Pander Society; Paleontological Society.* Fri. evening–Saturday, 13–14 April. James Miller, Missouri State University, +1-417-836-5447, jimmiller@missouristate.edu; Kevin Evans, Missouri State University, +1-417-836-3231, kevinevans@missouristate.edu. Max.: 30. Cost: US$95. Includes 1 night lodging, 1 lunch, and guidebook.
5. **Sequence Stratigraphy of Delta-Dominated, Mixed Carbonate-Siliciclastic Depositional Systems of the Upper Pennsylvanian Ochelata Group, Oklahoma and Kansas.** Fri. evening–Sun., 13–15 April. Peter Holterhoff, Texas Tech University, +1-806-742-1818, peter.holterhoff@ttu.edu; Tim Demko, University of Minnesota–Duluth, +1-218-726-8340, tdemko@umn.edu. Max.: 20. Cost: US$205. Includes 2 nights lodging, lunches, and guidebook.
6. **Geoarchaeology and Alluvial Stratigraphy of the Claussen Paleoarchaic Site.** Half-day, Sat., 14 April. Rolfe Mandel, Kansas Geological Survey, +1-785-864-2171, mandel@kgs.ku.edu; Jack Hofman, +1-785-864-2634, hofman@ku.edu. Max.: 35. Cost: US$17. Includes handout.
7. **Maximum Southwestern Extent of "Kansan" Ice Sheet and Newly Discovered Older Till.** Sat., 14 April. Wakefield Dort, Jr., Emeritus, University of Kansas, +1-785-864-4974. Max.: 48. Cost: US$35. Includes guidebook.

MENTORING PROGRAMS

Roy J. Shlemon Mentor Program in Applied Geoscience. Sponsored by *GSA Foundation.* Thurs.–Fri., 12–13 April, 11:30 a.m.–1 p.m.

The John Mann Mentors in Applied Hydrogeology Program. Sponsored by *GSA Foundation.* Thurs., 12 April, 5–6:30 p.m.

For details, see page 20 of this issue, go to www.geosociety.org/students.htm, or contact Jennifer Nocerino, jnocerino@geosociety.org.

ACTIVITIES

Welcoming Reception. Wed., 11 April, 5:30–7:30 p.m., Ballroom, Kansas Memorial Union, University of Kansas.

Keynote Presentation of the Birdsall Dreiss Lecture by Bridget Scanlon, Texas Bureau of Economic Geology, *Impacts of Changing Land Use on Subsurface Water Resources in Semiarid Regions,* Wed., 11 April, 7:30 p.m.

Association for Women Geoscientists Social Breakfast Meeting. Wed., 11 April, 7–8 a.m. Cost: US$10.

North-Central Section GSA Management Board Breakfast Meeting. Thurs., 12 April, 7–8 a.m.

Great Lakes SEPM and Paleontological Society Luncheon. Thurs., 12 April, noon–1 p.m. Cost: US$20.

South-Central Section GSA Management Board Meeting. Thurs., 12 April, 4–5 p.m.

South-Central Section GSA Business Meeting. Thurs., 12 April, 5:30–5:40 p.m.

North-Central Section GSA Business Meeting. Thurs., 12 April, 5:40–5:50 p.m.

Keynote Presentation by James Kirkland, Utah Geological Survey, *Utah's Early Cretaceous Dinosaur Assemblage: The China Connection.* Thurs., 12 April, 6 p.m.

GSA Campus Representatives and North-Central Section GSA Technical Program Advisory Committee Breakfast Meeting. Fri., 13 April, 7–8 a.m.

Central Section, National Association for Geoscience Teachers (NAGT) Luncheon and Business Meeting. Fri., 13 April, noon–1 p.m. Cost: US$20.

North-Central Section GSA Local Committee Meeting (2006–2010). Fri., 13 April, 5 p.m.

EXHIBITORS

Exhibit booths will be available at this meeting for universities, government, and companies. For further information, please contact Gregory Ohlmacher, Gregory Ludvigson, Allen Macfarlane, or Matt Joeckel.

CONTACT INFORMATION

Requests for information should be addressed to the meeting co-chairs, Gregory C. Ohlmacher, +1-785-864-2194, ohlmac@kgs.ku.edu, and Gregory Ludvigson, +1-785-864-2734, gludvigson@kgs.ku.edu, or meeting vice-chairs, Allen Macfarlane, +1-785-864-2068, dowser@kgs.ku.edu, and R. Matt Joeckel, University of Nebraska–Lincoln, +1-402-472-7520, rjoeckel@unlnotes.unl.edu. **Late-breaking information on the meeting** will be posted on the Web at www.kgs.ku.edu/Conferences/GSA07/index.html.

Call for Geological Papers

2007 GSA Section Meetings

Northeastern Section

12–14 March 2007
University of New Hampshire
Durham, New Hampshire
Information: Wally Bothner, University of New Hampshire, Dept. of Earth Sciences, James Hall, 56 College Rd., Durham, NH 03824-3578, USA, +1-603-862-3143, wally.bothner@unh.edu.

Southeastern Section

29–30 March 2007
Hyatt Regency Savannah on the Historic Riverfront
Savannah, Georgia
Information: Pranoti Asher, Georgia Southern University, Dept. of Geology and Geography, Statesboro, GA 30460-8149, USA, +1-912-681-0338, pasher@georgiasouthern.edu.

Joint Meeting
South-Central and North-Central Sections

11–13 April 2007
Kansas Memorial Union, University of Kansas
Lawrence, Kansas
Abstract Deadline: 23 January 2007
Information: Greg Ludvigson, +1-785-864-2734, gludvigson@kgs.ku.edu—or—Greg Ohlmacher, +1-785-749-4502, ohlmac@kgs.ku.edu; both at Kansas Geological Survey, University of Kansas, 1930 Constant Ave., Lawrence, Kansas 66047-5317, USA.

Cordilleran Section

4–6 May 2007
Western Washington University
Bellingham, Washington
Abstract Deadline: 6 February 2007
Information: Bernie Housen, Western Washington University, Dept. of Geology, MS 9080, 516 High St., Bellingham, WA 98225-5946, USA, +1-360-650-6573, bernieh@cc.wwu.edu.

Rocky Mountain Section

7–9 May 2007
Dixie Center
Saint George, Utah
Abstract Deadline: 13 February 2007
Information: Jerry Harris, Dixie State College, Science Building, 225 South 700 East, Saint George, UT 84770-3875, USA, +1-435-652-7758, dinogami@gmail.com.

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CORDILLERAN

103rd Annual Meeting
Cordilleran Section, GSA
Western Washington University
Bellingham, Washington

4–6 May 2007

THEME: NORTHWEST CONVERGENCE

The 2007 Annual Meeting of GSA's Cordilleran Section will be held at Western Washington University in Bellingham, Washington. The meeting theme is inspired by the Pacific Northwest's geological setting: *converging plates will inspire the convergence of a diverse group of geologists, producing a convergence of disciplines, ideas, and discoveries.* We invite you to partake of this opportunity to meet with your fellow geologists and geoscience professionals in a truly outstanding corner of our nation.

SETTING

Bellingham is part of a geological paradise featuring active volcanoes, large glaciers, active and ancient fault zones, subduction complex rocks, ophiolites, terranes, exhumed mantle massifs, migmatites, and flood basalts. Traditionally the gateway to the San Juan Islands, Bellingham hosts an active population and an epic range of outdoor recreational pursuits. Temperatures in early May range from the low 50s–70s (°F), with variable rain, wind, or sun.

Bellingham's regional airport is served by two airlines, or use the easy bus and train service from Seattle or Vancouver, BC. The meeting site is the Western Washington University (WWU) campus, one of the region's premier undergraduate institutions. WWU is near many lodging and dining establishments, which will be served by a shuttle bus during the meeting. Shops, museums, waterfront activities, and entertainment possibilities are located on campus or nearby.

CALL FOR PAPERS

Papers are invited for a variety of technical sessions. Sessions provide opportunities for either poster or oral presentations; authors interested in volunteering papers for a symposium should contact the appropriate convener prior to submitting an abstract. Oral presentations will utilize a single digital projector and standard presentation software, and an overhead projector will be available in each room. Use of 35 mm slides is not encouraged; to obtain special permission to do so, contact the technical program committee no later than 30 days before the meeting. Presentation lengths, dimensions for poster space, and other details are posted at www.geosociety.org/sectdiv/cord/07cdmtg.htm.

ABSTRACTS

Abstract Deadline: 6 February 2007

Submit abstracts online at www.geosociety.org/sectdiv/cord/07cdmtg.htm. An abstract submission fee of US$10 will be charged. An individual may submit only one volunteered paper but may be a co-author on several presentations. Those invited to present at a symposium may present an additional paper.

REGISTRATION

Early Registration Deadline: 2 April 2007

Register online at www.geosociety.org/sectdiv/cord/07cdmtg.htm. Early registrants receive a significant discount. On-site registration at WWU campus will be available during the meeting.

Registration Fees

	Early	Standard
Professional Member	US$160	US$190
Professional Member—1 day	US$100	US$120
Professional Nonmember	US$190	US$230
Professional Nonmember—1 day	US$130	US$160
Student Member	US$65	US$80
Student Member—1 day	US$50	US$60
Student Nonmember	US$90	US$110
Student Nonmember—1 day	US$65	US$80
K–12 Teacher or student	US$30	US$33
K–12 Teacher or student—1 day	US$20	US$24
Guest	US$50	US$60
Field Trip or Workshop only	US$45	US$55

ACCOMMODATIONS

Rooms have been reserved at a number of local motels near the meeting headquarters, with special meeting rates available. Find more information and a link to make hotel reservations at www.geosociety.org/sectdiv/cord/07cdmtg.htm. Complimentary shuttle bus service will be provided. Parking on campus is limited.

ACCESSIBILITY

GSA and WWU are committed to making this meeting accessible to all people interested in attending. Please indicate any special requirements on your registration form.

FIELD TRIPS

A short description and itinerary for some of these trips will be posted at www.geosociety.org/sectdiv/cord/07cdmtg.htm or can be obtained by contacting the field trip leaders or a member of the field trip committee: Pete Stelling, pete@geol.wwu.edu; Ned Brown, ehbrown@cc.wwu.edu; or Dave Tucker, tuckerd@cc.wwu.edu. **For field trip pricing, please check www.geosociety.org/sectdiv/cord/.**

Premeeting

1. **Selected Mount Baker Volcanic Deposits in the Baker River Valley: 19th Century Lahars, Tephras, and Debris Avalanches, and Early Holocene Subaqueous Lava.** Dave Tucker, WWU, tuckerd@openaccess.org; Kevin Scott, USGS-CVO; Dave Lewis, Mount Baker High School. Thurs., 3 May. Includes a field guide, sack lunch, and transportation.

2. **Late Pleistocene and Holocene Glaciation and Volcanism in the Northern Puget Lowland and North Cascades.** Don Easterbrook, WWU, dbunny@cc.wwu.edu; Dori Kovanen, UBC; Olav Slaymaker, UBC. Thurs., 3 May. One-day trip, includes transportation and lunch only.
3. **Lively Landscapes: Major Holocene Geomorphic Events in the Nooksack/Sumas Valley.** Scott Linneman, WWU, scott.linneman@wwu.edu; Paul Pittman, Whatcom County Public Works; Laura Vaugeois, WA-DNR. Wed.–Thurs., 2–3 May. Includes transportation, guidebook, meals, and one night lodging double-occupancy.

During the Meeting

4. **Murrelets and Molasse in the San Juan Islands.** Dave Engebretson, WWU, engebret@cc.wwu.edu; Clark Blake, mcblake@nas.com, WWU. Sun., 6 May. Includes transportation and lunch.

Postmeeting

5. **Structure and Evolution of the San Juan Islands, Northwest Cascades Thrust System.** Ned Brown, WWU, ehbrown@cc.wwu.edu; Liz Schermer, WWU, schermer@geol.wwu.edu; Bernie Housen, WWU, bernieh@cc.wwu.edu. Sun.–Wed., May 6–9.
6. **Early Fraser Glacial History of the Skagit Valley.** Jon Riedel, National Park Service, jon_riedel@nps.gov. Mon.–Tues., 7–8 May.
7. **Quaternary Glaciovolcanism along the Whistler Corridor and the 2460 B.P. Plinian Eruption Deposits at Mount Meager.** Kelly Russell, University of British Columbia, krussell@eos.ubc.ca. Mon.–Tues., 7–8 May.
8. **Regional Tertiary Sequence Stratigraphy and Structure on the Eastern Flank of the Central Cascade Range, Washington.** Eric Cheney, University of Washington, vaalbara@u.washington.edu. Sun.–Tues., 6–8 May.
9. **Geology and Paleobotany of the Eocene Chuckanut Formation.** Rick Dillhoff, rdillhoff@evolvingearth.org; Tad Dillhoff; George Mustoe, WWU, mustoeg@cc.wwu.edu. Mon., 7 May.
10. **Flood Basalts and Ice Age Floods: Repeated Late Cenozoic Cataclysms of Eastern Washington.** Bruce Bjornstad, Pacific Northwest National Laboratory, bruce.bjornstad@pnl.gov; Scott Babcock, WWU; George Last, PNNL. Mon.–Wed., 7–9 May.

TECHNICAL SESSIONS

Session details are posted at www.geosociety.org/sectdiv/cord/07cdmtg.htm and may also be obtained by contacting members of the technical program committee, Sue DeBari, debari@geol.wwu.edu; Liz Schermer, schermer@geol.wwu.edu; and Juliet Crider, criderj@cc.wwu.edu, or the session conveners.

Symposia

Contributions to these sessions are by invitation only.

1. **Quaternary and Tertiary Records of Past Environments, Pacific Northwest.** Estella Leopold, University of Washington, eleopold@u.washington.edu; Rolf Mathewes, Simon Fraser University.
2. **Paleogeographic Reconstructions of Cordilleran Terranes: In Honor of David L. Jones.** Clark Blake, cblake@theriver.com; Jim Monger, jmonger@saltspring.com.
3. **Holocene Volcanic and Glacial Geology at Mount Baker, Washington: Reports from Ongoing Field Studies.** Dave Tucker, WWU, davetucker@mtbakervo.com; Kevin Scott, USGS, kscott@usgs.gov.
4. **Quaternary Glaciation of Washington: In Honor of Dwight (Rocky) Crandell.** Don J. Easterbrook, WWU, dbunny@cc.wwu.edu.

Theme Sessions

1. **Influence of Natural Hazard Assessments on Land-Use Policy—Is Anybody Listening?** John N. Thompson, Whatcom County Public Works Department, +1-360-715-7450, jnthomps@co.whatcom.wa.us.
2. **The Geology of Terroir, Techniques for the Evaluation of Viticultural Sites.** Kevin Pogue, Whitman College, +1-509-527-5955, pogue@whitman.edu.
3. **Origin and Accretionary Processes of Cordilleran Terranes: New Methods, Models, and Challenges.** James E. Wright, University of Georgia, +1-706-542-4394, jwright@gly.uga.edu; Sandra J. Wyld, University of Georgia, +1-706-542-9908, swyld@gly.uga.edu; Bernie Housen, WWU, +1-360-650-6573, bernieh@cc.wwu.edu.
4. **The Little Ice Age in Western North America.** John J. Clague, Simon Fraser University, +1-604-291-4924, jclague@sfu.ca; Brian Menounos, University of Northern BC; Dan Smith, University of Victoria.
5. **Pacific Northwest Paleoseismology and Neotectonics.** Brian Sherrod, USGS, bsherrod@ess.washington.edu; Thomas Pratt, USGS, tpratt@ocean.washington.edu.
6. **Environmental Geology in the Pacific Northwest (Posters).** Sian Davies-Vollum, University of Washington Tacoma, +1-253-692-4624, ksdavies@u.washington.edu.
7. **Hazards and Resources in the Portland, Tualatin, and Willamette Basins of Oregon and Washington (Posters).** Victoria E. Langenheim, USGS, zulanger@usgs.gov; Ian Madin, DOGAMI; Russ Evarts, USGS.
8. **Active Volcano-Glacier Interactions: Process, Products, Hazards.** Tina Neal, USGS, tneal@usgs.gov; Rick Wessels, USGS, rwessels@usgs.gov; Jackie Caplan-Auerbach, WWU, jackie@geol.wwu.edu.
9. **Council on Undergraduate Research (Posters).** Cosponsored by *Council on Undergraduate Research*. Jeff Marshall, Cal Poly Pomona University, marshall@csupomona.edu.
10. **Neogene Orogenesis in the North American Cordillera.** Sara Gran Mitchell, College of the Holy Cross, smitchel@holycross.edu; Owen A. Callahan, WWU, callaho@cc.wwu.edu.
11. **Volcanoes of the Pacific Basin and Rim: Geological and Geophysical Observations.** Michael Poland, Hawaiian Volcano Observatory–USGS, mpoland@usgs.gov; Glyn Williams-Jones, Simon Fraser University, glynmwj@sfu.ca.
12. **Crustal Differentiation Processes, Time Scales, and Products in the North American Cordillera.** Paul Hoskin, University of Calgary, hoskin@ucalgary.ca.

13. **New Developments in Understanding Cretaceous Crustal Structure in the Southern Coast Mountains of British Columbia and North Cascades of Washington.** Harold Stowell, University of Alabama, +1-205-348-5095, hstowell@geo.ua.edu; Robert Miller, San José State University, rmiller@geosun.sjsu.edu; Douglas Tinkham, Laurentian University, dtinkham@laurentian.ca.
14. **New Constraints on Cascadia Slow Slip Events.** Timothy Melbourne, Central Washington University, tim@geology.cwu.edu; Wendy McCausland, University of Washington, wam5@u.washington.edu.
15. **The Evolution of Transform Faulting and Propagation of Extension and Volcanism: The West-Northwest Margin of the Basin and Range Province, USA.** Kaleb C. Scarberry, Oregon State University, +1-541-908-5319, scarberk@geo.oregonstate.edu; James Faulds, University of Nevada–Reno, +1-775-784-6691 ext. 159, jfaulds@unr.edu.
16. **Landslide Hazards in the Forested Environment.** Laura M. Vaugeois, WA DNR–Forest Practices, +1-360-902-1405, laura.vaugeois@wadnr.gov.
17. **Engineering Geologic Challenges in the Pacific Northwest and Cordillera.** Cosponsored by *Association of Environmental and Engineering Geologists; GSA Engineering Division*. Mark Molinari, URS Consultants, mark_molinari@urscorp.com; Bill Haneberg, Haneberg Geosciences, bill@haneberg.com. **Companion to Session 18:** *Challenges of Mapping Geologic Hazards in the Pacific Northwest and Cordillera.*
18. **Challenges of Mapping Geologic Hazards in the Pacific Northwest and Cordillera.** Cosponsored by *Association of Environmental and Engineering Geologists; GSA Engineering Division; Pacific Northwest Center for Geologic Mapping Studies at the University of Washington; WDNR-DGER*. Kathy Troost, University of Washington, ktroost@u.washington.edu; Tim Walsh, Washington State Dept. of Natural Resources, tim.walsh@wadnr.gov. **Companion to Session 17:** *Engineering Geologic Challenges in the Pacific Northwest and Cordillera*.
19. **Best Practices for Teaching Introductory Geology: Preparing Future Teachers and Informed Citizens.** Susan DeBari, WWU, +1-360-650-3588, debari@geol.wwu.edu; Scott Linneman, WWU, scott.linneman@wwu.edu.
20. **Eocene Evolution of the NW Cordillera.** Robert B. Miller, San José State University, rmiller@geosum.sjsu.edu.

WORKSHOPS

For details, contact the workshop leaders or the workshop chair, Jackie Caplan-Auerbach, jackie@geol.wwu.edu.

1. **Exploring Earth through a Virtual Globe.** 3 May. John Bailey, Arctic Region Supercomputing Center, jbailey@gi.alaska.edu. Cost: US$85. Max.: 20.
2. **The Basics of Terrestrial LiDAR Scanning, from Acquisition to Processing.** 3 May. Tim F. Wawrzyniec, University of New Mexico LiDAR Lab, tfw@unm.edu. Cost: US$270. Max.: 20.
3. **Airborne Remote Sensing: Recent Technological Advances and Relevant Applications to the Geology Field.** Fri., 4 May, 8 a.m.–noon. Nicholas Barrett, Osyris Airbourne Inc., nicholasb@osyrisairborne.com. Cost: US$40. Max.: 50.
4. **Introduction to Ground Penetrating Radar for Near Surface Geophysical Investigations.** 3 May. Dan Welch, Geophysical Survey Systems Inc., welchd@geophysical.com. Cost: US$175. Max.: 15.

STUDENT ACTIVITIES

Roy J. Shlemon Mentor Program in Applied Geoscience. Cosponsored by *GSA Foundation*. Fri.–Sat., 4–5 May, 11:30 a.m.–1 p.m. Lunch provided. For more information, see page 20, or contact Jennifer Nocerino, jnocerino@geosociety.org.

The John Mann Mentors in Applied Hydrology Program. Cosponsored by *GSA Foundation*. Sat., 5 May, 5–6:30 p.m. Dinner provided. For more information, see page 20, or contact Jennifer Nocerino, jnocerino@geosociety.org.

Careers in Engineering and Environmental Geology. Cosponsored by *Association of Engineering and Environmental Geologists (AEG); Association of Women Geologists (AWG)*. Fri., 4 May, 6–8 p.m. Informal evening session to acquaint students and attendees with the field of engineering and environmental geology. Three AEG members will present case studies to give attendees an idea of the type of work engineering and environmental geologists do. This will be followed by an informal discussion while practicing geologists describe their jobs. Pizza and drinks provided by one of the region's top employers of engineering and environmental geologists. AEG member participants: Kathy Troost, Bill Haneberg, and Katie Lewis.

STUDENT TRAVEL

GSA's Cordilleran Section and 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 Cordilleran Section. For more information, contact the Section secretary, Joan Fryxell, +1-909-537-5311. The travel grant application form is online at www.geosociety.org/sectdiv/cord/07cdmtg.htm.

STUDENT FIELD TRIP SUBSIDIES

The Cordilleran Section offers limited field trip subsidies to students to facilitate first-hand experience. Students who register for field trips can also apply for a Field Trip Grant, which will reimburse a significant portion of the field trip registration cost. **Application deadline: 2 April 2007.** Checks will be available at the meeting. Please use our secure Field Trip Grant application form at www.geosociety.org/sectdiv/cord/07cdmtg.htm.

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

Exhibit booths will be available for commercial and nonprofit organizations. For more information or to reserve a booth, contact Karen Henriksen, karen.henriksen@wwu.edu, or Bernie Housen, bernieh@cc.wwu.edu.

SPECIAL EVENTS

Icebreaker Reception: Thurs., 3 May, 5–7 p.m.

Association for Women Geoscientists and Association of Engineering and Environmental Geologists Reception: Fri., 4 May, 6–8 p.m.

Book Signing: Sun., 6 May, noon–4 p.m., Exhibits area. Geologist and author David Montgomery will autograph copies of his newest book *Dirt: The Erosion of Civilizations.*

Annual Business Meeting: GSA Cordilleran Section, Sat., 5 May, 5–7 p.m.

SPOUSE AND GUEST ACTIVITIES

Bellingham is one of the northernmost cities in the continental United States, located in a wonderful coastal setting. Seattle and Vancouver, BC, are an easy drive away. A variety of activities are available on the WWU campus and in the city of Bellingham. Farther afield, hiking, climbing, boating, biking, and running activities are abundant, recently making Bellingham one of *Outdoor Magazine's* top 10 best places to live. For more information, please visit the Bellingham Visitor's Bureau Web site, www.bellingham.org.

ADDITIONAL INFORMATION

To obtain the most complete and up-to-date information, go to www.geosociety.org/sectdiv/cord/07cdmtg.htm. If you have questions or need further clarification, contact the convention chair, Bernie Housen, +1-360-650-6573, bernieh@cc.wwu.edu.

STUDENTS—Meet Your Career Mentor

Each 2007 Section Meeting offers students access to two highly acclaimed programs: the Shlemon Mentor Program and the Mann Mentor Program in Applied Hydrogeology. Through these programs, you will be given the opportunity to talk one-on-one with practicing geoscientists who will answer questions and share insights on how to get a job after graduation. For more information, contact Jennifer Nocerino, jnocerino@geosociety.org.

Roy J. Shlemon Mentor Program in Applied Geology: Students will receive a free lunch ticket with their registration badge to attend each Shlemon Program. Each day's program will offer a different set of mentors. Space is limited, so plan to arrive early.

Mann Mentor Program in Applied Hydrogeology: Students will receive a free pizza supper ticket with their registration badge to attend the Mann Program, which is geared toward careers in hydrology and hydrogeology. Whether you have already decided to head down this career path or you are curious about the field and its career options, this meeting is for you! Space is limited, so plan to arrive early.

Mentor Programs for 2007 Section Meetings

For program locations, ask at the Section Meeting registration desk.

NORTHEASTERN SECTION MEETING
University of New Hampshire, Durham, N.H., USA
Shlemon Mentor Program Luncheons:
Mon.–Tues., 12–13 March, 11:30 a.m.–1 p.m.
Mann Mentors in Applied Hydrogeology Program:
Mon., 12 March, 5–6:30 p.m.

THE GEOLOGICAL SOCIETY OF AMERICA

SCIENCE ▪ STEWARDSHIP ▪ SERVICE

Joint Meeting
SOUTH-CENTRAL SECTION
NORTH-CENTRAL SECTION
Kansas Memorial Union,
University of Kansas,
Lawrence, Kans., USA
Shlemon Mentor Program Luncheons:
Thurs.–Fri., 12–13 April, 11:30 a.m.–1 p.m.
Mann Mentors in Applied Hydrogeology Program:
Thurs., 12 April, 5–6:30 p.m.

SOUTHEASTERN SECTION MEETING
Hyatt Regency Savannah
on the Historic Riverfront, Savannah, Ga., USA
Shlemon Mentor Program Luncheons:
Thurs.–Fri., 29–30 March, 11:30 a.m.–1 p.m.
Mann Mentors in Applied Hydrogeology Program:
Thurs., 29 March, 5–6:30 p.m.

CORDILLERAN SECTION MEETING
Western Washington University, Bellingham, Wash., USA
Shlemon Mentor Program Luncheons:
Fri.–Sat., 4–5 May, 11:30 a.m.–1 p.m.
Mann Mentors in Applied Hydrogeology Program:
Sat., 5 May, 5–6:30 p.m.

ROCKY MOUNTAIN SECTION MEETING
Dixie Center, Saint George, Utah, USA
Shlemon Mentor Program Luncheons:
Mon.–Tues., 7–8 May, 11:30 a.m.–1 p.m.
Mann Mentors in Applied Hydrogeology Program:
Tues., 8 May, 5–6:30 p.m.

Call For Nominations: GSA Division Awards

Funds for the following GSA Division awards are administered through the GSA Foundation.

DON J. EASTERBROOK DISTINGUISHED SCIENTIST AWARD

Quaternary Geology and Geomorphology Division

GSA's Quaternary Geology and Geomorphology Division seeks nominations for the Don J. Easterbrook Distinguished Scientist Award. This award is given to an individual who has shown unusual excellence in published research, as demonstrated by a single paper of exceptional merit or a series of papers that have substantially increased knowledge in Quaternary geology or geomorphology. No time limitations apply to the recognized research. The recognition is normally extended to an individual, but in the event of particularly significant research, two people may share the award. Monies for the award are derived from the Don J. Easterbrook Fund annual interest income, administered by the GSA Foundation.

Although recognition of extraordinary prior research excellence is the principle goal of this award, it carries with it an opportunity to fund additional research. The Easterbrook Distinguished Scientist is eligible to draw funds for research from the GSA Easterbrook Fund in an amount to be determined by availability of funds. This opportunity to fund additional research by the awardee is a secondary consideration of this award.

Members of the Quaternary Geology and Geomorphology Division Award Panel will evaluate nominations for the Easterbrook Award. Because the award primarily recognizes research excellence, self-nomination is not allowed. Nominees need not be members of the division. Nominations are not automatically carried forward to subsequent years, but individuals may be renominated.

Nominations must be accompanied by supporting documentation, including a statement of the significance of the nominee's research, a curriculum vitae, letters of support, and any other documents deemed appropriate by the nominating committee. **Send nominations by 2 April 2007** to Jack F. Shroder Jr., Dept. of Geography & Geology, University of Nebraska, Omaha, NE 68182-0199, USA; jshroder@mail.unomaha.edu.

FAROUK EL-BAZ AWARD FOR DESERT RESEARCH

Quaternary Geology and Geomorphology Division

GSA's Quaternary Geology and Geomorphology Division seeks nominations for the Farouk El-Baz Award for Desert Research. This award rewards excellence in desert geomorphology research worldwide. It is intended to stimulate research in desert environments by recognizing an individual whose research has significantly advanced the understanding of the Quaternary geology and geomorphology of deserts. Although the award primarily recognizes achievement in desert research, the funds that accompany it (US$7,500 anticipated for 2007) may be used for further research. The award is normally given to one person but may be shared by two people if the recognized research was the result of a coequal partnership. Monies for the award are derived from the Farouk El-Baz Fund annual interest income, administered by the GSA Foundation.

Any scientist from any country may be nominated. Because the award recognizes research excellence, self-nomination is not permitted. Neither nominators nor nominees need be members of GSA. Nominations must be accompanied by a statement of the significance of the nominee's research, a curriculum vitae, letters of support, and documentation of published research results that have significantly advanced the knowledge of the Quaternary geology and geomorphology of desert environments.

Send nominations by 2 April 2007 to **Lisa L. Ely**, Dept. of Geological Sciences, 400 E University Way, Central Washington University, Ellensburg, WA 98926; +1-509-963-2821; ely@cwu.edu.

LAURENCE L. SLOSS AWARD FOR SEDIMENTARY GEOLOGY

GSA's Sedimentary Geology Division solicits nominations for the 2007 Laurence L. Sloss Award for Sedimentary Geology. This award is given annually to a sedimentary geologist whose lifetime achievements best exemplify those of Larry Sloss—i.e., achievements that contribute widely to the field of sedimentary geology and service to GSA. Monies for the award are derived from the Laurence L. Sloss Award for Sedimentary Geology Fund annual interest income, administered by the GSA Foundation.

Nominations should include a cover letter describing the nominee's accomplishments in sedimentary geology and contributions to GSA, and curriculum vitae. The Sedimentary Geology Division's management board will choose the recipient from two nominees selected by the nominations committee, and the award will be presented at the October 2007 GSA Annual Meeting in Denver.

Send nominations electronically by 20 February 2007 to Paul Link, secretary, Sedimentary Geology Division, linkpaul@isu.edu.

GILBERT H. CADY AWARD

Coal Geology Division

GSA's Coal Geology Division seeks nominations for the 2007 Gilbert H. Cady Award, given for outstanding contributions in the field of coal geology. The first award, established by the Division in honor of Gilbert H. Cady, was presented in 1973. Monies for the award are derived from the Gilbert H. Cady Memorial Fund annual interest income, administered by the GSA Foundation. The award recognizes contributions that advance the field of coal geology within and outside North America and will be presented at the Coal Geology Division Business Meeting at the October 2007 GSA Annual Meeting in Denver.

Nominations will be evaluated by the Gilbert H. Cady Award Panel and should include the name, office or title, and affiliation of the nominee; date and place of birth; education, degree(s), and honors and awards; major events in his or her professional career; and a brief bibliography noting outstanding achievements and accomplishments that warrant nomination.

Send three copies of the nomination by 28 February 2007 to Christopher J. Carroll, Colorado Geological Survey, 1313 Sherman St Suite 715, Denver, CO 80203-2239, USA; +1-303-866-3501; chris.carroll@state.co.us.

Medlin Scholarship Award Offered

by GSA Coal Division

GSA's Coal Geology Division announces the availability of the Antoinette Lierman Medlin Scholarship in Coal Geology for the 2007–2008 academic year. The scholarship provides full-time students who are involved in research in coal geology (origin, occurrence, geologic characteristics, or economic implications of coal and associated rocks) with financial support for their project for one year.

Scholarship funding can be used for field or laboratory expenses, sample analyses, instrumentation, supplies, or other expenses essential to the successful completion of the research project. About US$2,000 will be available for the 2007–2008 scholarship award. In addition, the recipient of the scholarship may be provided with a stipend to present the results of the research at the 2007 or 2008 GSA Annual Meeting.

For the academic year 2007–2008, the Coal Geology Division is also offering a field study award of about US$1,500. The recipient of this award will also be eligible to receive travel funds to present the results of his or her study at the 2007 or 2008 GSA Annual Meeting.

A panel of coal geoscientists will evaluate proposals for the scholarship and the field study award. Students may apply for the scholarship award, the field study award, or both; however, only one award will be made to a successful applicant.

Interested students should submit five copies of the following: (1) a cover letter indicating which award(s) is(are) sought; (2) a concise statement of objectives and methods and a statement of how the scholarship funds will be used to enhance the project (the proposal should be no more than five double-spaced pages, including references); and (3) a letter of recommendation from the student's immediate advisor that includes a statement of financial need and the amount and nature of other available funding for the research project.

Send the material to: Glenn B. Stracher, Dept. of Geology, East Georgia College, Swainsboro, GA 30401, USA; stracher@ega.edu.

The proposal and letter of recommendation must arrive no later than **15 February 2007.** Applicants will be notified of the scholarship committee's decision by 2 April 2007.

This scholarship was established as a memorial to Antoinette "Toni" Medlin, who for many years dedicated her efforts toward the advancement of coal geoscience and to the encouragement of students in coal geology. Monies for the scholarships are derived from the annual interest income of the Antoinette Lierman Medlin Scholarship fund, which is managed by GSA Foundation.

CALL FOR APPLICATIONS

Stephen E. Dwornik Student Paper Award
Planetary Geology Division

The Award:

Planetary geologist Stephen E. Dwornik established this award in 1991 to provide encouragement, motivation, and recognition to outstanding future scientists. Two awards are given annually, one for the best oral presentation, the other for the best poster presentation. Each winner receives a citation and US$500. The program is administered through GSA's Planetary Geology Division; GSA Foundation manages the award fund.

Criteria:

The Dwornik Student Paper Award applies to papers presented at the Lunar and Planetary Science Conference held each March in Houston. Student applicants must be (1) the senior author of the abstract (the paper may be presented orally or in a poster session); (2) a U.S. citizen; and (3) enrolled in a college or university, at any level of their education, in the field of planetary geosciences. Papers will be judged on the quality of the scientific contributions, including methods and results; clarity of material presented; and methods of delivery, oral or display.

To Apply: The application form and instructions are in the call for papers for the 38th Lunar and Planetary Science Conference, 12–16 March 2007, League City, Texas, USA. Please go to www.lpi.usra.edu/meetings/upcomingmeetings.shtml for more information.

PENROSE CONFERENCE REPORT

Arc Crustal Genesis and Evolution

Valdez, Alaska, USA

9–15 July 2006

Conveners:

Peter Kelemen, *Columbia University, 58 Geochemistry Building, Lamont-Doherty Earth Observatory, Palisades, New York 10964, USA, peterk@ldeo.columbia.edu*

Brad Hacker, *Geological Sciences and Institute for Crustal Studies, University of California, Santa Barbara, California 93106-9630, USA, hacker@geol.ucsb.edu*

The Penrose Conference on arc crustal genesis and evolution was convened in Valdez, south-central Alaska on 9–15 July 2006 near the accreted Jurassic Talkeetna arc. In general, presentations integrated recent results on well-exposed arc crustal sections—in the Jurassic Talkeetna arc in south-central Alaska and in the Cretaceous Ladakh-Kohistan arc in northern Pakistan and India—with important new developments in active-arc geochemistry, petrology, and geophysics. The Talkeetna and Ladakh-Kohistan arcs provide exposures of relatively complete sections from Moho depth (30–40 km in both cases), to volcanic rocks and volcaniclastic sediments, and depth sections and temporal progressions that are not accessible in active oceanic arcs. Both areas have been the subject of large, multidisciplinary projects over the past decade, including the Talkeetna Continental Dynamics Project funded by the U.S. National Science Foundation.

Recent intensive investigations of arc plutonic suites elsewhere complement these projects. New data from the MARGINS Initiative, Sierra Nevada Continental Dynamics Projects, Aleutian studies, and similar international initiatives provide constraints on crustal thickness and volcanic fluxes in active arcs. Studies of ultrahigh-pressure metamorphic rocks and new experimental methods have yielded insights into mantle-wedge melt generation and subduction-zone dehydration and anatexis. This conference provided an opportunity to synthesize these results, with a focus on direct observations of arc crustal sections, from the uppermost mantle to the volcanics, that constrain arc processes and their role in the genesis and evolution of continental crust.

Fifty-five participants engaged in discussions of new developments in arc geochemistry, petrology, tectonics, and geophysics while overlooking the waters of Prince William Sound. The Talkeetna arc was showcased by day-long field trips to the volcanic carapace (led by Peter Clift and Amy Draut) and Moho (led by Luc Mehl) in the Chugach Mountains, and to the Red Mountain mantle tectonite south of Homer, Alaska.

Peter Kelemen kicked off the conference with an overview of the Talkeetna arc and implications of recent discoveries for arc crustal genesis. Matt Rioux followed with a description of the geochronology and the Talkeetna section in the Chugach and Talkeetna Mountains. In their papers and presentations at the meeting, Matt Rioux and Andrew Greene provided comprehensive summaries of arc geochemistry in the Chugach and Talkeetna Mountains. Mike Johnsen presented complementary data for the Alaska Peninsula section of the arc. Brad Hacker reported on thermobarometry and thermochronology of the Talkeetna arc and concluded with a discussion of the effects of ultrahigh-pressure and ultrahigh-temperature reworking on the continental crust.

Placing the Talkeetna arc section in a regional context, Sarah Roeske provided an introduction to the tectonics of Alaska, including the Cenozoic history of the Talkeetna arc and related structures. Chris Nye presented detailed geophysical and geochemical data from Recent volcanoes of Alaska. Jeff Freymueller showed GPS data indicating that the locked and creeping segments of the Aleutian subduction zone may control the first-order segmentation of the arc. Brian Jicha presented new $^{40}Ar/^{39}Ar$ ages from the Aleutians that show episodic plutonism and volcanism along the entire arc, with peak periods of activity from 38–29, 16–11, and 6–0 Ma. David Farris used structural relationships in the Kodiak portion of the Talkeetna arc to propose that the arc was exhumed following an episode of subduction erosion during which blueschist units were underplated directly beneath the former arc crust.

As noted, observations of the Talkeetna arc section are complemented by work on the very similar Kohistan arc section in the northwestern Himalaya. Oliver Jagoutz began a series of talks on the Kohistan arc section by discussing Sr-Nd-Pb systematics. Othmar Müntener discoursed on the genesis of garnet in Kohistan, concluding that some of the garnets crystallized during cooling of a melt based on petrography, phase relations, and thermometry. Carlos Garrido offered an alternative interpretation, based on rock textures, that some of the garnet-bearing lower crustal rocks are restites from dehydration melting of amphibole-bearing gabbro. Bruno Dhuime discussed the evolution of the mafic–ultramafic rocks of Kohistan. Pierre Bouilhol talked about the effects of melt infiltration in the lower crust of Kohistan.

Several presentations focused on development of arc batholiths. Linc Hollister described the magmatic, structural, and metamorphic evolution of the Coast Mountains Batholith of Canada. Mihai Ducea described the temporal variations in magma flux through the arcs of western North America. Cin-Ty Lee used observations from the Sierra Nevada and Peninsular Ranges batholiths, and lower crustal xenoliths in the same regions, to conclude that delamination of the lower crust of island arcs is important in the formation of continental crust. Allen Glazner reported on the importance of subsolidus-metamorphic

processes in plutonic rocks, highlighting the long emplacement time scales of some plutonic suites. Dave Kimbrough spoke on the distinct spatial, temporal, and compositional patterns in the Peninsular Ranges batholith, with particular attention to the role of underplating of isotopically primitive accretionary wedge material. Marty Grove presented a compelling story that emplacement of the massive La Posta tonalite-trondhjemite-granodiorite suite of the Peninsular Ranges batholith was triggered by subduction-accretion of the Catalina Schist.

Ongoing studies of active arcs, particularly intra-oceanic arcs in the western Pacific, complement work on Mesozoic crustal sections. Donna Shillington contrasted Aleutian seismological data with velocities calculated for rocks from the Aleutians and Talkeetna. Simon Klemperer gave a tutorial on constraining uncertainties in geophysical models, compared various ways of modeling geophysical data, and presented new P-wave velocity data for the Izu-Bonin-Mariana arc. Patricia Fryer noted that the unusually silicic character of the Mariana arc crust may be due to tectonic erosion exposing crust as old as Cretaceous. James Hawkins documented marked similarities between the Zambales Range ophiolite and rocks from the Mariana Trench, concluding that a supra-subduction zone origin is likely for both. Richard Arculus presented a panoply of recently acquired images, including 70 new volcanoes, from the Tonga-Kermadec arc. Katy Kelley discussed the implications of new measurements of the H_2O contents of magmas on subduction zone magma genesis. Mindy Zimmer used new H_2O measurements from Aleutian volcanoes to argue that H_2O is the primary factor controlling tholeiitic versus calc-alkaline fractionation. Kirstin Nicolaysen showed that recycling of subducted sediment has an isotopic signal in east-central Aleutian arc lavas.

Shifting focus to active continental arcs, Mariek Schmidt gave geochronologic and isotopic evidence that the evolution of the Three Sisters volcano is controlled by processes in the upper and lower crust. Sue Kay spoke on the roles of "flat" subduction, subduction erosion, and delamination on the evolution of the Andean arc. Art Snoke described the magmatic arcs of Tobago and the Ivrea-Verbano zone, emphasizing the interaction between magmatism and deformation. Riccardo Tribuzio interpreted a mafic to ultramafic pluton in the Transantarctic Mountains as the result of formation from a boninite-like primary melt in a backarc continental environment.

Offering specific views of related topics, Neptune Srimal speculated on whether the Cenozoic alkaline magmatism of Tibet was produced by a slab window. Stephanie Briggs presented new ion microprobe zircon ages for the Altai Mountains of NW China, demonstrating Ordovician, Devonian, and Permian crustal growth.

Experimental studies provide an increasingly detailed characterization of the effects of crystal fractionation of arc magmas and at the same time open dramatic new vistas into the range of pressures, temperatures, and bulk compositions that are involved in arc melt generation. Peter Ulmer summarized the results of fractional crystallization experiments on basaltic andesite and picrobasalt and noted that calculated velocities for these rocks suggest that some arc seismic sections likely contain ultramafic cumulates that are being interpreted as mantle tectonite. Tim Grove used new melting experiments on H_2O-saturated peridotite to demonstrate that the H_2O-saturated solidus of peridotite is similar to that determined in much older studies, but colder than has been inferred or assumed in relatively recent work. Max Schmidt summarized a comprehensive suite of experiments on materials at conditions relevant to subduction zones, including a tutorial on super-critical behavior in silicate-H_2O systems at high pressure and temperature. Robert Rapp detailed experiments on the production of adakites by melting of mantle wedge metasomatically altered by slab melts.

Lower crustal and upper mantle processes in arcs were the focus of several presentations. Massimo Tiepolo spoke on chemical disequilibria in mafic magmas, drawing on examples from the Alps and Antarctica. Mike Dungan lectured on the effect of xenolith melting and assimilation on volcanic rock composition, noting that the effect may be most pronounced during the assimilation of mafic rocks by mafic magma. Geoff Clarke presented examples of melt production and garnet granulite formation from hornblende-bearing plutonic rocks in New Zealand. Peter Luffi calculated that water-fluxed melting of vapor-free arc rocks generates mainly trondhjemitic liquids and 3–5 times more garnet than melting in closed systems, concluding that garnet porphyroblasts in trondhjemitic leucosomes need not form by dehydration melting.

Focusing more on tectonics than geochemistry, Jason Saleeby spoke on the deep structures and exhumation of the southern Sierra Nevada batholith, emphasizing the variations in magmatic-structural processes at different depths. Ned Brown showed persuasive evidence that the metamorphic pressures in the Coast Plutonic Complex and Fiordland were caused by magmatic loading. Gene Yogodzinski and Jason Bryant described mafic and ultramafic xenoliths from deep crust and shallow mantle of the Aleutians, whose composition constrains the origin of several different types of primitive lava with widely differing trace element contents.

Taking a more theoretical approach, Greg Hirth gave a wide-ranging overview of the latest developments in the rheology of mafic and ultramafic rocks. Erik Kneller showed the results of calculations using recent experimental determinations of olivine rheology to simulate olivine fabrics in subduction zones. Marc Parmentier showed results of subduction zone models coupling temperature with melt production and flow. Richard Katz presented models of reactive flow and channelized melt transport in subduction zones, showing that cold plumes develop in the hot part of the mantle wedge and hot plumes develop in the crust.

Taber Hersum explained recent work on finite element models that simulate the elastic deformation of partially molten basaltic microstructures and infer wave speeds and yield stress. Thierry Menand presented an analog model of sill injection into the crust, concluding that rigidity contrasts may play a major role in the location and geometry of sills and the development of igneous complexes. George Bergantz assessed the thermal and dynamic response of the lower crust to the intrusion of basaltic dike swarms, showing that thicker arcs produce garnet pyroxenite residues that are convectively unstable. Mark Behn showed how Rayleigh-Taylor instabilities may perturb arc-wedge corner flow and affect densities and seismic velocities.

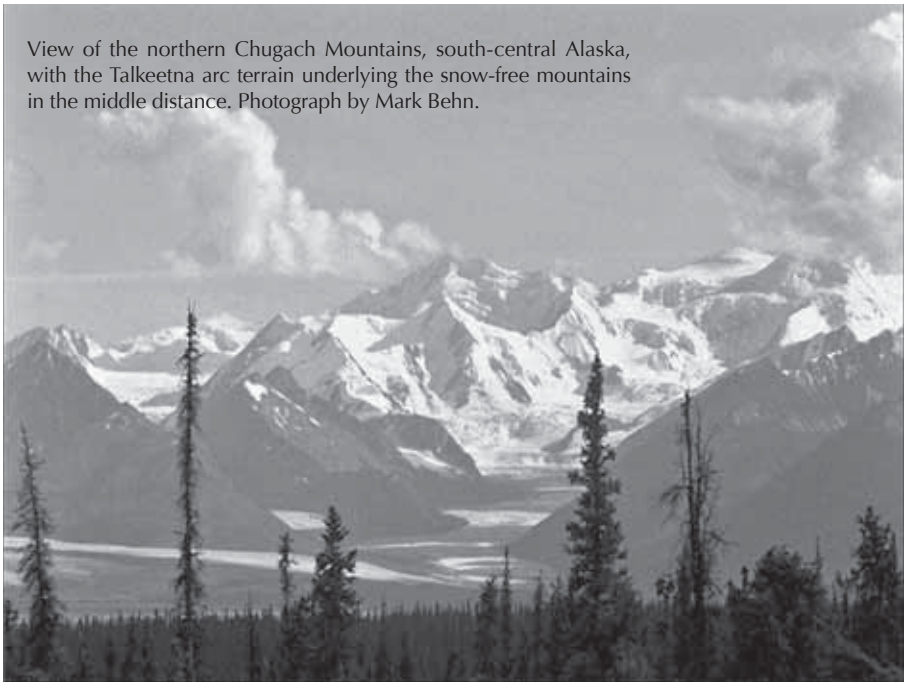
Last, but certainly not least, the genesis of continental crust through arc magmatism and crustal recycling was a central focus

of the Talkeetna Continental Dynamics Project and a theme in many talks at the Penrose Conference. Peter Kelemen and Brad Hacker showed that new bulk compositional estimates for the Talkeetna arc section, informed by thermobarometry indicating the possible depth variation for different lithologies, range from basaltic to andesitic, with the most felsic estimates falling into the range for bulk continental crust. However, Talkeetna trace elements, and even potassium contents, are very different from both Precambrian and Phanerozoic continental crust. This is also true for the tonalitic Tanzawa batholith in SW Japan and its inferred extension in the mid-crust of the Izu-Bonin-Marianas arc system (e.g., presentations by Fryer, Klemperer).

In contrast, some modern arc lavas (western Aleutian) and accreted arc plutons (Peninsular Ranges; Kimbrough and M. Grove presentations) do have the right major and trace element characteristics to form juvenile continental crust. The reasons this varies from place to place remain unclear. In presentations focusing on these and closely related issues, Bob Kay proposed that adakites—lavas close to continental crust in composition—can form from partial melting of crustal material that enters the mantle wedge beneath arcs as a result of subduction erosion. Peter Clift and David Scholl presented separate views of processes and magnitudes of subduction erosion and its effects on trench retreat rates and rates of crustal subduction.

The group gathered for the Valdez Penrose Conference was highly multidisciplinary, with much to learn from each other. The conveners learned a great deal as a consequence, and have received highly positive reports from other participants, focusing on the benefits of such a multidisciplinary discussion. We would like to take this opportunity to thank everyone for traveling so far, both geographically and intellectually, to share results on this important topic.

Participants: Carlos Aiken, Mohammed Alfarhan, Frank Arnott, Jerome (Jerry) Bellian, Richard Blewett, Nicola Boak, Clare Bond, Simon Bukley, Christian Carlsson, Chris Crosby, Mauro De Donatis, Wetherbee Dorshaw, Amy Ellwein, Havard Enge, Luigi Ferranti, Kurt Frankel, Klaus Gessner, Alan Gibbs, Jiulin Cole Guo, Ronan Hennessy, Paul Henson, Bob Holdsworth, Nick Holliman, Andy Howard, John Howell, David Hughes, David Hunt, Jonny Imber, Don Keefer, Tobias Kurz, Zbigniew Malolepszy, Ken McCaffrey, Erik Monsen, Robert Moroz, Ian Mynatt, Iulia Olariu, John Oldow, Douglas Paton, Geoffrey Phelps, Jamie Pringle, Adam Pugh, Steven Smith, Bonnie Souter, Ken Thomson, John Thurmond, Mark Tomasso, Dean Tuck, Erik Venteris, Douglas Walker, Cameron Walsh, Tim Wawrzyniec, and Ruth Wightman.



View of the northern Chugach Mountains, south-central Alaska, with the Talkeetna arc terrain underlying the snow-free mountains in the middle distance. Photograph by Mark Behn.

Field Forum Report

Tectonic Significance of Vertical Boundaries in the Cordillera

McCall, Idaho, USA

30 July–5 August 2006

Conveners:

Scott Giorgis, *Department of Geosciences, SUNY–Geneseo, 1 College Circle, Geneseo, New York 14454, USA, giorgis@geneseo.edu*

Basil Tikoff, *Department of Geology and Geophysics, University of Wisconsin, Madison, Wisconsin 53706, USA, basil@geology.wisc.edu*

William McClelland, *Department of Geological Sciences, University of Idaho, Moscow, Idaho 83844-3022, USA, wmcclell@uidaho.edu*

This GSA Field Forum gathered 27 geologists to examine a well-exposed, easily accessible vertical boundary in the Cordillera: the western Idaho shear zone (WISZ) near McCall, Idaho. The University of Idaho Field Campus in McCall, Idaho, hosted the field forum that ran from 30 July to 5 August 2006.

The conveners' opening presentations gave a broad overview of the tectonic history, general rock types, and goals of the conference. The next day, participants concentrated on the field evidence for transpressional kinematics, high contractional strains, and the Late Cretaceous timing of deformation within the WISZ. Discussion on the outcrop focused on ambiguities associated with constraining fabric or deformation age and a comparison of lithologies and structures observed in the McCall area with other areas along strike in the shear zone.

The third day began with presentations by participants with expertise in the region. Talks included mapping in Idaho, the accreted terranes west of the WISZ, the nature of the WISZ in the Salmon River gorge, and events in western Idaho geologic history that preceded movement on the WISZ as recorded north and west of McCall. These presentations gave a broader context to the rocks and relationships examined during the field conference. Field stops in the afternoon illuminated the scope of neotectonic extensional deformation and its effects on the orientation of preexisting structures. Discussion centered on the active nature of extensional faulting in Idaho.

The morning of day four was devoted to presentations by the participants concerned with vertical boundaries elsewhere in the Cordillera (Peninsular Range shear zone and the western Nevada shear zone) and worldwide. Although similarities exist between these vertical boundaries—most are zones of high strain that record contractional to transpressional deformation—there is large variation in their tectonic interpretations. An afternoon hike into the Hazard Creek Complex, the westernmost granitic complex that intrudes the edge of the accreted terranes, sparked debate centered on the kinematics and timing of the deformation recorded by the fabrics in the Complex.

Day five began with several talks concerning new methods for analyzing fault zones. In the late morning, the group arrived at the outcrop to examine the youngest unit to intrude the WISZ: the Payette River tonalite. Exposures of high-strain tonalite were compared to the low-strain portions that preserve magmatic fabrics. Discussions on the outcrop ranged from the uncertainties associated with vorticity analysis of the Payette River tonalite to the relationship between movement on the WISZ and emplacement of the Idaho Batholith.

On the last day, the group completed a traverse of an exposed portion of the shear zone near Snowbank Mountain, ~40 miles south of McCall. The views toward Oregon encouraged participants to discuss the relationship of the WISZ in the larger context of the North American Cordilleran orogenic belt. In general, the structural style of the shear zone was relatively constant along strike, although there was some variation in lithology.

A final evening session included discussion about Idaho tectonics and about vertical boundaries in general, as well as some directions for future research. Participants agreed that the Salmon River suture zone should refer to the area of western Idaho that marks the collision of accreted terranes with North America. The WISZ, in contrast, is a mid-Cretaceous shear zone within the larger suture zone. Participants also agreed that the WISZ is a transpressional structure, which apparently records a large contractional component. Issues still needing resolution are the amount of contraction versus strike-slip recorded by the shear zone, the effect of preexisting architecture controlling the current vertical geometry, whether an earlier (strike-slip) history occurred in the region, the relationship of magma intrusion and/or transfer to deformation, and the along-strike variations and intersection of other shear zones in the WISZ. These issues are equally applicable to other vertical boundaries both within and outside the North American Cordillera. Another major issue was the role of reactivation: When and why are these zones reactivated? Vertical structural boundaries in the lithosphere that do not exclusively record strike-slip motion occur in many locations, yet are not well understood. Moreover, although vertical boundaries often occur within magmatic arcs in the North American Cordillera, they occur in other tectonic settings as well. While the field forum allowed discussion of the formation, reactivation, and tectonic significance of these structures, further work is still needed to fully understand these enigmatic structures.

Participants: Bryn Benford, Dave Blake, Kenneth Brown, Clay Conway, Keith Gray, Eric Horsman, Zeshan Ismat, Kim Johnson, Dan Jones, Richard Jones, Baird King, Todd LaMaskin, Reed Lewis, Paul Link, Karen Lund, Cathryn A. Manduca, Matthew Mookerjee, Keegan Schmidt, Josh Schwartz, Art Snoke, Caleb Stroup, Sarah Titus, Markos Tranos, and Sandra Wyld.

PENROSE CONFERENCE SCHEDULED

Extending a Continent: Architecture, Rheological Coupling, and Heat Budget

Island of Naxos, Aegean Sea, Greece

9–13 October 2007

Conveners:

Uwe Ring, *Department of Geological Sciences, Canterbury University, Christchurch 8004, New Zealand; uwe.ring@canterbury.ac.nz*

Klaus Regenauer-Lieb, *School of Earth and Geographical Sciences, The University of Western Australia, 35 Stirling Highway, Crawley 6009 WA, Australia; klaus@cyllene.uwa.edu.au*

Brian Wernicke, *Division of Geological and Planetary Sciences, California Institute of Technology, 1200 East California Blvd., Pasadena, California 91125, USA; brian@gps.caltech.edu*

Charalampos Fassoulas, *Natural History Museum, University of Crete, Knossou Ave., Heraklion 71409, Crete, Greece; fassoulas@nhmc.uoc.gr*

DESCRIPTION AND OBJECTIVES

Continental breakup and the formation of oceanic basins is a fundamental process in the earth sciences. Most of our process understanding of the early and intermediate stages of continental extension comes from landborne studies of incipient or failed rifts, such as the East African Rift (especially as gleaned from the new, exciting work in the Afar triangle through the EAGLE project), the Taupo Volcanic Zone, the Rio Grande Rift, the Rhine Graben, and many others. Over the last two decades, there has also been a growing appreciation of the role of extensional tectonics in convergent orogens. This trend was initiated early on by the discovery of highly attenuated crustal sections in the Basin and Range province and the recognition that the attenuation was caused by regional-scale horizontal extension, as manifested by low-angle normal faulting.

The Basin and Range province is considered an archetypal area for continental extension by low-angle normal faulting. However, the dynamic setting of horizontal extension is complex, given that extension began during mid-Tertiary plate convergence and continued to evolve through a transition to dextral-oblique shear. The Aegean Sea above the retreating Hellenic subduction zone is another well-known example of large-scale continental extension. Here, the dynamic forcing of crustal extension is better known, and horizontal extension occurs directly above the subducting plate; lithospheric extension there is caused by slab rollback. Extension in the Aegean occurs from the forearc through the backarc. Furthermore, it is an onshore/offshore setting that allows a combination of land and seaborne studies. The latter, in particular, offers convenient and fast marine geophysical methods that have an advantage in imaging the present state of the crust.

The nature of metamorphic events associated with lithospheric extension is an important topic that is still not well understood. Usually large-scale extension in convergent mountain belts is associated with some sort of "Barrovian-type" metamorphism. In many rift settings, extension is also associated with a temperature-dominated metamorphism, but because deep crustal sections of modern rifts are generally not exposed, our knowledge mainly stems from xenolith studies. A fundamental question is, what mechanism is driving this metamorphism? Is it mainly radioactive decay from upper crustal rocks now buried at depth? Or does the asthenospheric mantle play an important role? Closely related to this question is the role of magmatic processes and whether magmatism can trigger extension and associated metamorphism or whether it is a consequence of these processes.

New theoretical and observational insights into the mechanics of continental extension are just now coming to light through fresh approaches in numerical modeling and measuring active strain. Novel, fully coupled thermomechanical approaches are capable of predicting major detachments self-consistently; i.e., without assuming implicitly or explicitly a weak material layer for nucleating the detachment. This may mark a genuinely new direction in understanding the mechanics of continental extension and the rheological coupling in the lithosphere. Space geodetic techniques, continuous GPS in particular, are beginning to reveal the behavior of deeper parts of active rifts, including episodic tectonic and magmatic events indicative of non–steady-state rheological behavior below the seismogenic layer.

Another important and controversial aspect of continental extensional tectonics is the possibility that extension may be responsible for exhuming metamorphic rocks within convergent orogens, such as onland thrust belts (i.e., Himalaya, European Alps, Betic Cordillera of southeastern Spain, Brooks Range of Alaska) and subduction-related convergent margins (i.e., Franciscan of California, Sanbagawa of Japan, Hellenic/Aegean convergent margin of western and southern Greece, Hikurangi accretionary wedge of northeastern New Zealand). Extension may be particularly responsible for exposing ultra-high-pressure metamorphic rocks. Orogenic belts, especially the older ones, present geoscientists with one of the most difficult questions: What is the contribution of normal/extensional faulting in the exhumation of deep crustal rocks? There is growing evidence that extrusion wedges can accomplish exhumation of deeply buried rocks from great depth soon after these rocks experienced their maximum metamorphism. The normal fault at the top of the extrusion wedges is a geometric effect—it

is not due to lithospheric extension of the region. Although the tectonics community appears to be moving toward a general consensus that deep exhumation is most often a result of continental extensional processes, unequivocal evidence for this inference is still lacking.

Within this context, we propose a Penrose Conference to examine all processes that contribute to horizontal extension of continental lithosphere and the origin of oceanic basins. We want to look at processes at all scales: normal faulting during early stages of plate convergence and the exhumation of (ultra)high-pressure rocks, late orogenic extension and core-complex formation, postorogenic extension associated with an extensional boundary condition (i.e., rifting), and processes at continent-ocean transitions. At the broadest scale, the conference will have five distinct goals: (1) to review and synthesize our knowledge about continental extension processes; (2) to examine the geologic and geophysical evidence relevant to resolving a quantitative understanding of the important tectonic processes, as deduced from seismic imaging, metamorphic and magmatic petrology, isotopic thermochronlogy, structural and kinematic analysis, synorogenic stratigraphy, geomorphology, and paleoelevation data; (3) to examine relevant geodynamic models and their predictions for conditions that might trigger the onset of continental extension; (4) to reconcile new geodetic data and computational geodynamic inferences on rheological coupling within the lithosphere with genuine structural observation of these processes; and (5) to define new research frontiers for studying extension.

At present, there are a number of high-quality studies available for these areas that have generated diverse interpretations and new ideas. While new numerical methods of continental extension are emerging, an exciting opportunity has also arisen to test these models against geological and geophysical evidence and to build new consensus on the great diversity of continental extension in order to understand the different styles of continental extension and find common themes.

Proposed Itinerary

The conference will be five days long, with two days of field trips and three days of presentations. Presentations will consist of six half-day sessions. Each session will have about two hours of oral presentations, including a keynote speaker, a one-hour discussion session, and a one-hour poster session. During the discussion session, individuals will be able to present one or two slides to emphasize a point, but no formal presentations will be allowed. We want to avoid the typical meeting format with back-to-back talks, and instead focus on fleshing out old controversies and new ideas.

Tentative session titles are: (1) local expression of extensional deformation and the role and significance of low-angle normal faulting causing large-scale extension; (2) tectonic implications of metamorphism associated with extensional deformation; (3) geodynamic implications of magmatism associated with extensional deformation; (4) the influence of deep-seated phenomena on the geodynamic evolution of extensional provinces: heat input from the mantle, lithospheric delamination, slab rollback, and gravitational collapse; (5) geodetic data and their implications for the behavior of the deep lithosphere and its coupling to upper crustal extension; and (6) feedback between the brittle and ductile crust and the Moho on the geodynamic evolution of extensional provinces.

Venue

The conference will be held on the Island of Naxos, north of the active Hellenic subduction zone. The island has spectacular exposures of synextensional high-temperature metamorphic rocks exhumed from depths as great as 30 km during Miocene extension. The field trips will be led by Olivier Vanderhaeghe (Université Henri Poincaré in Nancy, France). Vanderhaeghe and colleagues have developed a multidisciplinary study of Naxos, combining structural geology, metamorphic petrology, geochemistry, and sedimentology in order to decipher the thermomechanical evolution of the island. Naxos records a complex geologic history, from the genesis of blueschists, attesting to burial and accretion under a low geothermal gradient, to genesis of granites and exhumation of migmatites in metamorphic core complexes resulting from a drastic change in the geothermal gradient over time. Naxos displays the most complete section, from blueschists to migmatites, exposed in the core of a kilometer-scale dome.

Our objective in selecting Naxos for the meeting is to expose participants, especially those from North America, to an extensional setting different from that of the Basin and Range, which would be the natural site of choice if the conference were to be held in the United States. Although the location will mean more expensive airfare for North American participants, it should easily attract participants from Europe.

Attendees and Estimated Cost

The conference will be limited to about 80 people. Participants will be selected to ensure broad representation by nationality, occupation (i.e., faculty, graduate students, and industry and government scientists), and research interest (i.e., structural geology, metamorphic petrology, isotope geochronology, sedimentology, geomorphology, and geodynamics). Students, early career professionals, women, and minority participants are particularly encouraged to apply.

The registration fee is expected to be about US$950, which will cover all costs, including food and lodging for six nights (8–13 October 2007), local travel, and field trip expenses. Airfare is not included. We hope to be able to partially subsidize the participation of some graduate students, early career professionals, women, and minorities.

Application Deadline: 1 April 2007

Interested persons should send a letter of application to Uwe Ring, Dept. of Geological Sciences, Canterbury University, Christchurch 8004, New Zealand. We also encourage people to send their letters by e-mail to Naxos-Penrose@canterbury.ac.nz. The letter should include a brief statement of the applicant's research interests, relevance of those interests to the focus of the conference, and a potential topic that the applicant might want to present. Please note that we are planning to allow a limited number of oral presentations, but we strongly encourage poster presentations and comment presentations in order to ensure an informal and interactive conference.

Backbone of the Americas:
From Patagonia to Alaska—A Super Rock Star Event

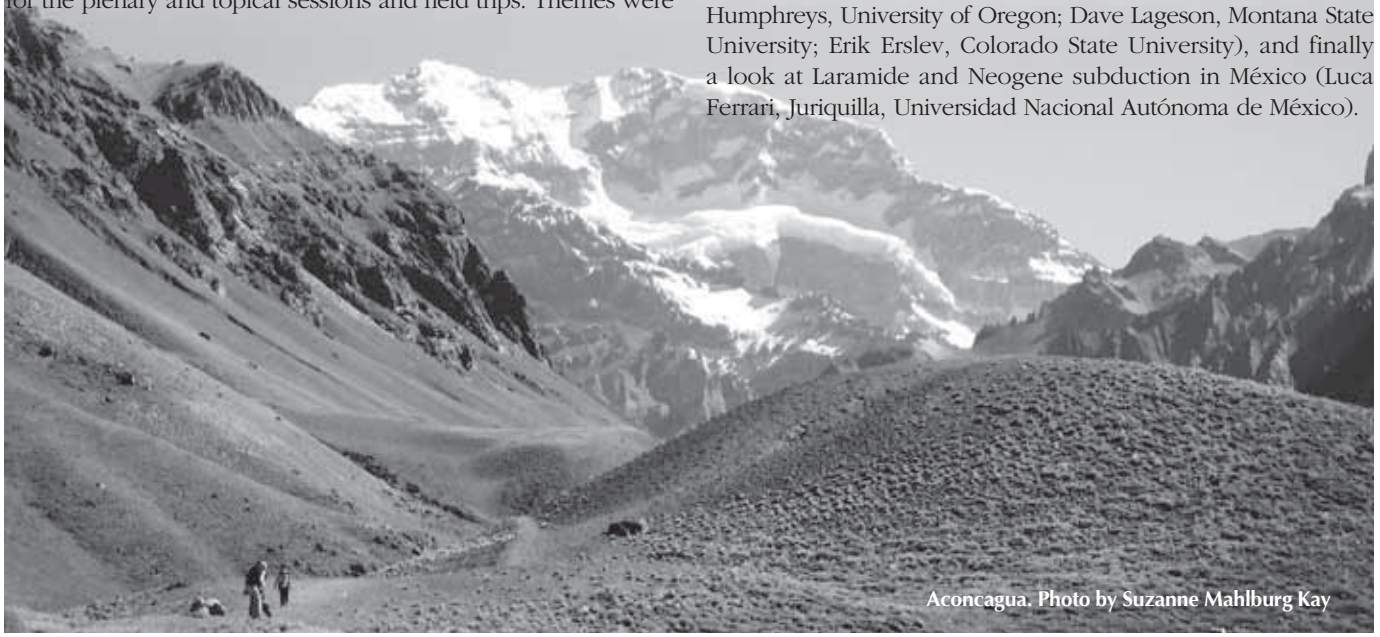
Suzanne Mahlburg Kay *and* ***Victor Ramos,*** *Asociación Geológica Argentina and Geological Society of America*

More than 40 years after the publication of the classic 1963 American Association of Petroleum Geologists Memoir, *Backbone of the Americas, tectonic history from pole to pole*, the geological community studying the Americas gathered in Mendoza, Argentina, to compare, analyze, and discuss the vast orogenic belt that extends along the western margins of the Americas. The occasion was the "Backbone of the Americas: From Patagonia to Alaska" meeting, which was jointly convened by the Geological Society of America (GSA) and the Asociación Geológica Argentina (AGA) with the support of the Sociedad Geológica de Chile. The meeting was held 3–7 April 2006 in the spectacular city of Mendoza in the eastern foothills of the high Central Andes. The venue's location in an active orogenic front in a high-risk seismotectonic area above a shallowly subducting portion of the downgoing Nazca plate provided an exciting backdrop for wide-ranging discussions of tectonic and magmatic processes and a mid-week field trip to the high Andes. The meeting brought together more than 400 participants from 22 countries, including Canada, the United States, México, the Andean countries, Central America, Europe, Asia, and Australia. Student and professional participants came from academia, the petroleum and mineral industry, consulting companies, and government agencies. Special events with a local flavor included a Sunday evening opening reception with Argentine folk singers, sponsored by Repsol-YPF and IAMGOLD, daily lunches sponsored by Barrick Minería Responsible, and a dinner, sponsored by ExxonMobil, at a Mendoza winery complete with professional tango dancers.

Three tectonic processes affecting the western margins and cordilleras of the Americas provided the impetus and focal points for the plenary and topical sessions and field trips. Themes were (1) the effects of shallowing and steepening subduction zones, (2) the processes and consequences of plateau and orogenic uplift, and (3) the results of colliding active spreading centers and oceanic ridges with continental margins. A commonly repeated theme throughout the meeting was the comparison of active processes in the South American Andes with postulated fossil analogies on the western margin of North America and elsewhere.

Plenary Sessions. The plenary sessions on Monday and Tuesday featured invited talks highlighting multidisciplinary approaches and synthesis with the aim of generating discussion and comparisons of concepts and processes along the entire western margin of the Americas. The Monday session began with stimulating general introductions of the northern American margin by Bill Dickinson (University of Arizona) and the southern American margin by Victor Ramos (University of Buenos Aires). These talks were followed by presentations on topics featuring the entire margin including Cenozoic plate kinematics (Tanya Atwater, University of California at Santa Barbara), the upper mantle seismic structure (Steve Grand, University of Texas at Austin), Neogene magmatism (Suzanne Kay, Cornell University), subduction erosion and material balance (Roland von Huene, University of California at Davis) and crustal root foundering (Mihai Ducea, University of Arizona).

The next group of talks featured the meeting themes. The first set on Monday afternoon focused on shallowing and steepening subduction zones. They included overviews of seismicity of shallow subduction zones (Steve Kirby, U.S. Geological Survey), geophysical and geological perspectives of the Chilean flat-slab region (Mario Pardo, University of Chile, Santiago, and Victor Ramos), perspectives on the Peruvian (Antenor Aleman, Peru) and central American shallow subduction zones (Gerhard Wörner, Universität Göttingen), geophysical and geological overviews of western North America with a focus on the Laramide province (Gene Humphreys, University of Oregon; Dave Lageson, Montana State University; Erik Erslev, Colorado State University), and finally a look at Laramide and Neogene subduction in México (Luca Ferrari, Juriquilla, Universidad Nacional Autónoma de México).



Aconcagua. Photo by Suzanne Mahlburg Kay

On Tuesday, the second set of talks featured the plateau and orogenic uplift theme and included presentations on the seismic structure and tectono-structural evolution of the southern Rockies and Colorado plateau (Alan Levander, Rice University, and George Davis, University of Arizona) and the Central Andean plateau (Onno Oncken, GeoForschungsZentrum Potsdam, and Beatriz Coira, Universidad Nacional de Jujuy, Argentina). The third set on the ridge collision theme included perspectives on the Chile Triple junction region (Steve Cande, Scripps Institution of Oceanography, and Constantino Mpodozis, SiPetrol, Chile), the triple junctions of North America (Tim Henstock, University of Southampton, UK), the opening of the Gulf of California (Peter Lonsdale, Scripps Institution of Oceanography), triple junction influences on Baja California (Joann Stock, Caltech) and an overview of the Carribean tectonic picture (Jim Pindell, Rice University). The final plenary talks featured petroleum (Tony Tankard, consultant, Canada) and mineral resources with a focus on gold and copper deposits (Dick Sillitoe, consultant, UK, and Pepe Perelló, Antofagasta Minerals, Chile).

The scientific program ended Friday afternoon with a final plenary session featuring six contributed papers addressing large issues and a summary session where international teams of mature and young scientists reported on the highlights of each meeting theme. The final talk by Dave Scholl (Stanford University), featuring the consequences of subduction erosion, was humorously titled "Removing the Backbone of the Americas."

Topical Sessions. Contributed papers were organized into three sessions, one for each theme. Oral sessions took place on Thursday and on Friday mornings. Poster sessions on meeting themes and related issues were on view for the entire week. Many participants commented on the overall high quality of the presentations, the value of multidisciplinary sessions, and the integrated science presented. There was something for everyone. Presentations in the plateau and orogenic uplift session featured the dynamic and thermal uplift of the plateaus of the Americas and discussed the role of delamination, crustal shortening, magmatism and giant calderas, rapid exhumation and climate in plateau formation, and orogenic uplift. Presentations in the shallow and steepening subduction zone sessions included discussions of Laramide processes, the modern Chile (Pampean) and Peruvian shallow subduction segments, the distinctive styles of shallow subduction zones in México, Alaska, and Central America, and postulated previous shallowly subducting slab in the Neuquén Andes and elsewhere (including China). Presentations on thermal structure, magmatism, and structural and landscape evolution associated with shallow subduction provided insights and led to discussion. Presentations in the ridge collision session truly extended from Alaska to Patagonia, highlighting different settings and the effects in the forearc, arc, and backarc. Discussions on the region of the Chile triple junction extended to climatic changes and the rain shadow effect on the sediment supply to the trench. The interaction between orogenic uplift in these settings and subduction erosion was documented and evaluated.

Field Trips. The conference was complemented by an intrameeting field trip to the high Andes for all meeting participants and optional pre- and postmeeting trips that highlighted the meeting themes and ranged from southern Patagonia to the high Central Andean Puna–Altiplano plateau. Field trip guides are being assembled into a joint publication of GSA and AGA.

Meeting participants unanimously agreed that a high point of the week was the intracongress field trip to the high Andes that was held on an extraordinarily beautiful day. The ~380 participants on trip 403, "Main and Frontal Andean Cordillera near the Southern Boundary of the Pampean Shallow Subduction Zone," loaded into seven buses and two minibuses, each with its own leader and co-leader. The success of the trip was aided by spectacular exposures and capped by a truly magnificent view of the south face of Cerro Aconcagua (~7000 m high)—the highest peak in the Americas. Leaders were from the University of Buenos Aires Laboratorio de Tectónica Andina (Victor Ramos, Daniel Perez, Andrés Folguera, Silvia Barredo, Fernando Pose, Daniel Yagupsky), the CRICYT institute in Mendoza (Laura Giambiaggi, Florencia Bechis), Rio Tinto exploration (Sergio Orts), the Chilean SERNAGEOMIN (Estanislao Godoy), SiPetrol of Chile (Constantino Mpodozis, Pamela Alvarez), and Cornell University (Suzanne Kay).

Pre- and postmeeting field trips followed the conference themes. The two premeeting trips occurred from 27 March to 1 April. Trip 401, "Ridge-Trench Collision East of the Chilean Triple Junction," went to southern Patagonia and was led by Matt Gorring (Montclair State University, New Jersey), who was assisted by Maxie Naipauer (University of Buenos Aires). Trip 402, "Andean Cordillera and Retroarc of the South-Central Andes (~38° to 34°S)," went to the region of the Neuquén Andes, where late Miocene shallow subduction has been proposed. The trip was led by Tomas Zapata of Repsol-YPF, who was assisted by Gonzalo Zamora (Repsol-YPF) and Andreas Folguera (University of Buenos Aires). Postmeeting trip 404 (8–13 April), "Evolution of the Pampean Flatslab Region over the Shallowly Subducting Nazca Plate," led by Victor Ramos, explored the geologic evolution of the Central Andes over the modern Chilean flatslab. Trip 405, "Plateau Uplift—The Central Andean Puna Plateau and the Southern Central Volcanic Zone," took place 9–14 April and was led by Beatriz Coira (Universidad Nacional de Jujuy, Argentina) and Suzanne Kay. This adventurous trip to the high Puna plateau, all in 4-wheel drive vehicles, went to remote localities and was the first of its kind in the region.

Final Comments. A volume of contributions from the meeting is being planned; we hope that it, along with the field trip guides, will be another benchmark in the comprehension of the tectonic processes along the western margin of the Americas. We also hope that future meetings will continue to link the interests of scientists from all along the Americas and elsewhere in the world who are working on the origin and evolution of the American cordilleras from Patagonia to Alaska.

The following are thanked for providing financial support for individual participants: the Jackson School of Geosciences of the University of Texas, the U.S. National Science Foundation, the Argentine CONICYT and Agencia de Promoción Científica y Tecnología, GSA International Division, GSA Structural Geology and Tectonics Division, GSA Foundation, Rio Tinto Mining, Goldfield Corporation, and ILP-Project ERAS.

THE GEOLOGICAL SOCIETY OF AMERICA

Donna L. Russell, *Director of Operations*

GSA Programs for Priority Funding by GSA Foundation

CORNERSTONE INITIATIVE

Funding the future of the geosciences
A continuation of GSAF's 25th Anniversary

Cornerstone for the Future: In order to provide an increased level of funding to substantially impact the critical areas of concern of GSA Members, GSA Foundation is launching this major initiative to raise additional support for the following critical programs over the next two to three years.

We are asking every GSA member to make a contribution toward the success of this initiative.

Student Research Grants: $150,000

The GSA research grants program provides partial support of graduate thesis research in the geological sciences for students at universities in the United States, Canada, Mexico, and Central America.

Mentor Programs: $100,000

These programs provide students with the opportunity to speak with mentors from the applied fields of the geosciences and learn about career choices. The programs operate at Section meetings as well as the Annual meeting and their impact grows each year.

GeoCorps America™ Program: $120,000

This program places geoscientists within National Parks plus Forest Service and BLM lands as summer interns. The interns can be university students, professionals including teachers, or retirees. Since the program began, 200 interns have been placed in National Parks, National Forests, and BLM lands.

Field Forums: $60,000

Field Forums offer the opportunity for exchange of current knowledge and ideas in a field setting. They are designed after Penrose Conferences and stimulate individual and collaborative research, thereby accelerating the advance of the geosciences by interactions in the field.

Penrose Conferences: $40,000

Penrose Conferences provide the opportunity for exchange of current information and advances pertaining to the science of geology and related fields. This level of support would allow student participation in the conferences.

Congressional Science Fellow: $75,000

Congressional Science Fellows work as special legislative assistants within the congressional staff system, and thus contribute to more effective use of scientific and technical knowledge in government. The requested level of annual support would enable GSA to sponsor two Congressional Fellows per year, provided the U.S. Geological Survey continues to match funds.

Total annual priority funding needs: $545,000.

Most memorable early geologic experience:

In mountainous central Puerto Rico in the early 1960's, I came on a stream that headed in erosion-resistant boulder-forming Malo Breccia, dropped off a fault-controlled waterfall, and ran off over relatively soft and friable Cotorra Tuff. When the stream was in spate, boulders from the Malo rolled down and laterally across the Cotorra, like huge billiard balls from cushion to cushion, grinding down a flat-bottomed U-shaped valley. I thought this a neat feature in a tropical terrain.

—Reginald P. Briggs

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In Memoriam

John P. Craddock
Saint Paul, Minnesota
23 July 2006

Roger B. Morrison
Tucson, Arizona
Notified 25 October 2006

William B. Heroy Jr.
Durham, North Carolina
25 September 2006

Jack Edward Schoellhamer
Aromas, California
1 June 2006

James Edward Kahle
Castle Rock, Washington
28 January 2006

Theodore D. Lee
Puyallup, Washington
24 October 2006

Robert M. Linsley
Hamilton, New York
25 July 2006

Please contact the GSA Foundation at +1-303-357-1054
or drussell@geosociety.org
for information on contributing to the Memorial Fund.

About People

GSA Senior Member, **Marcus E. Milling,** who passed away on 17 October 2006, has received a posthumous honor from the American Geological Institute (AGI). AGI has renamed its Legendary Geoscientist Award the Marcus E. Milling Legendary Geoscientist Medal. This medal is awarded annually to a geoscientist who has attained significant scientific achievement as well as provided sustained service to the geosciences.

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Kahiltna Glacier, Denali National Park.

Alaska: Changing Glaciers–Changing Landscapes

21–28 July 2007 (8 days); Location: Southern and central Alaska, USA; Scientific Leader: Bruce Molnia

Who Should Attend? Geologists and students interested in glaciology or climate change. Min.: 10; max.: 25.

Fee: US$2,700 for GSA Members and spouses; US$2,800 for nonmembers. **Deposit: US$300**, due **1 June 2007.** The balance is due **18 June 2007. Included:** All hotels, transportation, museum, National Park, and other entrance fees, most meals, all boat cruise tours (Prince William Sound, Kenai Fjords), and guidebook. **Not Included:** Airfare to Anchorage or Fairbanks and some meals. Find flight info and our cancellation and refund policy at www.geoventures.org.

Trip Overview: The educational objective of the tour is to introduce participants to the unique, dynamic, and rapidly changing glaciers of south-central Alaska. Tour participants will also be introduced to the area's spectacular landscapes and geology.

Scientific Program and Itinerary: During "up-close" visits to several dozen glaciers in southern and central Alaska, participants will get a first-hand view of the recent behavior of these glaciers and their response to climate change. Participants won't be able to miss the outstanding geology and dynamic landscapes of southern Alaska, and will have the opportunity to learn about permafrost as well. The level of instruction will be suitable for both professionals and lay geologists. See a detailed itinerary on the GeoVentures Web site, www.geoventures.org.

Scientific Leader: Bruce Molnia, U.S. Geological Survey (USGS). Molnia has studied Alaska's glaciers for more than 37 years. He has authored several books and authored or coauthored more than 100 abstracts, maps, and articles about Alaska. Molnia is now conducting field studies in Glacier Bay and Kenai Fjords National Parks.

Questions about the agenda? Concerns about accessibility? Contact Wesley Hill, whill@geosociety.org, +1-303-357-1005. GSA is committed to making this program accessible to all people interested in attending.

Questions about the science? Contact Bruce Molnia, USGS, bmolnia@usgs.gov.

2007 GSA GeoVentures™

Participants must be 18 or older and in good health. Any physical condition requiring special attention, diet, or treatment must be noted in writing when reservations are made. GSA is committed to accommodating special needs. Deposits and payments are refundable under certain conditions. Please check www.geoventures.org for our refund policy. Please do not make flight reservations until GSA has confirmed that the trip will run. Contact Wesley Hill, whill@geosociety.org, +1-303-357-1005, if you need further information.

Colorado River.

Geology of the Grand Canyon—River Trip

2–9 June 2007 (7 days, 6 nights on the river)
Location: Grand Canyon National Park, Arizona, USA
Scientific Leader: Wayne Ranney

Who Should Attend? Professional and amateur geologists and students. Basic geology coursework required. Min./max.: 13. Limited space: register today!

Fee: US$2,410 for GSA Members and spouses; US$2,510 for nonmembers. **Deposit: US$300**, due **20 February 2007.** The balance is due **1 March 2007. Included:** First night hotel stay in Flagstaff (2 June); transportation to/from Flagstaff–Grand Canyon; all meals on the river; all river gear; guidebook and field notes. **Not Included:** Airfare to/from Flagstaff, Arizona; dinner the first night. Find flight info at www.geoventures.org. Cancellations for this trip must be received in writing by 2 March 2007. All monies paid will be refunded if the cancellation is received by this date, less a US$50 processing fee.

Trip Overview: Join us for this incredible opportunity to float the grandest canyon in the world with expert Grand Canyon geologist Wayne Ranney. This 280-mile trip will travel the entire length of the Grand Canyon, over all the infamous canyon rapids. We will stop for short side-canyon hikes and camp under the stars as Ranney explains the science behind the beauty. You will learn about the varied ideas concerning the Grand Canyon's origin, both depositional and erosional. Traveling by boat gives you a sequential view of the named rock formations.

Scientific Program and Itinerary: The trip will highlight the formation of Grand Canyon's major rock groups: the tectonic development of the Middle Proterozoic Vishnu Group, the deposition of the Late Proterozoic Grand Canyon Supergroup, and the Paleozoic rocks in the Grand Canyon. It will also focus on the Laramide to Quaternary development of the Grand Canyon landscape, with an emphasis on the enigmatic timing of the Colorado Plateau uplift, the Laramide age peneplane, and the various modes that may have given rise to the Grand Canyon: headward erosion, stream capture vs. catastrophic spillover of ancient lakes, etc. The science presented will be geared for students and professionals with some geologic training. See a detailed itinerary at www.geoventures.org.

Scientific Leader: Wayne Ranney. Ranney has extensive experience in communicating complex scientific ideas to nonscientists and has published several books and articles on the landscape development and geology of the American Southwest, including *Carving Grand Canyon.* He is now professor of geology at Yavapai College, Sedona. Ranney is also an outdoor educator for the Museum of Northern Arizona, Grand Canyon Field Institute, and Elderhostel.

Questions about the river trip or its accessibility? Contact Canyoneers river outfitter, +1-800-525-0924. GSA is committed to making this program accessible to all people interested in attending.

Questions about the science? Contact Wayne Ranney, wayneranney@earthlink.net.

China's Feathered Dinosaurs—Paleo-Expedition

20–29 July 2007 (10 days); Location: Western Liaoning Province, China; Scientific Leader: Hailu You

Beijing, China.

Who Should Attend? Professional or amateur paleontologists and students. Min.: 10; max.: 17.

Fee: US$2,800 per person (double occupancy) for GSA Members and spouses; US$2,900 per person (double occupancy) for nonmembers. For single occupancy, add US$300. **Deposit: US$500,** due **14 May 2007.** The balance is due **14 June 2007. Included:** Deluxe accommodations in Beijing and comfortable accommodations in Yixian County of western Liaoning Province; all meals with beverages; all transportation within China, including transfers between airports and hotels; all sight-

seeing tickets; all tools for digging fossils, including hammers, gloves, chisels for individual use, and other equipment; English-speaking professional leadership and guide; local permits for exploring and digging of feathered dinosaurs. **Not Included:** International airfare; passport and visa fees; tips; travel insurance. Pre-trip or post-trip sightseeing in Beijing and/or Xi'an and Lanzhou is available at an additional charge. Find flight info and our cancellation and refund policy at www.geoventures.org.

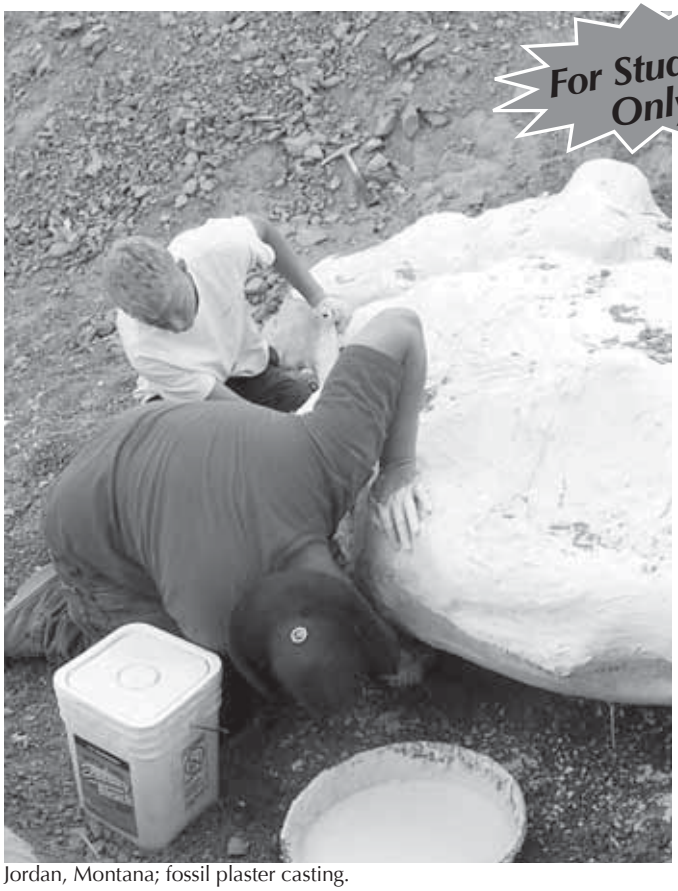
How to obtain your tourist visa to China: Check www.flychina.com for information on Chinese visas and air tickets. Allow at least 30 days to obtain your tourist visa.

Trip Overview: Following the discovery of the first feathered dinosaur in 1996, the western Liaoning Province in northeastern China has yielded an exceptionally well-preserved late Mesozoic biota and provides a rare opportunity to inquire into the world lost for 100 million years. The discovery and study of numerous specimens of feathered dinosaurs in this area has greatly advanced our understanding of the relationship between dinosaurs and birds, and the origin and early evolution of feathers and flight. On this tour, participants will have the opportunity to see the fossil museums in Beijing and Liaoning Province, to search and dig dinosaurs with Dr. You, and to study sedimentology and taphonomy based on the exceptionally well-exposed rocks in the western Liaoning Province, as well as visit the Great Wall and other areas. See detailed itinerary and pre/post trip options on the GeoVentures Web site: www.geoventures.org.

Scientific Program and Itinerary: The primary goals of this expedition include (1) find missing parts of known feathered dinosaurs; (2) find new feathered dinosaurs and their relatives (non-feathered herbivorous dinosaurs); (3) find different aged specimens to learn the growth history and population structure of these dinosaurs; (4) prospect this horizon laterally in search of more sites; and (5) collect additional sedimentological and taphonomical data to test theories on cause of mass-mortality and the burial history of bones.

Scientific Leader: Hailu You, Institute of Geology, Chinese Academy of Geological Sciences. You gained extensive knowledge of vertebrate paleontology, especially dinosaurs, through six years of Ph.D. studies at the University of Pennsylvania, as well as 15 years of field and laboratory work on vertebrate fossils. You's recent research focuses on two projects: the search for the new evolutionary "missing links" from the Early Cretaceous of China, and the evolution of basal horned dinosaurs. You functions as a lead scientist in collaboration with colleagues from Carnegie Museum of Natural History, the University of Pennsylvania, the Canadian Museum of Nature, and various Chinese institutions. Since 2003, You has named nine new dinosaur genera.

Questions? Concerns about accessibility? Contact Joe Cornwell, PaleoWorld Research Foundation, cornwell@paleoworld.org. GSA is committed to making this program accessible to all people interested in attending.



Jordan, Montana; fossil plaster casting.

Montana Dinosaur Expedition for Students—Paleo-Dig

7–16 July 2007 (10 days)
Location: Hell Creek Formation, Jordan, Montana, USA
Trip Leader: Joseph Hatcher

Who Should Attend? University and college students studying paleontology or a related field. Min.: 10; max.: 14. Limited space; register today!
Fee: US$1,150. You must be a GSA Student Member to attend. **Deposit: US$200**, due **28 May 2007.** The balance is due **7 June 2007. Included:** Lodging: tent camping (bring your own tent); amenities: bathroom/showers/laundry provided; all meals; all entrance fees, site fees, and museum fees; ground transportation to sites; guidebook and field notes. **Not Included:** Airfare to and from Billings, Montana. Find flight info and our cancellation and refund policy at www.geoventures.org.

Trip Overview: This 100% hands-on expedition will focus on field-based research, including the importance of data analysis using fossils documented and collected in the field. Expert paleontologists will cover taphonomy, taxonomy, osteo-anatomy, sedimentology, fossil prep lab techniques and geologic time using real-life examples and museum artifacts. This is NOT a tour: as a research team member, you will learn field

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techniques and take part in field work to find, collect, and preserve dinosaur fossils.

Scientific Program and Itinerary: Mornings will be spent in the field, and afternoons will be spent in classes as well as in the museum cataloging finds and doing fossil preparation. Every student will have the opportunity to participate in each aspect of field and museum work. Evenings will be spent journaling, going over the day's activities, and planning for the next day; evenings are also the perfect time for answering larger questions and sharing experiences as a group. Also planned is a boat tour of Fort Peck Lake, to view exposures of different formations of strata in the Jordan area. Fort Peck Lake is a great place to explore, relax, and spend time with new friends. See a detailed itinerary at www.geoventures.org.

Scientific Leaders

Joseph Hatcher: Hatcher's experience includes five years as resident paleontologist at PaleoWorld Research Foundation (PWRF) in Jordan, Montana; as well as curator of paleontology, Garfield County Museum, Jordan, Montana; and assistant lab manager, Dinosaur Hall Fossil Preparation Lab, Academy of Natural Sciences, Philadelphia, Pennsylvania. Among his accomplishments is the successful collection of *Triceratops* and hadrosaur skeletons. Hatcher has lead five consecutive field seasons in the Cretaceous badlands of Montana's Hell Creek Formation. His field expeditions have included student field teams and public clients.

Jason Poole: Poole is the head fossil preparator for the Bahariya Dinosaur Project and PWRF Director of Educational Resources. His home base is the Academy of Natural Sciences in Philadelphia. Poole's focus is paleontology, and he is the Dinosaur Hall fossil prep lab manager and a teacher naturalist. He has spent time digging in Egypt, Patagonia, Montana, New Jersey, New York, and Pennsylvania.

Questions? Concerns about accessibility? Contact Joseph Hatcher, PaleoWorld Research Foundation, paleoworld@paleoworld.org, +1-941-473-9511. GSA is committed to making this program accessible to all people interested in attending.

Check the February issue of *GSA Today* to learn about an exciting GeoHostel trip to the California Eastern Sierra range! For a full list of trip details, daily itineraries, and registration form, go to **www.geoventures.org.**

REGISTER TODAY!

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

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Positions Open

ENVIRONMENTAL GEOCHEMIST
RUTGERS UNIVERSITY–NEWARK

A full-time, tenure-track position of Assistant Professor of Environmental Geoscience is offered in the Dept of Earth and Environmental Sciences at Rutgers University-Newark for Fall 2007. We are especially interested in candidates with specialization in soil and/or water geochemistry with emphasis on pollution, although other areas will be considered. Successful candidates should be able to collaborate with colleagues in environmental geophysics, air pollution, environmental engineering, and microbiology/ecology. Applicants must have a Ph.D., postdoctoral training, a record of research, and show potential for developing an independently-funded research program. Excellent laboratory facilities and a competitive start-up package. Participation in undergraduate teaching and graduate programs is expected. Applications will be reviewed beginning 15 January 2007. Interested individuals are asked to send a letter of application, Curriculum Vitae, statements of research and teaching interests, and three letters of recommendation should be sent to: Dr. Alexander E. Gates, Chair, Dept of Earth and Environmental Sciences, Rutgers University, 101 Warren Street, Newark, NJ 07102, USA, or agates@andromeda.rutgers.edu. For more information visit http://geology.newark.rutgers.edu. Rutgers University is an equal opportunity/affirmative action employer.

HYDROLOGY FACULTY AT NM TECH
ASSISTANT PROFESSOR OF HYDROLOGY

New Mexico Institute of Mining and Technology invites applications for a tenure-track position in the Hydrology Program. The position is a joint appointment between the Department of Earth and Environmental Science and the Geophysical Research Center, a state-funded research agency.

Applicants should have a Ph.D. in Earth Sciences, Civil or Environmental Engineering, or a related field at the time of appointment. We seek candidates with interest in combining hydrological modeling and field studies. Areas of particular interest include, but are not limited to, hydrogeology, karst hydrology, sedimentary-basin hydrology, and hydrological remote sensing/GIS. Potential for excellence in teaching and research are the most important qualifications. Women and underrepresented minorities are encouraged to apply.

Responsibilities will include developing an active program of extramurally funded research, supervising and supporting graduate students, and teaching two graduate or undergraduate courses per year.

The successful candidate will join a program of six full-time Hydrology faculty, eight adjunct faculty, and 30 graduate students. Hydrology is part of the Department of Earth and Environmental Science, consisting of 21 faculty and 150–120 undergraduate and graduate students. Additional geoscience professionals on campus include over 30 staff members of the Bureau of Geology and Mineral Resources, New Mexico's geological survey. For further information on the position and on New Mexico Tech see www.ees.nmt.edu/professional_ops.html.

For detailed inquiries, contact search committee co-chairs, Fred Phillips, phillips@nmt.edu, and/or Enrique Vivoni, vivoni@nmt.edu.

Applicants should submit a letter of interest, resume, a statement of teaching and research interests, and the names of three references to Hydrology Search, Human Resources, Box 96, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801. College transcripts will be required if selected to interview. Applications will be reviewed as received. E-mail applications are not accepted. New Mexico Tech is an equal opportunity/affirmative action employer.

TENURE-TRACK FACULTY POSITIONS
DEPARTMENT OF EARTH & SPACE SCIENCES
UNIVERSITY OF CALIFORNIA AT LOS ANGELES

Geology: We seek outstanding candidates for one or more positions in the general area of geology. We favor those who tackle major geoscience problems with innovative multidisciplinary approaches involving analytical, computational, and/or field studies. Applications should be mailed to the Chair of the Geology Search Committee #06-2, UCLA Department of Earth and Space Sciences, 595 Young Drive East, Los Angeles, CA, 90095-1567. Inquiries may be directed to **search062@ess.ucla.edu**.

Seismology: We seek one or more new faculty in the general field of seismology. A candidate must have an active research program and demonstrated excellence in research and teaching. Candidates should be able to combine observations, theory and models to investigate the physics of earthquake processes and/or processes within the Earth's deep interior. Applicants should complement our strengths in solid Earth and planetary geophysics. Please mail applications to the Chair of the Seismology Search Committee #06-3, UCLA Department of Earth and Space Sciences, 595 Young Drive East, Los Angeles, CA, 90095-1567. Inquiries may be directed to **search063@ess.ucla.edu**.

***For both positions*:** Applicants must hold a Ph.D. or equivalent. We anticipate appointments at the Assistant Professor level, but exceptionally qualified candidates will be considered at the Associate or Full professor levels. Applications must include a statement describing research and teaching interests, curriculum vitae with a complete list of publications, names and addresses of three referees, and paper copies of up to five important publications. Selection will begin on **15 January 2007** for appointment **1 July 2007.**

Information about Earth and Space Sciences at UCLA is available on the Web at **www.ess.ucla.edu**. UCLA and the Department are committed to the highest standards of scholarship and professional activities and to a campus climate supporting equality and diversity. The University of California is an affirmative action/equal opportunity employer.

ASSISTANT PROFESSOR OF GEOSCIENCES
(TENURE TRACK) UNIVERSITY OF CONNECTICUT

The Center for Integrative Geosciences at the University of Connecticut invites applications for a tenure-track faculty member whose research interest focuses on ancient and/or modern depositional systems. We are especially interested in applicants whose research and teaching interests cross traditional discipline boundaries, and the successful candidate is expected to have a strong interest in building interdisciplinary partnerships beyond the geosciences core provided by the Center. The candidate's interests should complement and augment existing strengths within the Center and Departments of Geography, Anthropology, or Marine Sciences. Anticipated start date for this position is August 2007.

Qualifications: Applicants must have a Ph.D. in geosciences or a related field at the time of appointment, and will be expected to participate in the Bachelor's, Master's and Doctoral programs in the Center for Integrative Geosciences as well as in the candidate's academic home department. Post-doctoral experience is also desirable.

Applicants should send a letter of application, statements of research and teaching interests, curriculum vitae, and contact information for three referees to Pieter T. Visscher, Search Committee Chair, Center for Integrative Geosciences, U-2045, Storrs 06269-2045. +1-860-486 4432, pieter.visscher@uconn.edu. Review of applications will begin February 1, 2007 and will continue until the position is filled. Salary is commensurate with background and experience.

At the University of Connecticut, our commitment to excellence is complemented by our commitment to build a culturally diverse community. We encourage members of under-represented groups, including minorities, women, and people with disabilities, to apply.

COLLEGE OF CHARLESTON, VISITING PROFESSOR
ENVIRONMENTAL GEOSCIENCES

The Department of Geology and Environmental Geosciences (www.cofc.edu/~geology/)at the College of Charleston invites applications for a visiting professor at the Assistant Professor level in Environmental Geosciences beginning in August 2007. Candidates working in the following areas are particularly encouraged to apply: geological applications of remote sensing, environmental geophysics, earth resources, global climate change. We seek applicants who can integrate field, experimental, and laboratory observations with relevant theory. Successful candidates are expected to teach undergraduate and graduate courses, and may supervise undergraduate and graduate research. Should the visiting professor position become permanent, the visiting professor may apply.

Interested persons should send a letter stating their interest in the position, curriculum vitae, statements of teaching philosophy, evidence of effective teaching, research interests, unofficial academic transcripts, and names of three references to: Environmental Geosciences Search Committee, Department of Geology and Environmental Geosciences, College of Charleston, Charleston, SC 29424. Review of applications will begin 29 January 2007 and continue until the position is filled.

COLLEGE OF CHARLESTON
TENURE-TRACK ASSISTANT PROFESSOR
COASTAL SEDIMENTOLOGY/STRATIGRAPHY

The Department of Geology and Environmental Geosciences (www.cofc.edu/~geology/ at the College of Charleston invites applications for a tenure-track assistant professor position in Coastal Sedimentology and Stratigraphy beginning in August 2007. We are seeking a broadly trained sedimentary geologist with knowledge of regional stratigraphy who will develop research programs and opportunities for undergraduate and graduate students. While coastal sedimentology and stratigraphy research is important, we value teaching excellence. The successful candidate must have a strong background in field and laboratory methods pertinent to the disciplines, and utilize state of the art technologies. Familiarity with geophysical techniques particularly, seismic stratigraphy, is highly desirable. The faculty member will also instruct and supervise graduate students in the Masters of Environmental Studies program.

Interested persons should send a letter of interest, curriculum vita, statement of teaching philosophy, evidence of effective teaching, research interests, unofficial academic transcripts, and names of three references to: Coastal Sedimentology/Stratigraphy Search Committee, Department of Geology and Environmental Geosciences, College of Charleston, Charleston, SC 29424. Review of applications will begin 29 January 2007 and continue until the position is filled.

ASSISTANT PROFESSOR
IGNEOUS/METAMORPHIC PETROLOGY
UNIVERSITY OF WEST GEORGIA

The Department of Geosciences at the University of West Georgia seeks an **Igneous and/or Metamorphic Petrologist** for a **full-time tenure-track Assistant Professor** position beginning August 2007. Candidates in all fields of igneous and/or metamorphic petrology are welcome. Teaching duties may include introductory courses in geology of national parks, physical geology and/or historical geology, and will include an upper-level course in igneous and metamorphic petrology as well as other courses depending on the candidate's field of specialty. Candidates should have a Ph.D. and a strong commitment to an undergraduate *field-based* education. Applicants should submit a letter summarizing research interests and teaching philosophy as well as a curriculum vita, copies of transcripts (official copies required upon hiring), and names of three professional references. Application materials should be sent to Dr. Timothy Chowns (tchowns@westga.edu), Petrology Search Committee Chair, Department of Geosciences, 1601 Maple Street, University of West Georgia, Carrollton, GA 30118. Application review will begin on January 1 and continue until the position is filled.

The Department of Geosciences (www.westga.edu/~geosci) offers undergraduate degrees in geography, geology, and earth science education. Its thirteen tenure-track faculty members and lab coordinator are strongly committed to high-quality undergraduate education and vigorous faculty-student research. Located fifty miles west of Atlanta, the State University of West Georgia is a growing regional university of the University System of Georgia with an enrollment of approximately 11,000. The University of West Georgia is an equal opportunity/affirmative action employer.

HARVARD UNIVERSITY
DEPARTMENT OF EARTH & PLANETARY SCIENCES

The Department of Earth & Planetary Sciences at Harvard University invites applications for tenure-track faculty positions at the assistant or associate professor level. We are seeking exceptional scientists and educators in the broadly defined field of earth and planetary

sciences including, but not limited to, the areas of geobiology, planetary science, geology and earth history, paleoclimatology, and solid earth geophysics. We particularly encourage applications from and nominations of women and minorities.

Applicants should send (by mail or e-mail) a statement of research and teaching interests, curriculum vitae, and the names and contact information, including e-mail addresses, of three references to: EPS General Search Committee, c/o Maryorie Grande, Department of Earth & Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138 USA; e-mail: grande@eps.harvard.edu.

Applications will be reviewed immediately and continue until the positions are filled. Harvard University is an Affirmative Action/Equal Opportunity Employer. For more information about the department, please visit our Web site at www.eps.harvard.edu.

DOCTORAL DIRECTOR
DEPT. OF EARTH AND ENVIRONMENTAL STUDIES
MONTCLAIR STATE UNIVERSITY

Applications are invited for the Director of our interdisciplinary Doctoral Program in Environmental Management. The starting date is July 1 or September 1, 2007, as available. The Director will hold a faculty appointment at the Associate/Full Professor rank with undergraduate and graduate teaching duties within the Department of Earth and Environmental Studies. The successful candidate will carry out an active, externally funded research program in a field within environmental management. The position includes reassigned time for administrative duties including recruiting and advising doctoral students. Preference will be given to candidates with a demonstrated record of scholarship, teaching, graduate advising, and leadership skills within an established doctoral program. Please visit www.csam.montclair.edu/earth/eesweb/ for more information. Applications should include a CV, statements of teaching, research, and administrative philosophies, and the names and contact information for five professional references. Hard copies or electronic applications should be sent to Dr. Stefanie Brachfeld, VF40 Search Committee Chair, Department of Earth and Environmental Studies, Montclair State University, Box C316-VF40, Montclair, NJ 07043; e-mail: brachfelds@mail.montclair.edu. Review of applications will begin immediately and continue until the position is filled. Montclair State University is an equal opportunity/affirmative action institution. Visit us at www.montclair.edu.

ASSISTANT/ASSOCIATE PROFESSOR, PEDOLOGY
FULL-TIME, TENURE-TRACK
THE PENNSYLVANIA STATE UNIVERSITY

The successful candidate is expected to develop an externally funded research program in soil genesis, classification, mapping, or morphology (including geomorphology). Research approaches to understand fundamental soil processes and applications that involve land use and environmental quality issues are highly desired. The candidate is also expected to teach one intermediate and one advanced course in pedology per year, coordinate the development of field skills of undergraduates, facilitate participation by graduate students a summer field trip, direct the studies of graduate students, and interface with government and professional organizations.

QUALIFICATIONS: Ph.D. in soil science or related field with an emphasis in soil mapping, morphology, genesis, classification, and interpretation. The candidate must have experience in the description and characterization of soils in the field. An interest in teaching undergraduates and in collaborative research is also required. Training and experience in pedochemistry (including mineralogy), pedometrics, geospatial technologies (especially remote sensing and spatial-temporal statistics), and geophysical techniques is desirable.

APPLICATION: Applicants should submit (electronic format preferred) a letter of application highlighting qualifications, statement of research interests, statement of teaching philosophy, curriculum vita, academic transcripts, and names and addresses (including e-mail) of three professional references to: Dr. Daniel D. Fritton, Search Committee Chair, Department of Crop and Soil Sciences, The Pennsylvania State University, 116 Agricultural Sciences and Industries Building, University Park, PA16802, 814-865-1143, ddf@psu.edu. The closing date for applications is February 1, 2007 or until a qualified candidate is identified. Further details are available at http://cropsoil.psu.edu/pdf/pedology_faculty_position.pdf.

EARTH AND OCEAN SCIENCES INSTRUCTOR
DUKE UNIVERSITY

The Nicholas School of the Environment and Earth Sciences of Duke University invites individuals to apply for a position as Instructor in the Division of Earth and Ocean Sciences to begin in fall 2007. The successful candidate will be expected to teach broad, introductory and upper-level undergraduate courses in earth, ocean, and/or atmospheric sciences and to contribute to the development of innovative undergraduate education in the geosciences at Duke. We seek candidates with a record of excellence in teaching and a commitment to mentoring undergraduate students.

The Nicholas School focuses on leadership in education, research, and service to understand basic Earth and environmental processes, to understand human behavior related to the environment, and to inform society about the conservation and enhancement of the environment and its natural resources for future generations. The Nicholas School includes 50 faculty representing a broad spectrum of disciplines within the earth and environmental sciences and offers graduate, professional and undergraduate programs. More information on the Nicholas School is available at www.nicholas.duke.edu/index.html.

Letters of interest should include a curriculum vitae and a teaching statement that explains the applicant's teaching experience and philosophy and identifies introductory and upper-level undergraduate courses within earth, ocean, and atmospheric sciences that the applicant can teach. Names and contact information of three references should also be included. Application material should be sent to Chair, Earth and Ocean Sciences Instructor Search, Division of Earth and Ocean Sciences, Nicholas School of the Environment and Earth Sciences, Box 90227, Duke University, Durham, NC 27708. The search committee will begin reviewing applications 1 February 2007: the search will remain open until the position is filled. The term of the appointment is for two years, with potential for renewal.

Duke University is an equal-opportunity/affirmative action employer. Women and minorities are encouraged to apply.

Colorado School of Mines
Department of Geology & Geological Engineering
Assistant Professor-Petrologist

The Department of Geology and Geological Engineering at the Colorado School of Mines invites applications for a tenure-track position in igneous or metamorphic petrology/earth materials/field geology to begin in August, 2007. The position will be filled at the Assistant Professor rank.

The successful candidate will be expected to participate in field camp and teach undergraduate courses in earth materials, petrology, and field methods.

Applicants must have a Ph.D. in a geosciences field. The successful candidate must demonstrate the potential for successful teaching and possess strong interpersonal and communications abilities. Preference will be given to applicants with specialties in metamorphic petrology, igneous petrology, and/or earth materials and extensive fieldwork and geologic mapping experience.

For a complete job announcement, more information about the position and the university, and instructions on how to apply, please visit our web site at:
http://www.is.mines.edu/hr/Faculty_Jobs.shtm

CSM is an EEO/AA employer and is committed to enhancing the diversity of its campus community. Women, minorities, veterans, and individuals with disabilities are encouraged to apply.

Colorado School of Mines
Department of Geology & Geological Engineering
Assistant Professor-GIS

Colorado School of Mines Department of Geology & Geological Engineering invites applications for an anticipated tenure-track Assistant Professor to begin in August 2007. The Geological Engineering program awards an ABET accredited BS degree and graduate degrees at the ME, MS and Ph.D. levels.

Candidates must possess a doctoral degree in geological engineering is registered as a professional engineer, or meets the qualifications to become registered. Preference will be given to applicants who can teach undergraduate and graduate courses in Geographic Information Systems (GIS), data analysis, or remote sensing. Research interests should complement and support existing campus programs, specifically in the areas of engineering geology and geotechnics such as applied geomorphology, neotectonics and Quaternary geology.

For a complete job announcement, more information about the position and the university, and instructions on how to apply, please visit our web site at:
http://www.is.mines.edu/hr/Faculty_Jobs.shtm

CSM is an EEO/AA employer and is committed to enhancing the diversity of its campus community. Women, minorities, veterans, and individuals with disabilities are encouraged to apply.

ASSOCIATE OR ASSISTANT PROFESSOR
DEPARTMENT OF GEOLOGY
UNIVERSITY OF TORONTO

The Department of Geology, University of Toronto is seeking an outstanding individual for a tenured or a tenure-track appointment at its St. George (downtown) campus at the rank of associate or assistant professor to begin 1 July 2007. We invite applications from Earth scientists, preferably in the areas of climate change or environmental geosciences, who use radiogenic or cosmogenic isotope geochemistry in their research. Applicants should possess a Ph.D. in Geology or Geochemistry, a strong academic background, an excellent research record and potential for excellence in teaching. The successful candidate will be expected to conduct an active, independent and innovative research program as well as teach core Geology courses at the undergraduate and graduate levels. The department is seeking to strengthen its considerable expertise in isotope geochemistry and has excellent facilities for analytical, radiogenic and stable isotope research (www.geology.utoronto.ca). Salary and rank will be commensurate with qualifications and experience.

Applicants should provide their curriculum vitae, including a list of publications, and 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, Search Committee, Department of Geology, University of Toronto, 22 Russell Street, Room 1066, Toronto, Ontario, CanadaM5S 3B1.

E-mailed applications will not be accepted nor will letters of reference submitted with the application package. Letters of reference may be faxed or e-mailed but must be followed by an original signed copy. The application deadline is 16 February 2007. Applications received after this date will be considered only if the position has not been filled. Enquiries about the application should be sent to geol_sec@geology.utoronto.ca.

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 PROFESSOR, UNION COLLEGE

The Geology Department at Union College seeks to fill a tenure track line at the Assistant or Senior Assistant Professor level in Petrology/Structure with an anticipated starting date of September 2007. We seek a dynamic teacher and scholar capable of teaching introductory geology courses as well as two or three of the following areas: Petrology, Mineralogy, Geochemistry, Structure, Geophysics, Tectonics, and Economic geology.

The specific area of research is broadly defined as Petrology/Structure. We are interested in candidates with research amenable to undergraduate involvement. Ideally the research focus should include a field component as well as laboratory measurements that can be accomplished in an undergraduate setting by undergraduates. The research statement in the application should clearly and directly state a research plan that would be implemented. A Ph.D. is required at the time of the appointment.

Union College is a selective liberal arts college with a strong tradition of science and engineering at the undergraduate level. The Geology Department is a member of the Keck Geology Consortium, and is very well equipped with analytical instrumentation that includes an ICP-MS, two ion chromatographs, fission track lab, a wide variety of sample prep and geophysical equipment, core analysis lab, and a new SEM system on order (with EDX and CL). The Geology Department has a strong record of student-faculty research. More information about Union College is available on the web at: www.union.edu.

We will begin reviewing applications starting on 1 March 2007. To apply, please send a cover letter along with resume, list of publications, teaching, and research statements, and a list of contact details for three references. Send application material to: John I. Garver, Chair, Department of Geology, Union College, 807 Union St., Schenectady NY 12308-2311, USA.

Union College is an equal opportunity employer and strongly committed to student and workforce diversity.

EARTH SCIENCES CURATOR/ PALEONTOLOGIST
UNIVERSITY OF ALASKA FAIRBANKS

The University of Alaska Museum of the North and the Department of Geology & Geophysics at the University of Alaska Fairbanks invite applications for a tenure-track, Assistant Professor position as Curator of Earth Sciences. We seek a dynamic individual who will instill their enthusiasm for paleontology in both students and the public. Applicants who can successfully implement their vision for using natural history collections on the leading edge of science are especially encouraged to apply.

Applicants must have an earned Ph.D. in paleontology or a closely related field prior to hire. Teaching, curatorial, and postdoctoral experience is preferred. The successful candidate is expected to establish a vigorous, externally funded research program; curate and expand the Museum's Earth Sciences collections; collaborate with existing faculty with interests in sedimentology, stratigraphy, geochronology, Quaternary geology, evolutionary biology, and paleoclimatic or paleoenvironmental reconstruction; teach at least one course per year; and advise undergraduates, M.S., and Ph.D. students. Preferred applicants will have a strong background in developing, managing, and using museum collections, and in a specialized research area in paleontology, which is flexible. Experience working with or teaching diverse student populations is desirable. A newly expanded museum, collections laboratory, start-up funds and supercomputer facilities are available. Further information about both the Department and Museum is available at www.uaf.edu/geology and www.uaf.edu/museum.

Interested applicants should apply online at www.uakjobs.com by completing an application form and uploading a curriculum vitae; three letters of reference; copies of key publications; and separate statements summarizing experience and long-term goals in research, curation, and teaching. Screening of applications will begin on 1 January 2007, and continue until the position is filled. Questions about this announcement can be addressed to Molly Lee (ffmcl@uaf.edu).

The University of Alaska is an Affirmative Action/ Equal Opportunity Employer. Women and minorities are encouraged to apply.

BELOIT COLLEGE
VISITING ASSISTANT PROFESSOR OF GEOLOGY
GEOMORPHOLOGY/PALEOCLIMATOLOGY

Beloit College invites applications for an anticipated full-time, one-year sabbatical replacement, beginning mid-August 2007. Applicants should be environmental geologists, with expertise in geomorphology or paleoclimatology. The successful candidate will teach four laboratory courses over the year. Courses will consist of two offerings of an introductory course in environmental geology, and two courses from the following: geomorphology, paleoclimatology, and interdisciplinary applications of GIS. The successful candidate will also be expected to supervise undergraduate research projects.

Beloit College is a selective undergraduate liberal-arts college with an enrollment of 1,250 students. The college emphasizes excellence in teaching, breadth and versatility in its faculty, and collaborative research between students and faculty. The department is a member of the Keck Geology Consortium. The city of Beloit is located in southern Wisconsin, close to Madison, Milwaukee, and Chicago.

Applicants should have a Ph.D. by the time of appointment. Send a letter of application, a statement of teaching and research interests, a vita, college-level transcripts, and three letters of reference to Carl Mendelson, Geology Search Committee, Beloit College, 700 College St., Beloit, WI 53511. This position will remain open until filled; to ensure full consideration, submit materials by 1 March 2007. Inquiries may be directed to Prof. Mendelson (+1-608-363-2223 or mendelson@beloit.edu). More information about the department may be found at geology.beloit.edu.

Beloit College is committed to the educational benefits of diversity and urges all interested individuals to apply.

AA/EEO Employer.

TEXAS STATE UNIVERSITY–SAN MARCOS
RENEWABLE-TERM SENIOR LECTURER, GEOLOGY

The Department of Geography at Texas State University–San Marcos invites applications for a three-year renewable-term Senior Lecturer position, beginning Fall 2007, with expertise in geology. Teaching duties will include introductory physical geology, historical geology, and mineralogy, plus one or more advanced courses selected from sedimentation and stratigraphy, structural geology, or paleontology and biostratigraphy. Minimum qualifications: Master's degree in geology or earth science (Ph.D. preferred); must have a demonstrated record of excellence in teaching geology at the college level. The successful candidate will help to coordinate the University's undergraduate geology minor, which is housed within the Department of Geography. This individual will join a department with 29 full-time geography faculty members, including five geomorphologists.

Review of applications will begin on February 19, 2007. Applicants are to submit a letter of application, curriculum vitae, and the names and contact information of three references to: Dr. Philip W. Suckling, Professor and Chair, Department of Geography, Texas State University-San Marcos, San Marcos, TX 78666-4616. Voice: 512-245-2170. Fax: 512-245-8353. E-mail: ps33@txstate.edu. Texas State is an equal opportunity educational institution and as such does not discriminate because of race, color, creed or religion, sex, national origin, age, physical or mental handicaps, or status as a disabled or Vietnam era veteran. Texas State is committed to increasing the diversity of its faculty. Texas State University–San Marcos is a member of the Texas State University System.

LAWRENCE UNIVERSITY
POSTDOCTORAL FELLOWSHIP
GEOBIOLOGY OR PALEOCLIMATOLOGY

Lawrence Fellowships in the Liberal Arts and Sciences are postdoctoral positions for recent Ph.D. who seek to develop a record of excellence in teaching and research in a liberal arts college setting. A detailed description of the program is posted at www.lawrence.edu/dept/fellows. Initial appointments are for 2 years. These full-time fellowships carry a stipend of $35,000 per year, plus benefits, and a $2500 annual fund to support research, travel, and other initiatives.

For 2006–2007, the Department of Geology seeks Fellows applicants in paleobiology, geomicrobiology and paleoclimatology. Applicants must have received the Ph.D. by August of 2007 but no earlier than August 2001. Applicants should clearly indicate in their cover letters that they are applying to the Department of Geology. Those who might additionally contribute to Lawrence's interdisciplinary program in environmental studies will be given special consideration.

Lawrence University, located in Appleton, Wisconsin, is a highly selective undergraduate liberal arts college and conservatory of music, known for the quality of its classroom and tutorial education, research opportunities for undergraduates, and faculty of teacher/scholars and teacher/artists.

Applicants should send a letter of interest (including teaching and research statements), curriculum vitae, and three letters of recommendation to: Lawrence Fellows Committee, Office of the President, Lawrence University, P.O. Box 599, Appleton, WI 54912. Closing date is 29 January 2007. Lawrence University is an Equal Opportunity Employer and encourages applications from individuals of diverse backgrounds.

MIT
FACULTY POSITIONS IN ATMOSPHERIC SCIENCE

The MIT Department of Earth, Atmospheric and Planetary Sciences seeks applicants for two faculty positions in atmospheric science. One position is in Atmospheric Chemistry, the second is in other areas of Atmospheric Science.

Atmospheric Chemistry: Areas of specific interest include multiphase (gas, aerosol, cloud) chemical and physical processes, and the multiple roles of atmospheric chemistry in climate. Our preference is for a scientist with strong laboratory and/or field measurement experience but scientists with outstanding theoretical and modeling experience applied to field measurements are also encouraged to apply. Depending on accomplishments and experience, the appointment can be at any level including Full Professor. The successful candidate will have an outstanding record of accomplishment in their discipline, a strong commitment to teaching and student advising, and an abiding interest in relating their work to complementary work in the atmospheric and climate sciences at MIT. Joint appointments with other MIT departments are also potentially negotiable where appropriate.

Atmospheric Science: We seek individuals with a strong background and interest in atmospheric physics, dynamics, synoptic meteorology, and/or climate science. Candidates should have a thorough understanding of theory and a desire to build a top-quality research program which can link to ongoing projects in the department. We are particularly interested in individuals with a strong commitment to research, teaching, and graduate advising. Strong preference will be given to candidates at the junior faculty level.

To apply to either of these positions, please send your curriculum vitae, a statement of your research and teaching objectives, and the names of 5 potential references to: Professor Maria Zuber, Head, Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA 02139; and to mjr@mit.edu. MIT is an equal opportunity/affirmative action employer. Applications from women, minorities, veterans, older workers, and individuals with disabilities are strongly encouraged.

WILLIAM L. FISHER
CONGRESSIONAL GEOSCIENCE FELLOWSHIP

The American Geological Institute is pleased to announce the William L. Fisher Congressional Geoscience Fellowship. The successful candidate will spend 12 months (starting September 2007) in Washington, D.C., working as a staffer for a Member of Congress or congressional committee. The fellowship is a unique opportunity to gain first-hand experience with the legislative process and contribute to the effective use of geoscience in crafting public policy.

Minimum requirements are a master's degree with at least three years of post-degree work experience or a Ph.D. at the time of appointment. The fellowship carries an annual stipend of up to $55,000.Support for the fellowship is provided by an endowment, established through the AGI Foundation, in honor of William L. Fisher.

All application materials must be transmitted by 1 February 2007.

For more details, visit www.agiweb.org/gap/csf. AGI is an equal opportunity employer.

VISITING ASSISTANT PROFESSOR OF GEOLOGY
SPRING TERM 2007
NORWICH UNIVERSITY

The Geology and Environmental Science programs at Norwich University have an *immediate* opening for a visiting scholar for the spring semester of 2007 with possible extension through the fall semester of 2007.Teaching responsibilities include Structural Geology and Introduction to Geology. Qualified applicants may be considered for a full-time instructorship in Oceanography in lieu of Introductory Geology. Inquiries are welcome and directed to Dr. Richard Dunn, Chair, Geology and Environmental Science at rdunn@norwich.edu . Candidates must have a Ph.D. in Environmental Sciences or related discipline. Highly qualified ABDs may be considered.

Applicants should send a letter of interest, resume and contact information for three references to Geology Search-G, Human Resources, Norwich University, 158 Harmon Drive, Northfield, VT 05663 or via e-mail: jobs@norwich.edu . Candidates must be U.S. citizens or have permanent resident status. Review of applicants will begin immediately and continue until the position is filled.

WESTERN KENTUCKY UNIVERSITY
ASSISTANT PROFESSOR, ENVIRONMENTAL GEOLOGY

The Department of Geography and Geology at Western Kentucky University invites applications for a tenure-track position at the Assistant Professor rank in Environmental Geology. Earned Ph.D. in geology required, emphasizing near-surface geophysics or environmental mineralogy, but other areas of specialization will be considered. Desirable areas of specialization include: (1) applied geophysics, tectonics, and environmental site characterization, or (2) applications of mineralogy to clays, carbonates, and medicine/forensics. Previous university-level teaching experience, expertise with analytical instrumentation, and/or work experience in the environmental sector are also desirable qualifications. The successful applicant is expected to develop and teach high-quality undergraduate courses, encourage and supervise undergraduate research projects, and contribute to M.S. programs in Geoscience, Environmental Science, and university initiatives in Applied Research and Technology (http://artp.wku.edu). Teaching duties include general education and core courses in geology, as well as upper-level undergraduate and graduate courses in the specialization. Other responsibilities include scholarly research leading to publication, university and public service, and attention to professional development. For more information about the position and the Department, visit www.wku.edu/geoweb/info/geopos1.htm

Western Kentucky University is an Affirmative Action/Equal Opportunity employer. All qualified individuals are encouraged to apply, including women, minorities, persons with disabilities and disabled veterans. Applicants should provide a letter describing their interest in and qualifications for the position along with a curriculum vita, unofficial copies of university transcripts, and the names and addresses of three professional references. Applications should be sent to Search Committee Chair, Department of Geography & Geology, Western Kentucky University, 1906 College Heights Blvd. #31066, Bowling Green, KY 42101-1066. Review of applications will begin on 1 February 2007 and continues until the position is filled.

ASSISTANT PROFESSOR OF GEOSCIENCES
VERTEBRATE PALEONTOLOGY
UNIVERSITY OF NEBRASKA

Applications are invited for a tenure track position as Assistant Professor in the Department of Geosciences with specialization in vertebrate paleontology. Candidates with research interests in Cenozoic mammals are preferred due to responsibility for the internationally significant mammal collections of the University of Nebraska State Museum. The Department faculty currently has strong research interests in sedimentology, stratigraphy, paleoclimate, paleontology/paleobiology, Quaternary studies, and meteorology/climatology. The successful candidate will be expected to participate in teaching of undergraduate and graduate courses, to advise and direct graduate students, and to develop a rigorous research program that is supported by external funding. The candidate will also be encouraged to interact with faculty and students in the Ecology and Evolution Group within the School of Biological Sciences. In addition, the candidate will oversee curation of collections within the Vertebrate Paleontology Division of the State Museum. The Museum administers a National Science Foundation award for renovation and database management of the fossil mammal collections; the candidate will be expected to participate in this project. Applicants that complement the strengths of the department are desirable, including candidates with research interests in paleoecology/paleoclimate and phylogeny. The candidate should hold the Ph.D. degree and demonstrate strong potential for research and teaching. Female and ethnic minority candidates are strongly encouraged to apply.

To apply, go to http://employment.unl.edu requisition 060971 and complete the "faculty/administrative form." Applicants must submit a cover letter, curriculum vitae, statement of research, teaching, and curatorial interests, and names of at least three references via the above Web site. We will begin to review applications on 15 January 2007, but the position will remain open for applications until it is filled.

The University of Nebraska is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity, and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act. For further information, Dr. David Loope, Search Committee Chair by e-mail, phone, or mail at: dloope1@unl.edu; 1.402.472.2647; Department of Geosciences, University of Nebraska–Lincoln, 214 Bessey Hall, Lincoln, NE 68588-0340.

U.S. GEOLOGICAL SURVEY, CHIEF SCIENTIST
CENTRAL ENERGY TEAM, SUPERVISORY GEOLOGIST
GEOPHYSICIST/CHEMIST/PHYSICAL SCIENTIST
GS-1350/1313/1320/1301-15

The U.S. Geological Survey (USGS) invites applications for the position of Chief Scientist, Central Energy Resources Team, in Lakewood, Colorado. The Team Chief Scientist supervises a staff of approximately one hundred ten (110) research and operational personnel. Strong scientific leadership and managerial skills are essential. Also required is a comprehensive knowledge of the scientific principles, concepts, and practices that apply to the Team's principal areas of investigation, which include the assessment of solid, liquid, and natural gas energy resources, energy economics, geochemistry, and geophysics related to petroleum systems. The primary research emphases of the Team are the geologic and geochemical processes that lead to assessment of oil, natural gas, and coal. Strong written and oral communication skills are required in order to effectively convey the USGS results to other Federal and State agencies, universities, and other institutions, and to engender their support and participation of USGS programs.

This is an interdisciplinary position that can be filled as either a Supervisory Geologist, GS-1350-15 (CR-2007-0083), Supervisory Geophysicist, GS-1313-15 (CR-2007-0089), Supervisory Chemist, GS-1320-15 (CR-2007-0090), or Supervisory Physical Scientist, GS-1301-15 (CR-2007-0091).

This is a permanent position with the starting annual salary ranging from $109,342 to $142,142. The position is located in Lakewood, Colo., a suburb of Denver. This vacancy opens on 11/06/2006 and closes on 1/26/2006. **You must apply online in order to be considered for this position.** Complete qualifications information and application procedures can be found at: www.usgs.gov/ohr/oars/. Contact: Mary Dunlap, mmdunlap@usgs.gov or +1-303-236-9563 or Tina Garcia, tpgarcia@usgs.gov or +1-303-236-9569 with any questions. **U.S. citizenship is required.**

The U.S. Geological Survey is an equal opportunity employer.

DEPT. OF GEOLOGICAL SCIENCES
COLLEGE OF ARTS AND SCIENCE
UNIVERSITY OF SASKATCHEWAN

The Department of Geological Sciences at the University of Saskatchewan, is accepting applications for a tenure-track position at the Assistant Professor level in the broad area of Crustal Tectonics. The department seeks

Vassar College

The Department of Earth Science and Geography at Vassar College invites applications for a one-year sabbatical replacement position. The position will begin August 2007 and will be at the rank of visiting assistant professor.

Vassar College is an equal opportunity/affirmative action employer, and is strongly and actively committed to diversity within its community.

Candidates should have completed or be nearing completion of a Ph.D. in geology or earth science at the time of appointment. The successful candidate will teach earth materials (mineralogy and petrology) at the intermediate level, non-lab introductory courses including Geohazards, and an advanced level course in his or her specialty. In addition, she or he will be expected to advise undergraduate research work.

Vassar College is a private liberal-arts college in New York's Hudson River valley. The Earth Science and Geography department presently consists of 4 earth scientists with specialties in geophysics, sedimentology, and Quaternary geology, and 4 geographers with specialties in cultural, urban, and physical geography. The earth science program emphasizes surficial processes and is active in the environmental studies program. The program has ~20 students and graduates 6-8 students per year.

Instrumentation in the department includes XRD, laser-particle size analyzer, coulometer, fully equipped sedimentology, paleoclimatology, and clay mineralogy laboratories, GIS computer lab, various field geophysical instruments, and a meteorological station. In addition, the department shares an ICPAES with the Department of Chemistry. Vassar College also owns a 500-acre ecological preserve with a laboratory field station.

Send a letter of application that includes a description of teaching experience as well as a description of the proposed advanced level course. Please also include a curriculum vitae and the names and addresses of at least 3 references. Address these materials to: Department Chair, Department of Earth Science and Geography, Vassar College Box 735, Poughkeepsie, NY 12604. No electronic submissions, please.

Review of applications will begin January 30, 2007.

a versatile researcher who takes an integrative approach to elucidating the structural and tectonic evolution of the Earth's crust.

The successful candidate will be expected to develop a vigorous, externally funded research program, and participate broadly in undergraduate and graduate student teaching and research, including introductory courses, structural geology, and field schools. Candidates must hold a Ph.D. when appointed, which is expected to be 1 July 2007.

The University of Saskatchewan is located in Saskatoon, Saskatchewan, a city with a diverse and thriving economic base, a vibrant arts community and a full range of leisure opportunities. The University has a reputation for excellence in teaching, research and scholarly activities and offers a full range of undergraduate, graduate, and professional programs to a student population of about 20,000. The university is one of Canada's leading research-intensive universities.

The College of Arts & Science offers a dynamic combination of programs in the humanities and fine arts, the social sciences and the sciences. There are over 8,000 undergraduate and graduate students in the College and 325 faculty, including 14 Canada Research Chairs. The College emphasizes student and faculty research, interdisciplinary programs, community outreach and international opportunities. The Department of Geological Sciences in the Division of Science has 16 full-time faculty, including two Canada Research Chairs and two endowed research chairs, and excellent analytical and computing facilities. For detailed information about the Department, the applicants are encouraged to visit www.usask.ca/geology/.

Applications, including résumé, statement of research interests and teaching philosophy, and three letters of reference, should be sent to: Crustal Tectonics Search Committee, Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, SK S7N 5E2, Canada, e-mail: kevin.ansdell@usask.ca, fax: 306-966-8593.

We will begin reviewing applications after 1 March 2007.

The University of Saskatchewan is committed to increasing representation of equity groups (women, people of aboriginal ancestry, visible minorities and/or people with disabilities). Applicants from these groups are encouraged to self-identify in their applications. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

DEPUTY DIRECTOR
KANSAS GEOLOGICAL SURVEY
UNIVERSITY OF KANSAS, LAWRENCE

Academic rank position to play major role in the planning and execution of research programs that position the Survey to meet earth-sciences challenges of the future. Ph.D. and professional experience in the geosciences with supervisory/management experience in scientific programs or organizations. Demonstrated experience in budgeting, personnel evaluation, and program development. Position provides opportunities to continue active research. Women and minority candidates are particularly encouraged to apply. Further information at www.kgs.ku.edu/General/jobs.html. Priority date: 1 Feb. 2007. For questions about the position contact Evan Franseen at evanf@kgs.ku.edu. EO/AA employer.

COAL GEOLOGY
SOUTHERN ILLINOIS UNIVERSITY–CARBONDALE

The Department of Geology at Southern Illinois University–Carbondale invites applications for a tenure-track position in coal geology at the rank of assistant professor with a start date of 16 Aug. 2007. 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 coal geologist who will advance our long-standing, internationally recognized coal petrology program (http://mccoy.lib.siu.edu/projects/crelling/; http://mccoy.lib.siu.edu/projects/crelling2/atlas/). 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 one to two courses per semester. 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 15 February 2007 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. Ken Anderson, Search Committee Chair, Department of Geology, Mail Code 4324, Southern Illinois University Carbondale, 1259 Lincoln Drive, Carbondale, IL 62901. Fax: +1-618-453-7393. E-mail: kanderson@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. SIUC has energy programs and facilities that provide opportunities for collaborative research including the Coal Research Center, the Center for Advanced Friction Studies, and the Mining and Mineral Resources Program.

For further information, please visit our comprehensive Web site 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.

IGNEOUS PETROLOGY/VOLCANOLOGY
THE UNIVERSITY OF ALABAMA

The Department of Geological Sciences invites applications for a tenure-track faculty position to be filled at the Assistant Professor level beginning in August 2007. The candidate will be expected to: teach introductory geology, undergraduate igneous & metamorphic petrology, an undergraduate elective (e.g., volcanology), and graduate courses in igneous petrology and/or volcanology; attract and supervise masters and doctoral students; and develop a externally-funded research program with strong field and lab components. Possible areas of research emphasis include the evolution of subduction or spreading center magmatic systems, and/or modeling of volcanic and magmatic processes. This position compliments existing research programs in metamorphic petrology, geophysics, and tectonics. Geological Sciences is an active and growing department within an expanding and dynamic university. Available equipment includes: an automated X-ray fluorescence spectrometer, an automated X-ray diffractometer, an inductively-coupled plasma mass spectrometer, an electron probe microanalyzer, a transmission electron microscope, and scanning electron microscopes. State-of-the-art computational resources and software are also available. Applicants should send a vita, statements of research and teaching interests, and contact information for 4 referees to Dr. Harold Stowell, Igneous Petrology & Volcanology Search Committee Chair, The University of Alabama, Department of Geological Sciences, Box 870338, Tuscaloosa, AL34587-0338. Further information is available on our Web site at www.geo.ua.edu. Review of applications will begin on 22 January 2007, and continue until the position is filled.

The University of Alabama is an Equal Opportunity, Affirmative-Action Employer and applications are solicited from women and minority candidates.

SURFICIAL PROCESSES
WESTERN ILLINOIS UNIVERSITY
FULL-TIME TENURE-TRACK ASSISTANT PROFESSOR

The Department of Geology at Western Illinois University invites applications for a full-time tenure-track position in surficial processes to start Fall 2007. A Ph.D. in geosciences or a related field is required by the time of appointment; teaching experience a plus. We seek an applicant with experience in surficial processes; possible areas of interest include geomorphology, engineering geology, or environmental geology. The successful applicant will teach introductory physical geology and advanced courses such as Geomorphology, Engineering Geology, Environmental Geology, Glacial Geology and possibly new courses developed by the applicant. This individual is expected to develop a field-oriented research program involving undergraduates in active research.

The Department of Geology offers a B.S. in Geology, provides courses that satisfy general education science requirements, and actively mentors undergraduate research. Collaboration opportunities are available within the department and with the McDonough County GIS Center and the WIU Institute for Environmental Studies. More information about the department can be found on our Web site: www.wiu.edu/geology/.

Applicants should submit a letter of application, vita, teaching and research statements, and the names, addresses and phone numbers of three current references to: Search Committee, Department of Geology, Western Illinois University, 1 University Circle, Macomb, IL, 61455. Review of applications will begin 1 Feb. 2007 and will continue until the position is filled.

Western Illinois University is an Affirmative Action/Equal Opportunity employer and has a strong institutional commitment to diversity. WIU has a non-discrimination policy that includes sex, race, color, sexual orientation, religion, age, marital status, national origin, disability, or veteran status.

TWO FACULTY POSITIONS
DEPARTMENT OF GEOSCIENCES
INDIANA UNIVERSITY-PURDUE UNIVERSITY FORT WAYNE (IPFW)

IPFW seeks to fill two full-time, tenure-track positions at the Assistant Professor level in (1) sedimentology/stratigraphy/surface processes; and (2) structural geology/neotectonics/applied geophysics. The successful applicant for each position will be expected to share with other faculty responsibilities for teaching introductory geology, introductory planetary geology, introductory climatology, and regional field geology. Over a multi-year cycle, each successful applicant will teach additional courses in his/her specialty, including elementary field geology and sedimentology/stratigraphy (Position 1), and structural geology and geomorphology (Position 2). Familiarity and experience with GIS will be a plus. Geosciences faculty are expected to maintain an active research program and to involve undergraduate students in research. IPFW's geology research program is well-supported in both equipment (e.g. thin section lab, SEM, XRD) and opportunities for new faculty.

There are three other full-time faculty in the department. IPFW is a comprehensive university. Send a letter of application, statement of teaching and research interests, curriculum vitae, copies of transcripts, and the names and contact information for three references to: Prof. J. Farlow, Search Committee Chair, Department of Geosciences, Indiana University-Purdue University Fort Wayne, 2101 East Coliseum Boulevard, Fort Wayne, IN 46805. Review of applications will begin 1 February 2007. IPFW is an equal opportunity, equal access, affirmative action university.

TWO TENURE-TRACK FACULTY POSITIONS
MICHIGAN TECHNOLOGICAL UNIVERSITY

The Dept. of Geological and Mining Engineering and Sciences at Michigan Tech seeks applications for two tenure-track appointments at the Assistant Professor level. A Ph.D. is required in geosciences, geological engineering, or a related field. Candidates with demonstrated achievements commensurate with appointment at Associate or Full Professor will also be considered. Applicants will be evaluated based on their ability to obtain funding and publish research and their potential for effectiveness in education. We encourage applicants who can either complement our department's existing strengths (remote sensing, volcanology, hydrology, petroleum geology, and geophysics) or can help expand our department into new directions that show promise of future development.

Michigan Tech has a student population of ~6300 and is located in Michigan's Upper Peninsula, a pristine area surrounded by Lake Superior, which provides a wide variety of opportunities for outdoor recreational activities. The department prides itself on its strong educational focus and applications of research, with programs in geology, geological engineering and applied geophysics. For more information about our faculty, research and educational programs, please visit our Web site, www.geo.mtu.edu.

Applicants should send their curriculum vitae, a statement of research capabilities and interests, a statement of teaching experience and interests, and the names and complete contact information for three professional references to Search Committee Chair, Dept. of Geological and Mining Engineering and Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931. Applications received by 30 January 2007 are assured of receiving the fullest attention.

Michigan Tech University is an equal opportunity educational institution/equal opportunity employer.

ASSISTANT PROFESSOR
GEODYNAMICS OR GEOPHYSICS/TENURE-TRACK
LOUISIANA STATE UNIVERSITY

The Dept. of Geology and Geophysics at Louisiana State University invites applications for a tenure-track Assistant Professor position to begin fall semester of 2007. Appointment at the Associate Professor level may be considered for an exceptional candidate.

Required Qualifications: Ph.D. in geology, geophysics, or related field at the time of appointment; outstanding geoscientist with demonstrated expertise in surface or near-surface geodynamics or geophysics; research program that combines quantitative modeling with field and/or analytical components; development of a strong research program, including supervision of graduate student research, active publication in highly ranked journals, and the generation of external funding. **Additional Qualification Desired:** teaching experience. The successful candidate is expected to contribute to our undergraduate and graduate teaching programs and develop courses in his or her area of specialization.

The department consists of 18 faculty members covering a wide range of expertise. In support of our faculty

and students, we have well-equipped analytical and computational laboratories. LSU also has a major initiative in high performance computing through the Center for Computation and Technology, www.cct.lsu.edu. Geology and Geophysics has strong support from LSU alumni and administration. For more information about our department, visit our Web site, geol.lsu.edu.

An offer of employment is contingent on a satisfactory pre-employment background check. The review process will begin 16 January 2007 and will continue until candidate is selected. Interested persons should send a copy of their vita (including e-mail address), a statement of their research and teaching interests, and the names, addresses, phone numbers, and e-mail addresses of at least three references to Jeffrey A. Nunn, Geodynamics Search Committee, Dept. of Geology and Geophysics, Louisiana State University, jeff@geol.lsu.edu, ref. #000162, Baton Rouge, LA 70803. Applications from members of underrepresented groups are encouraged.

LSU IS AN EQUAL OPPORTUNITY/EQUAL ACCESS EMPLOYER.

Opportunities for Students

Ph.D. and M.S. Opportunities in Earth and Environmental Sciences—University of Illinois at Chicago. The Department of Earth and Environmental Sciences, University of Illinois at Chicago, invites applications for graduate admission in Fall 2007. We are seeking students interested in Geobiology (including Geomicrobiology and Paleontology), Geochemistry (including Aqueous, Environmental, Isotopic, and Organic), Global Change (including ice sheet dynamics, Quaternary geomorphology, geochronology, paleoclimatology), Hydrology/Limnology, Geophysics, and Mineralogy. Financial support is available to successful applicants through Research and Teaching Assistantships, and NSF-IGERT fellowships (www.uic.edu/depts/bios/leap/). Our research involves a variety of field investigations (e.g. Antarctica, Asia, Egypt, Yellowstone) and uses state-of-the-art laboratory instrumentation within the department, elsewhere at UIC, and at nearby facilities such Argonne National Laboratory. We are located in a vibrant, growing urban neighborhood, with convenient access to all that the great city of Chicago has to offer. Application deadline is 1 February. For more information and application procedures, visit www.uic.edu/depts/geos/ or contact Dr. Peter Doran at pdoran@uic.edu.

M.S. and Ph.D. Opportunities at Miami University, Oxford, Ohio. The Miami University Geology Department invites applications to our M.S. and Ph.D. programs. Grant-funded Research Assistantships and university-funded Teaching Assistantships are available for students starting Fall 2007.

The Department maintains active field and laboratory based research programs in geomicrobiology, geomorphology, geophysics, hydrogeology, igneous petrology, isotope geochemistry (stable and radiogenic), low-temperature geochemistry, mineralogy and crystallography, mineral surface geochemistry, sedimentology and stratigraphy, seismology, structural geology, tectonics, and volcanology.

For more information about the application process and graduate student research opportunities, please visit our departmental Web site (www.muohio.edu/geology) or contact Cathy Edwards (cathy.edwards@muohio.edu). Prospective students are also encouraged to contact faculty directly to discuss potential research projects.

The application deadline for consideration in first-round funding offers is 1 February 2007.

NASA Planetary Biology Internship Program. The NASA Planetary Biology Internship Program (PBI) provides opportunities to explore scientific questions of global scale about planet Earth. For eight weeks graduate students are granted a one-time opportunity to travel outside their home institutions to participate in research related to NASA's planetary biology objectives. Interns have participated in a wide variety of planetary biological studies including metal precipitating bacteria; microbial ecology of extreme environments; morphological, biochemical, and isotopic analyses of stromatolites and microbial mats; and molecular evolution.

Students should obtain an application brochure by contacting the PBI Administrator, Michael Dolan, Department of Geosciences, University of Massachusetts, Amherst, MA 01003. Telephone +1-413-545-3223, fax: +1-413-545-1200, e-mail pbi@geo.umass.edu or from the Web page, www.mbl.edu/education/courses/other_programs/pbi.html.

Application packages must be mailed directly to the MBL Admissions Office by 1 March 2007. Students are admitted without regard to race, age, sex, national origin, or physical handicap.

Graduate Research and Teaching Assistantships, Hydrologic Sciences Graduate Program, University of Nevada, Reno. We are seeking applicants for three teaching assistantships for the introductory graduate courses in groundwater, fluid mechanics and aqueous geochemistry. The remainder will be research assistantships in the same general subject areas. The annual salary is $17,000 for M.S. students and $18,000 for Ph.D. students and includes medical benefits and tuition, for a total package worth up to $31,000/year. Additional research assistantships may be available from the Desert Research Institute (www.dri.edu) and from the U.S.G.S. Water Resources Division in Carson City (nevada.usgs.gov). All applications shall be made to the UNR Hydrologic Sciences Program, regardless of the funding source. The Hydrologic Sciences Program at the University of Nevada, Reno is seeking to fill up to six graduate research and teaching assistantships starting in July/August, 2007. The Hydrologic Sciences Program has nearly 70 graduate students (30% Ph.D. and 70% M.S.) and more than 40 core faculty who teach courses, advise students and conduct research in the hydrologic sciences. The program is consistently rated nationally among the top ten by the U.S. News and World Report Guide to Graduate Schools. General areas of research in the program include groundwater, surface water, aqueous geochemistry, contaminant transport, soil physics and chemistry, aquatic ecology and fire science ecology. Approaches to research range from applied to theoretical. Students and faculty are very active in international water issues (www.saiwi.org). Instructions for application to the program can be found on our Web site: www.hydro.unr.edu and on the Graduate School's Web site: www.vpr.unr.edu/grad2. Additional information can be obtained by contacting our program office at +1-775-784-6469 or by e-mail: hydro@unr.edu.

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Lynn Margulis, Jim Secord (Camb.), Andy Watson (UEA), Nick Butterfield (Camb.), Paul Hoffman (Harvard), Mark Sephton (IC), Andrew Scott (RHBNC), Paul Pearson (Cardiff), Julian Dowdeswell (Camb.), Bernard Hallet (U. Wash), Greg Tucker (U. Colorado), Niels Hovius (Camb.), Chris Stringer (NHM), Liane Benning (Leeds), Eric Wolff (BAS), M J Benton (Bristol), Russell Coope, Paul Valdes (Bristol), Tim Lenton (UEA)

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Advocates for cold-blooded dinosaurs: The new generation of heretics

Timothy L. Clarey, *Delta College, Dept. of Geology, 1961 Delta Road, University Center, Michigan 48710-0002, USA, tlclarey@delta.edu*

INTRODUCTION

Robert Bakker (1986) branded himself and a small group of groundbreaking and upstart paleontologists in the 1960s and 1970s "heretics" because they challenged the mainstream view of dinosaurs as slow, sluggish, and cold-blooded reptiles. This view, that dinosaurs were warm-blooded, active, bird-like creatures, much different than extant reptiles of today, is now widely accepted by scientists and the public alike. Yet, this viewpoint has been challenged in recent years by a small but active minority group of researchers, herein described as the new generation of heretics. This paper concentrates on some of the newer evidence suggesting that dinosaurs might have been cold-blooded or ectothermic. Unfortunately, the proof of whether an animal is endothermic or ectothermic is found only in soft tissue anatomy, which is not well preserved and is extremely rare in the fossil record (Ruben and Jones, 2000).

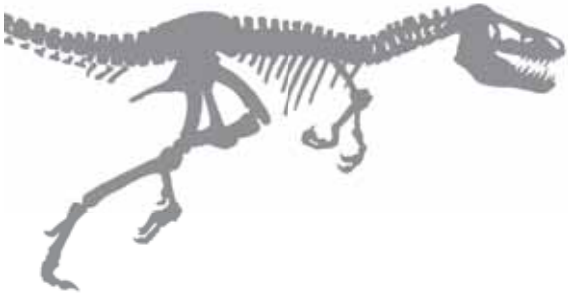
BONES, NASAL PASSAGES, AND SOFT-TISSUE DATA AS INDICATORS OF DINOSAUR METABOLISM

Bone histology involves study under a microscope of thin-sections of bone tissue. Two types of compact bone structure have been identified in these studies: lamellar-zonal and fibro-lamellar. Lamellar-zonal bone has a layered appearance with lines of arrested growth (LAGs), or growth lines, and is poorly vascularized, with few Haversian canals, like most modern reptiles and amphibians (Ruben and Jones, 2000). The age of such animals can be determined by counting the growth rings or LAGs in the bone, similar to counting tree rings. Fibro-lamellar bone has a fibrous, woven appearance and is highly vascularized, with numerous Haversian canals (Reid, 1997). This type of bone, which contains fewer LAGs, is found in birds, mammals, and most dinosaurs.

Histologic study of dinosaur bone has been hailed as "proof" of dinosaur endothermy because dinosaurs commonly exhibit the same highly vascularized, fibro-lamellar bone structure as seen in mammals (Bakker, 1986; Reid, 1997). Ruben and Jones (2000) argue that this type of bone cannot be used as absolute proof of metabolic rate, pointing out that this interpretation is inconsistent with a variety of paleontological and biological data. Fibro-lamellar bone is present in some modern turtles, crocodiles, and lizards, and some dinosaurs contain both fibro-lamellar and lamellar-zonal structures (Reid, 1997). A study by Tomasz Owerkowicz (Morell, 1996) has shown that the possession of highly vascularized bone merely means the animal was active and not necessarily endothermic. Owerkowicz raised two savannah monitor lizards and exercised one daily while letting the other remain inactive. After a few years, he killed the pair and examined their respective bone microstructure. He found that the active lizard had a bone microstructure that was highly vascularized, mimicking an endothermic animal and containing numerous Haversian canals. The inactive lizard had a poorly vascularized microstructure, typical of modern ectothermic animals. His study only "proved" that dinosaurs were active.

Ruben and Jones (2000) believe that the presence of respiratory turbinates makes a better "proof" of endothermy. Ninety-nine percent of endothermic animals have turbinates or coils of membrane-covered cartilage or bone in their nasal passages. These structures significantly reduce water and heat loss associated with rapid rates of lung ventilation as needed in endothermic animals. Although cartilaginous turbinates may not always be preserved as fossils, Ruben's team (1996) found that the presence of turbinates is directly correlated with larger nasal cavities in modern endothermic animals. They suspect that larger nasal passages in endotherms serve to accommodate greater lung ventilation rates and provide the room necessary to house the respiratory turbinates. Ruben et al. (1996) conducted CT-scans on several dinosaur skulls, including two theropods, *Tyrannosaurus* (*Nanotyrannus*) and *Ornithomimus*, and one ornithischian, *Hypacrosaurus*. These dinosaurs showed narrow nasal cavities, indicative of modern ectothermic animals, with little room for respiratory turbinates. Ruben et al. (1996) interpret this as strong evidence for low lung ventilation rates, implying ectothermy or near-ectothermy.

Ruben et al. (1997, 1999) also found limited soft-tissue and skeletal support for ectothermy in theropod dinosaurs. They interpreted soft-tissue impressions of the abdominal cavity in the theropod dinosaur *Scipionyx samniticus* as a hepatic piston, diaphragm-assisted, lung ventilation system similar to modern crocodiles. The attachment style of the intestines and colon also indicates that the avian-style abdominal air sacs and the flow-through air sac lung were not present in *Scipionyx*.



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In their analysis of the Early Cretaceous theropod *Sinosauropteryx*, Ruben and colleagues studied the fossilized outline of the abdominal cavity, finding complete thoracic-abdominal separation with a vertically oriented partition that appears coincident with the dome-shaped anterior surface of the liver. This condition is not found in mammals today and is more consistent with the lung system of modern crocodiles. They concluded that the crocodilian-style lung system and the lack of respiratory turbinates indicate that theropod dinosaurs probably maintained ectotherm-like resting metabolic rates. They also postulated that theropod dinosaurs had the capability of expanding their lung capacity to approach the ventilation levels of mammals during periods of high activity.

DINOSAUR GROWTH RATES AND METABOLISM

Growth rate is usually influenced by an organism's metabolism. Recent studies of dinosaur growth rates have shown most species experienced slow growth rates initially, followed by a period of accelerated growth, and finally, slowed or reduced growth rates in adulthood. This is called a "sigmoidal" growth curve (Erickson et al., 2001) and is typical of most vertebrate animals. Growth rates were determined by counting "growth rings" in bones (Erickson et al., 2001). In older individuals, where medullar expansion caused hollowing of the bones and growth ring loss in many of the adult bones, Erickson et al. (2004) used fibulae, ribs, cranial bones, and other non–weight-bearing bones for their analyses. They believe these bones do not lose the growth ring pattern with age. Carpenter (1999), however, disagrees. He believes that rib bones do not always show accurate growth rings and should be used for minimum ages only. Recent research by Yao et al. (2002) found that growth rings in juvenile ornithomimid dinosaurs did disappear in adult rib bones, reaffirming the minimum age determination of Carpenter. Therefore, all interpretations concerning the ages of adult dinosaurs and their growth rates must be accepted with some caution. Was *T. rex* "Sue" really 28 years old as Erickson et al. (2004) suggested, or was he/she really 40? No one can be sure at this point. *T. rex* "Sue," as one of the largest specimens ever found, was probably one of the oldest of his/her kind.

Does the growth rate data indicate dinosaurs were warm-blooded? Not necessarily. Erickson et al. (2001) found dinosaur growth rates were considerably slower than those for birds, but still much faster than modern reptiles. They concluded that small dinosaurs grew at rates similar to modern marsupials, while larger dinosaurs grew faster, at rates approaching placental mammals and precocial birds. As Owerkowicz observed (Morell, 1996), warmer temperatures in the Mesozoic Era could have had ectothermic dinosaurs growing at near mammalian rates.

In a separate study, Erickson et al. (2004) showed that tyrannosaurid dinosaurs had maximal growth rates between 33%–52% of the rates expected for other dinosaur groups. They concluded that the growth pattern of theropod dinosaurs, the purported ancestors to birds, was closer to marsupials and reptiles instead of comparably sized altricial birds. These data seem to take tyrannosaurids and dromaeosaurids a step back from warm-bloodedness (and birds) and not closer, as most paleontologists insist.

Additional support for dinosaur ectothermy comes from Barrick (2000). He calculated that a 7-ton, plant-eating, ectothermic *Triceratops* would only have to consume the same amount of food as a modern horse. By contrast, a similar-sized endothermic *Triceratops* would have needed to eat nearly 24 hours a day to maintain its metabolic requirements. Carnivores like a 7-ton ectothermic *T. rex* would have only needed the equivalent of a single adult hadrosaur per year, whereas an adult endothermic *T. rex* would have needed to consume almost one hadrosaur per week. Getting enough food each day into an endothermic, 40-ton vegetarian sauropod, with their poor dentition and tiny heads, would have been an even more difficult task.

CONCLUSIONS

It is too soon to conclude that all dinosaurs were warm-blooded. Recent studies of bone histology, nasal passages, growth rates, and soft-tissue data seem to indicate that some or all dinosaurs may have been ectothermic. They were active animals, without a doubt, growing at rates approaching those of mammals. How much of this growth rate was due to warmer Mesozoic temperatures is unknown.

When educating students and the public, geoscientists must be careful not to advocate only the prevailing viewpoint. Dinosaurs remain a popular and important source of fascination for children and adults alike. New discoveries are reported by the news media nearly every week. We can use this popularity to our advantage. Dinosaurs are an excellent avenue by which we can introduce other aspects of geology (such as anatomy, biostratigraphy, geologic time, and tectonics) to students and the general public (Padian, 1988). The irony is that the 1960s and 1970s generation of heretics has become the "establishment," and a new generation of heretics has emerged.

REFERENCES CITED

Bakker, R.T., 1986, The Dinosaur Heresies: New Theories Unlocking the Mystery of the Dinosaurs and Their Extinction: New York, William Morrow and Company, 481 p.

Barrick, R., 2000, The Thermodynamics of dinosaurs, *in* Paul, G., ed., The Scientific American Book of Dinosaurs: New York, St Martin's Press, p. 310–322.

Carpenter, K., 1999, Eggs, Nests, and Baby Dinosaurs: A Look at Dinosaur Reproduction: Bloomington, Indiana University Press, p. 336.

Erickson, G.M., Rogers, K.C., and Yerby, S.A., 2001, Dinosaurian growth patterns and rapid avian growth rates: Nature, v. 412, p. 429–432, doi: 10.1038/35086558.

Erickson, G.M., Makovicky, P.J., Currie, P.J., Norell, M.A., Yerby, S.A., and Brochu, C.A., 2004, Gigantism and comparative life-history parameters of tyrannosaurid dinosaurs: Nature, v. 430, p. 772–775, doi: 10.1038/nature02699.

Morell, V., 1996, A cold, hard look at dinosaurs: Discover, v. 17, no. 12, p. 98–108.

Padian, K., 1988, New discoveries about dinosaurs: Separating the facts from the news: Journal of Geological Education, v. 36, p. 215–220.

Reid, R.E.H., 1997, Dinosaurian physiology: The case for "intermediate dinosaurs," *in* Farlow, J.O., and Brett-Surman, M.K., eds., The Complete Dinosaur: Bloomington, Indiana University Press, p. 449–473.

Ruben, J.A., and Jones, T.D., 2000, Selected factors associated with the origin of fur and feathers: American Zoologist, v. 40, p. 585–596, doi: 10.1668/0003-1569(2000)040[0585:SFAWTO]2.0.CO;2.

Ruben, J.A., Hillenius, W.J., Geist, N.R., Leitch, A., Jones, T.D., Currie, P.J., Horner, J.R., and Espe, G., III, 1996, The metabolic status of some Late Cretaceous dinosaurs: Science, v. 273, p. 1204–1207.

Ruben, J.A., Jones, T.D., Geist, N.R., and Hillenius, W.J., 1997, Lung structure and ventilation in theropod dinosaurs and early birds: Science, v. 278, p. 1267–1270, doi: 10.1126/science.278.5341.1267.

Ruben, J.A., Dal Sasso, C., Geist, N.R., Hillenius, W.J., Jones, T.D., and Signore, M., 1999, Pulmonary function and metabolic physiology of theropod dinosaurs: Science, v. 283, p. 514–516, doi: 10.1126/science.283.5401.514.

Yao, J.-X., Zang, Y., and Tang, Z.-L., 2002, Histological study on the Late Cretaceous Ornithomimid and Hadrosaurid: Acta Palaeontologica Sinica, v. 41, p. 241–250.

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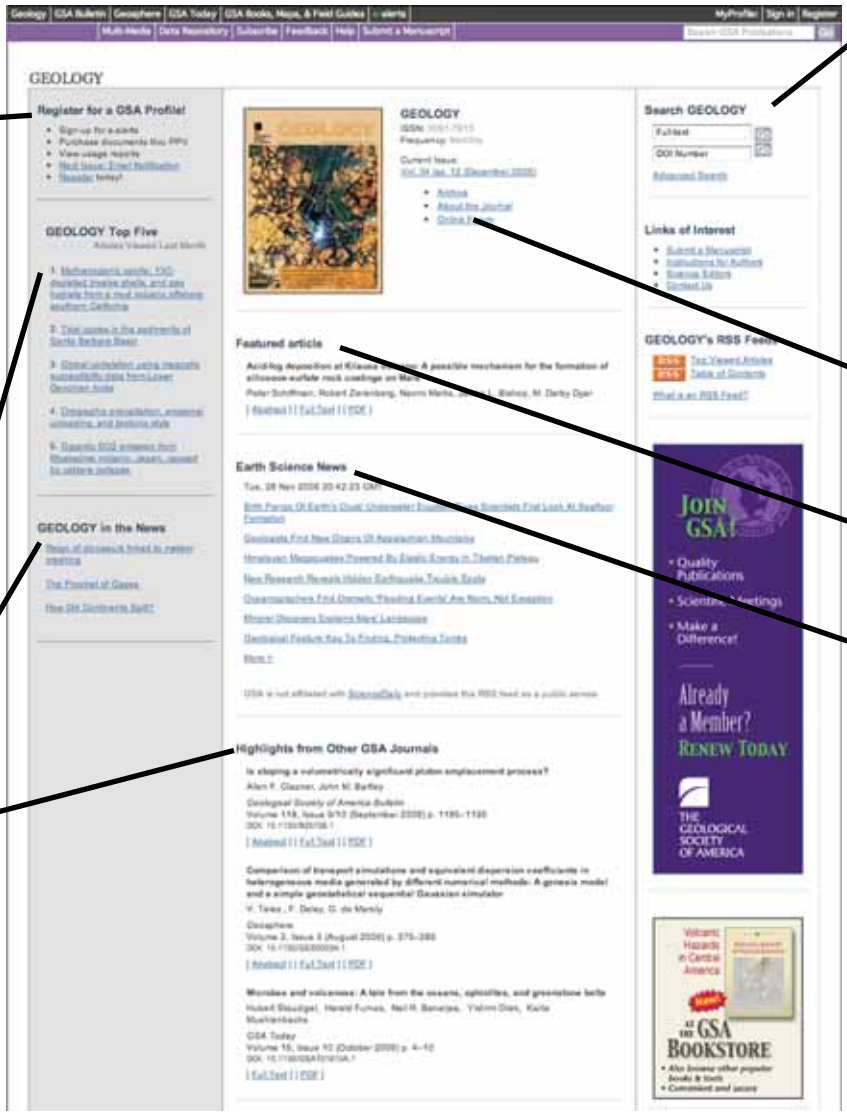

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