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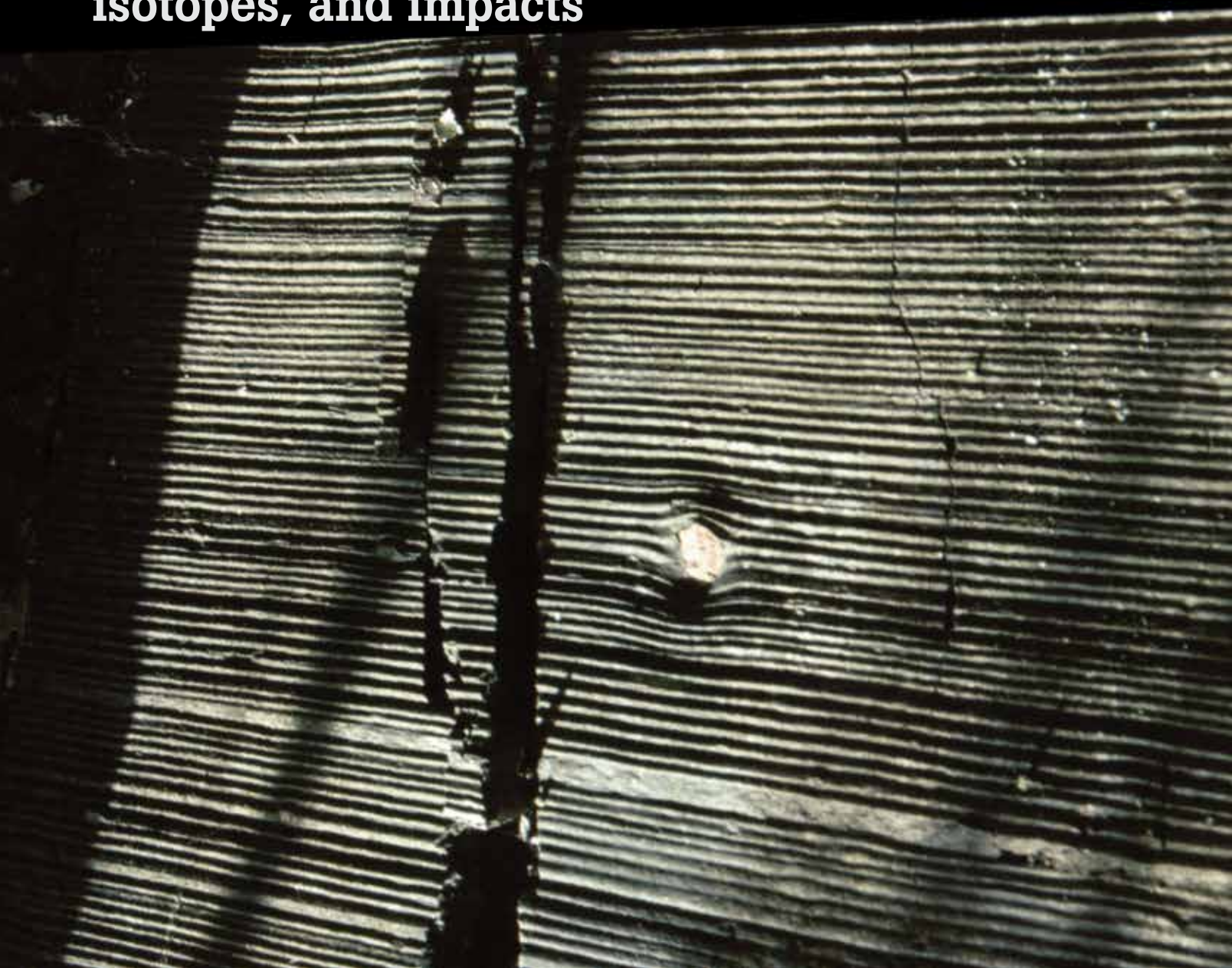
# Evolution of Earth's climatic system: Evidence from ice ages, isotopes, and impacts



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# SCIENCE ARTICLE



**Cover:** Laminated argillites of the Paleoproterozoic Gowganda Formation in the Huronian outcrop belt, Ontario, Canada. Fine (dark) and coarse layers are thought to represent seasonal freeze-thaw cycles, but paleomagnetic results indicate a tropical setting. Note striking occurrence of pairs of identical light layers, possibly representing two similar summer seasons in each year, as predicted under high obliquity conditions. Dropstone is about 10 cm in height. See "Evolution of Earth's climatic system: Evidence from ice ages, isotopes, and impacts," p. 4–10.



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# Evolution of Earth's climatic system: Evidence from ice ages, isotopes, and impacts

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## ABSTRACT

Multiple glaciations took place near the beginning and end of the Proterozoic Eon. Neoproterozoic (Cryogenian) glacial deposits are more widespread than those of older (Paleoproterozoic) glacial episodes. Paleomagnetic results suggest that most Proterozoic glaciogenic rocks were deposited at low paleolatitudes. Some contain enigmatic evidence of strong seasonal temperature variations, and many formed at sea level. These attributes inspired both the snowball Earth hypothesis and the high obliquity theory, but only the latter explains strong seasonality at low latitudes. The Proterozoic glaciations may have been triggered by drawdown of atmospheric $CO_2$ during enhanced weathering of elevated supercontinents. Multiple glaciations resulted from a negative feedback loop in the weathering system that ended when the supercontinent broke apart. A radical reorganization of the climatic system took place in the Ediacaran Period. In contrast to previous glaciations, these ice sheets developed in high latitudes and many follow mountain building episodes. During the Ediacaran Period, Earth's climatic zonation and controls appear to have undergone a radical change that persisted throughout the Phanerozoic Eon. The change may coincide with the world's greatest negative $\delta^{13}C$ excursion, the Shuram event, here interpreted as the result of a very large marine impact that decreased the obliquity of the ecliptic, causing the Earth's climatic system to adopt its present configuration. Attendant unprecedented environmental reorganization may have played a crucial role in the emergence of complex life forms.

## INTRODUCTION

There is evidence of local glaciation in Archean times (at ca. 2.9 Ga), and several Paleoproterozoic (Huronian) glaciations are recorded in North America, NW Europe, South Africa, Western Australia, and Asia (Young, 1973, 2013; Ojakangas, 1988; Tang

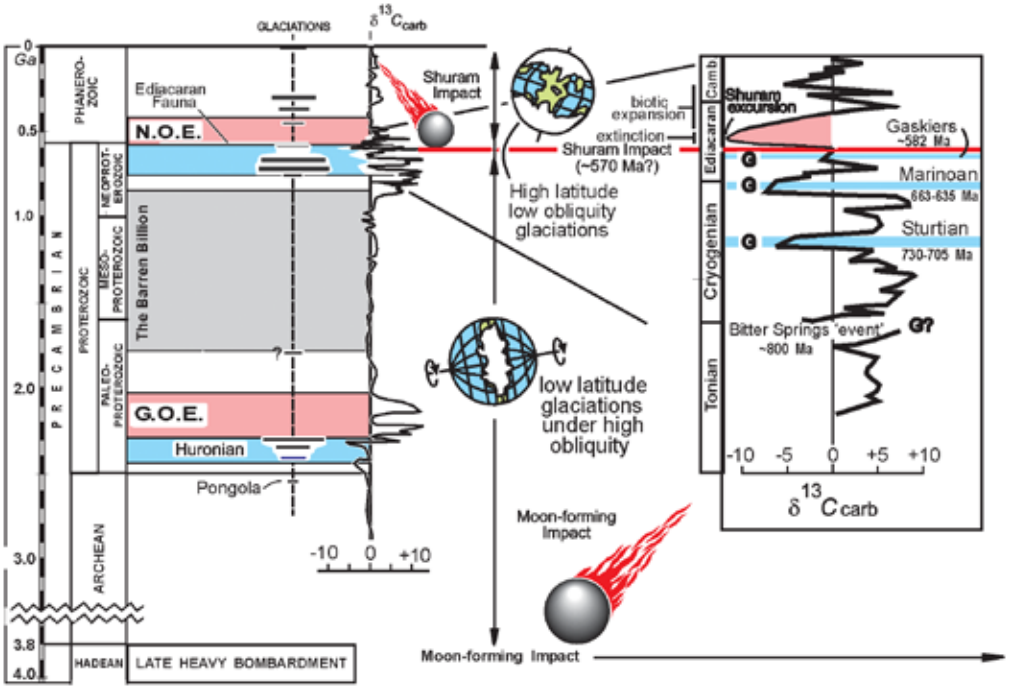


Figure 1. Schematic depiction of some aspects of Earth's climatic history. Note the two great Proterozoic glacial episodes (at left), each followed by an atmospheric "oxidation event." The "barren billion" has little evidence of glaciations or iron formations. Two contrasted climatic regimes are depicted in the central part of the diagram. During most of the Proterozoic eon, glaciations appear to have been concentrated in low latitudes, possibly as a result of Earth's high obliquity (Williams, 2008). A radical change occurred near the beginning of the Phanerozoic eon, when a putative large marine impact brought about a major shift in the orientation of the world's spin axis, resulting in a new climatic zonation that still exists today. The impact is inferred from the Shuram $\delta^{13}C$ anomaly (right side; modified from fig. 1 of Halverson et al., 2010) and associated stratigraphic and sedimentological evidence. Note that the Shuram anomaly and impact (age after Bowring et al., 2009) is depicted as younger than the Gaskiers glaciation (age after Mason et al., 2013, their fig. 3) but has been considered older by some. See text for full explanation. G.O.E.—great oxidation event; N.O.E.—Neoproterozoic oxidation event; G—glacial episode.



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and Chen, 2013). Among Neoproterozoic glaciations (Fig. 1), the most convincing and widespread are the Sturtian (730–705 Ma) and the Marinoan (663–635 Ma), although geochronological problems remain. Between ca. 2.2 Ga and 730 Ma, there is little evidence of glaciation (but see Williams, 2005). The temporal distribution of Precambrian glacial deposits is shown in Figure 1. Possible relationships to the supercontinental cycle (Fischer, 1984; Worsley et al., 1984; Bleeker, 2004) were discussed by Young (2013). For full documentation of ancient glacial occurrences, see Hambrey and Harland (1981), Eyles (1993), Deynoux et al. (1994), Crowell (1999), Chumakov (2004), Fairchild and Kennedy (2007), and Arnaud et al. (2011).

## IDENTIFICATION OF GLACIAL DEPOSITS

Physical criteria for the identification of ancient glacial activity are relatively simple, but few are unequivocal. These include widespread diamictites—conglomerates with a variety of clast types "floating" in a matrix of rock flour (Fig. 2A). A second criterion is the presence of laminated mudstones with scattered "outsize" clasts and "splash-up" structures indicating vertical emplacement, as from floating ice (Fig. 2B). These resemble "varved" deposits formed by annual freeze-thaw cycles in modern proglacial lakes. Other attributes include striations on rock pavements or contemporary sediments and striated, faceted, and "bullet-shaped" clasts. Evidence of ancient permafrost and other periglacial phenomena has also been used, as have geochemical data (Nesbitt and Young, 1982).

Diamictites can form in a variety of depositional and climatic settings (Crowell, 1957; Dott, 1961). Glacial deposits are susceptible to "resedimentation" related to seismic shock or slope failure, obscuring their original glacial character (Schermerhorn, 1974; Eyles and Januszczak, 2007). Many Proterozoic glacial deposits formed in active tectonic settings (Arnaud and Eyles, 2002; Basta et al., 2011; Freitas et al., 2011). Evidence of "resedimentation" does not, however, preclude a glacial origin.

## PRECAMBRIAN GLACIAL DEPOSITS IN TIME AND SPACE

The distribution of glaciogenic rocks (Hambrey and Harland, 1981) (Fig. 1, left side) suggests that younger Proterozoic glaciations were more widespread than their older counterparts. This may be due, in part, to growth of continental crust with time, providing a larger substrate for extensive ice sheets and increasing the preservation potential of their deposits.

Glacial deposits present great challenges to geochronologists, but, in some cases, ages can be obtained from interbedded tuffs and lavas, or they may be bracketed between dates from older and younger rocks.

The dearth of glacial deposits in the early part of Earth's history is surprising because of the less radiant young Sun (Sagan and Mullen, 1972; Sackmann and Boothroyd, 2003), but the surface of the early Earth was probably warmed by atmospheric greenhouse gases (notably $CO_2$). Archean supracrustal rocks attest to the presence of abundant surface water, but glacial deposits are rare. The Paleoproterozoic Huronian Supergroup (2. 45–2.21 Ga) includes three glacial formations (Young, 1970; Melezhik et al., 2013) separated by units formed under milder climatic conditions (Young, 1973; Eyles and Young, 1994). None of these glacial episodes has been precisely dated (Melezhik et al., 2013). Some early attempts at correlating Paleoproterozoic glaciogenic rocks in North America (Young, 1970, 1973), mainly based on lithostratigraphic criteria, are now broadly supported by geochronological data (Aspler et al., 2001; Vallini et al., 2006).

A discussion of individual Neoproterozoic glacial deposits is beyond the scope of this article but see Hambrey and Harland (1981), Arnaud et al. (2011), and Harland (2007). The snowball Earth hypothesis was proposed to explain the wide distribution of Cryogenian glaciations (Kirschvink, 1992; Hoffman et al., 1998), such as the Sturtian and Marinoan. Isotopic ratios of C and O from Neoproterozoic carbonates (e.g., Halverson et al., 2010) have been used to support the concept of sporadic, widespread

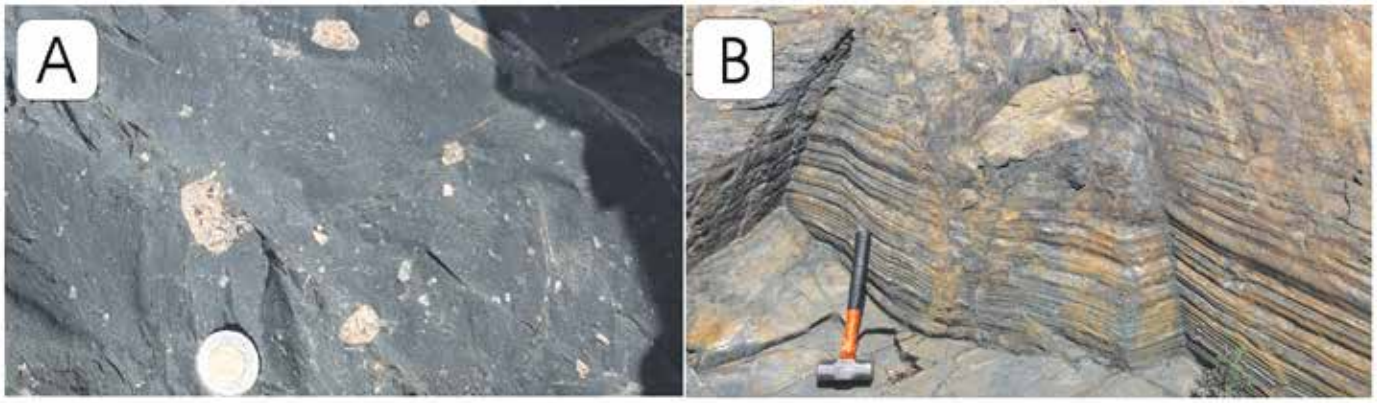


Figure 2. Some field attributes of glacial deposits. (A) Diamictite of the Paleoproterozoic Gowganda Formation, Ontario, Canada. Note that the clasts (mostly granitic) are "floating" in a matrix of crushed rock (rock flour). Coin is 2.8 cm in diameter. (B) Finely bedded mudstones of the Paleoproterozoic Pecors Formation (Huronian) north of Elliot Lake, Ontario, with dropstones that were transported by floating glacier ice. Hammer (head 10 cm long) lies on diamictites of the glaciogenic Ramsey Lake Formation.

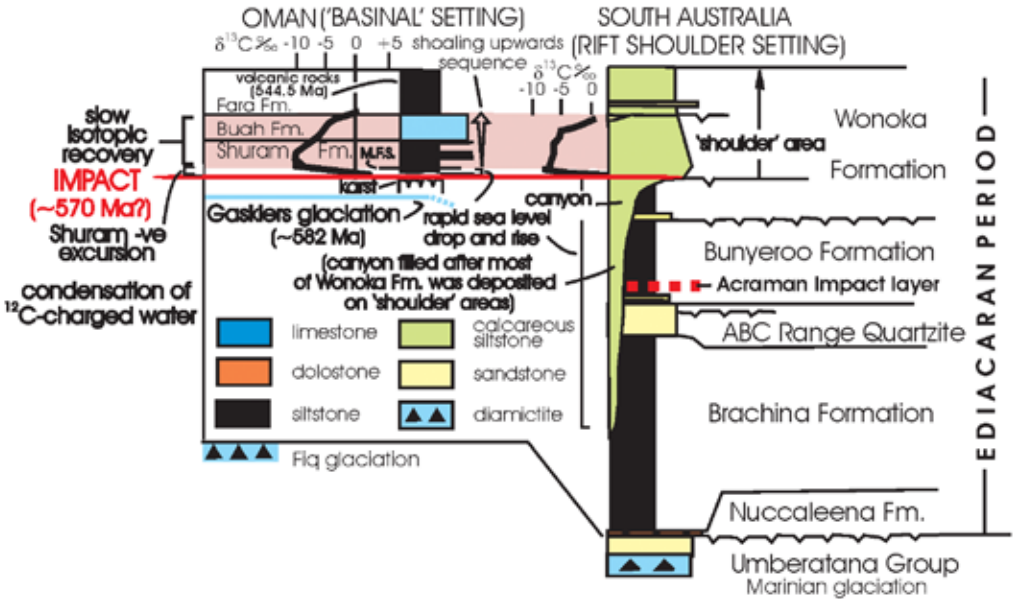


Figure 3. Two representative sections containing the Shuram isotopic anomaly. The Oman section is simplified from Le Guerroué et al. (2006, their fig. 2), and the Wonoka section is after Christie-Blick et al. (1995, their fig. 3). See Le Guerroué et al. (2006) for sources of isotopic profiles. The sections are not to scale, but the Wonoka canyons are up to 1 km deep. The Shuram excursion (age after Bowring et al., 2009) is younger than the Acraman impact layer. The Shuram excursion is shown as younger than the Gaskiers glaciations (Bowring et al., 2007; Macdonald et al., 2013) although some (Le Guerroué et al., 2006; Halverson et al., 2010) have considered the possibility that it may be younger. Much of the fill of the Wonoka canyons occurred after deposition of most of the Wonoka Formation on adjacent "shoulder" areas (Husson et al., 2012). The karst beneath the base of the Shuram Formation is after McCarron (2000). M.F.S.—maximum flooding surface.

glaciations that affected the chemistry of world oceans. Because most Neoproterozoic glacial deposits formed in low paleolatitudes near sea level (Hoffman et al., 1998; Hoffman and Li, 2009, their fig. 7b), it was suggested that Earth's surface was entirely frozen. This conclusion may, however, be invalid if glaciations were concentrated at low latitudes (see following section).

## PROBLEMATIC PALEOLATITUDES AND THE OBLIQUITY OF THE ECLIPTIC

Paleomagnetic results led Harland (1964) to suggest that the Varanger (Neoproterozoic) tillites of east Greenland and Norway were deposited between ~4.5°N and 11°N. Neoproterozoic glacial rocks from around the world have subsequently yielded similar low paleolatitudes, and Williams (1975) proposed that the angle between Earth's spin axis and a line perpendicular to its orbital plane (obliquity of the ecliptic) was much greater in the past. If the steeply tilted Earth (obliquity >54°) descended into a cool period, equatorial regions would have been preferentially glaciated and subject to seasonal temperature fluctuations. Annual temperature differences are small in today's tropical regions, but several Proterozoic glacial successions contain "varved" deposits and sand-wedge structures (Williams, 1986, 2008; Williams and Schmidt, 1997).

Phanerozoic glaciers were markedly different. They descended to sea level only at high latitudes (Crowell, 1999; Evans, 2003; Hoffman and Li, 2009). Paleomagnetic and sedimentological data point to a radically different climatic regime throughout most of the Precambrian eon. The proposed high-obliquity state in Earth's early history may have resulted from the huge impact that produced the Moon (Williams, 1998)—but how to explain the present situation? More than 70% of the surface of the solid Earth was ephemeral oceanic crust, so that craters produced by ancient marine impacts would have been destroyed during subduction. Other suggestions for a large obliquity adjustment include mass distribution changes associated with true polar wander (Williams, 2008) and obliquity-oblateness feedback (Williams et al., 1998).

## WHY DID "ICE-HOUSE" CONDITIONS OCCUR AT THE BEGINNING AND END OF THE PROTEROZOIC EON?

Numerous suggested causes of glaciations include both extraterrestrial and terrestrial processes. It was proposed by Melezhik (2006) that a "perfect storm," with a convergence of several factors, could have caused Proterozoic glaciations. Perhaps the most compelling explanation of long-term fluctuations in surface temperatures is variation in atmospheric $CO_2$, which has been linked (Young, 2013) to the supercontinental cycle (Fischer, 1984; Worsley et al., 1984; Nance and Murphy, 2013).

Phanerozoic glaciations do not appear to be related to supercontinent formation but may have been triggered by increased weathering during orogenic episodes at various stages in the supercontinental cycle. Low ambient Phanerozoic $CO_2$ levels would have made Earth susceptible to glaciation.

## EVIDENCE FROM STABLE ISOTOPES AND THE SHURAM EXCURSION

Some strong fluctuations in carbon isotopic ratios in Cryogenian carbonate rocks coincide with glacial episodes (Halverson et al., 2005, 2010) (Fig. 1). Carbonate rocks of the Ediacaran period (635–542 Ma) contain evidence of the world's deepest negative

$\delta^{13}C_{carb}$ excursion—the Shuram event—named from the type area in Oman. Unless otherwise indicated, $\delta^{13}C$ refers to $\delta^{13}C_{carb}$. In contrast to the Cryogenian isotopic anomalies, the Shuram excursion is believed by some (e.g., Le Guerroué et al., 2006) to lack any glacial influence (but see McGee et al., 2013). The Shuram anomaly has been identified in South Australia in the Wonoka Formation, parts of which are preserved in deep (>1 km) subaerially excavated canyons (von der Borch et al., 1989) (Fig. 3). The anomaly is also known from North America (Verdel et al., 2011), China, India, Siberia, Scandinavia, Namibia, Brazil, and Uruguay (Gaucher et al., 2004). It is widely believed to represent changes in the chemistry of world oceans (Le Guerroué, 2010) rather than secondary (diagenetic) modifications. Deep paleo-canyons have been described from a number of places, including South Australia, California (Clapham and Corsetti, 2005), and Uruguay (Gaucher et al., 2004), some possibly representing significant sea-level changes. The isotopic curves typically show an extremely abrupt drop in $\delta^{13}C$ values (Fig. 3). In California, the drop begins in the widespread Johnnie oolite, but the lowest values (<–10‰) occur in thin limestone beds representing a maximum flooding surface (Bergmann et al., 2011, their fig. 9), as in Oman (Le Guerroué et al., 2006, their figs. 2 and 6; Verdel et al., 2011, their fig. 15) (Figs. 3 and 4) and northwestern Canada (Macdonald et al., 2013).

The Shuram anomaly has defied explanation (Grotzinger et al., 2011; Verdel et al., 2011; Tahata et al., 2013; Bjerrum and Canfield, 2011). None of several theories for formation of the Wonoka canyons (Coats, 1964; von der Borch et al., 1989; Dyson, 2003; Williams and Gostin, 2000) provides an explanation for the contemporary widespread isotopic anomaly.

The Shuram excursion has been attributed by some to oxidation of a large amount of organic carbon in world oceans, both dissolved organic carbon and suspended particulate organic material (see Rothman et al., 2003; Fike et al., 2006; Halverson et al., 2010) (Fig. 1).

## AN IMPACT ORIGIN FOR THE SHURAM EXCURSION?

It is here proposed that the Shuram event may be the result of a large impact that occurred in the deep ocean. Such an impact, among other things, would have caused abrupt lowering of sea level by removal of significant volumes of sea water (and its dissolved and particulate carbon), giant tsunamis, and elevated temperatures (van den Bergh, 1989). Such violent events could have contributed to formation of deep subaerial canyons in appropriate locations. The canyons would have been initiated at the time of impact and eroded by flooding of continents followed by return of huge volumes of water to the oceans. The time involved is unknown, but canyon formation was probably relatively rapid. An "isotopic conglomerate test" by Husson et al. (2012) showed that filling of the Wonoka canyons took place after deposition of most of the eponymous formation on adjacent "shoulder" areas of the Adelaide Rift Complex.

Rocky impact debris would have been less voluminous than in a terrestrial impact. Widespread breccias and diamictites were described by Boggiani et al. (2010) and McGee et al. (2013) from Ediacaran successions in Brazil and elsewhere, associated with rocks displaying a negative $\delta^{13}C$ signal identified as a Shuram equivalent. Timing of the initiation of the Shuram event is poorly documented, as is its relationship to the Gaskiers glaciation.

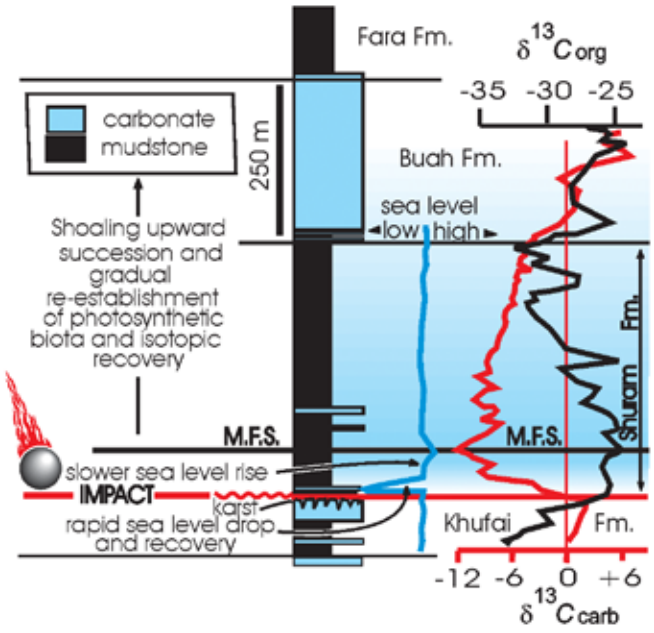


Figure 4. Simplified stratigraphic column from Jabal Akhdar in northern Oman (after Le Guerroué et al., 2006, their fig. 2), together with $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ curves from Fike et al. (2006, their fig. 1). An abrupt sea-level drop and subsequent rise are inferred from canyon incision elsewhere (see Fig. 3) and karst development in the Oman area. This was followed by slower sea-level rise due to condensation of vaporized sea water. The return of $^{12}C$-charged water is thought to have brought about the Shuram isotopic anomaly. A shoaling-upward succession then records a slow return to "normal" isotopic values. Note the unusual antithetic relationship between the two isotopic parameters in the Shuram Formation. See text for discussion. M.F.S.—maximum flooding surface (after Le Guerroué et al., 2006, their fig. 2).

Le Guerroué et al. (2006) thought that the Gaskiers glaciation occurred during the recovery period following the nadir of the isotopic excursion, but others (Bowring et al., 2007, 2009; Tahata et al., 2013; Macdonald et al., 2013, their fig. 13) considered the glaciations to be older than the Shuram event, as depicted in Figures 1 and 3 herein. Some paleolatitudes for the Gaskiers glaciation are quite high, but the majority are relatively low (<60°), and glaciations extended into tropical latitudes, like those of the Cryogenian (Hoffman and Li, 2009). Some of the problems regarding the age of the Gaskiers glaciation (and the wide range of its paleolatitudes) may be due to the gathering, under the same umbrella, of results from several Ediacaran glaciations (both older and younger than the Shuram event) (Hebert et al., 2010).

The abrupt negative $\delta^{13}C$ excursion may be explained by rapid introduction of large amounts of light carbon to the ocean, caused by oxidation and remineralization of much of the ocean's organic carbon content during an impact event (Fig. 4). Recovery from the light carbon-charged ocean may have involved gradual re-establishment of oceanic photosynthetic microorganisms. The unusual antithetic relationship between the $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ curves in the Shuram Formation (Fig. 4) and equivalents in southern China (Xiao et al., 2012, their fig. 8) is not understood but may indicate a common driver–recrudescence of a shallow marine $^{12}C$-sequestering biota. More $\delta^{13}C_{org}$ data are needed from sections around the world. Development of a negative $\delta^{18}O$ anomaly during the

Shuram $\delta^{13}C_{carb}$ excursion (Tahata et al., 2013, their figs. 1 and 7) in several locations suggests that both occurred during a period of general global warming.

Environmental changes related to Neoproterozoic glaciations are commonly cited as stimuli for metazoan evolution, but extinctions, followed by proliferation and increasing sophistication of the Ediacaran fauna, accompanied the Shuram event in several parts of the world (Le Guerroué et al., 2006, their fig. 6; Fike et al., 2006; Grey and Calver, 2007; McFadden et al., 2008, their fig. 1; Macdonald et al., 2013, their fig. 13), so that the proposed giant impact could have been a significant catalyst for these events.

In summary, evidence that the Shuram isotopic excursion may be related to an impact event includes the following:

1. The unusual character of the isotopic excursion, involving an abrupt drop in $\delta^{13}C_{carb}$ values, followed by a smooth and gradual recovery. Unlike the onset of a glaciation, an impact is instantaneous, but its effects can be manifested for a long time afterward.
2. The global nature of the anomaly precludes most explanations that involve secondary processes (such as diagenetic modification), which are generally only locally expressed.
3. Association of the onset of the anomaly with a dramatic fall in sea level, manifested in such settings as rift margins (e.g., Flinders Ranges), by incision of deep canyons. A large marine impact would temporarily displace huge volumes of sea water onto the continents and into the atmosphere.
4. Some sections (e.g., Brazil, western USA, Uruguay) contain coarse sedimentary breccias that could be products of tsunamis and impact-related storms.
5. Many successions that contain isotopic evidence of the Shuram event were storm-dominated.
6. The nadir of the isotopic excursion coincides with a maximum flooding surface (MFS), followed by gradual return to "normal" $\delta^{13}C_{carb}$ values. The opposite sea-level history would be expected if the excursion were related to a glaciation. The MFS could represent relatively rapid return of water to the oceans, first from flooded continents, then from the atmosphere—the latter introducing light carbon (dissolved organic carbon and particulate organic carbon) that was oxidized in the atmosphere following the impact and subsequently incorporated into carbonates. "Normalization" of oceanic carbon isotopic composition resulted from recovery of a $^{12}C$-secreting, photosynthesizing biota in the shallow oceans.
7. In some areas (e.g., Oman and southern China), the negative $\delta^{13}C_{carb}$ anomaly is accompanied by a "mirror image" positive $\delta^{13}C_{org}$ anomaly, whereas covariance is typical of most perturbations in ocean chemistry.
8. Unlike two large Cryogenian $\delta^{13}C_{carb}$ anomalies, there is no definitive association with glaciation. This could be explained by glaciation being located elsewhere, but the excursion is the deepest known, and therefore difficult to explain by local ice sheets.

## CONCLUSIONS

Most Proterozoic glaciogenic rocks appear to have been deposited at low paleolatitudes. The present climatic model does not adequately explain this or the evidence of strong seasonal temperature fluctuations in tropical regions. The snowball Earth hypothesis remains equivocal. The great Proterozoic glaciations followed periods of supercontinentality when weathering of collisional orogens and buoyant, thickened continental lithosphere resulted in drawdown of atmospheric $CO_2$. Between the Marinoan glaciation and the beginning of the Phanerozoic eon, Earth's climatic system appears to have undergone a radical change, for Phanerozoic glaciations took place at high latitudes. This dramatic change may be accommodated by a large reduction in the obliquity of the ecliptic. The previously unexplained Shuram isotopic excursion, together with excavation of deep subaerial canyons and deposition of breccias and diamictites, are considered to be the "smoking gun" for a cryptic, large oceanic impact. There is no compelling evidence that the Shuram excursion is related to, or affected by, glaciation, so that the important biological innovations of the Ediacaran period, commonly attributed to the "snowball Earth," may be allied to massive environmental perturbations accompanying the proposed oceanic impact. If the impact origin for the Shuram anomaly is correct, its widespread effects and "instantaneous" nature would provide one of the most useful and precise time markers in the geological record.

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CALL FOR NOMINATIONS

# 2014 GSA Medals & Awards

## PENROSE MEDAL

The Penrose Medal was established in 1927 by R.A.F. Penrose Jr. to be awarded in recognition of eminent research in pure geology, for outstanding original contributions, or for achievements that mark a major advance in the science of geology. This award is made only at the discretion of the GSA Council, and nominees do not need to be members of the Society. Penrose's objective was to encourage original work in purely scientific geology, which is interpreted as applying to all scientific disciplines represented by GSA. Scientific achievements should be the focus of the nomination rather than contributions in teaching, administration, or service, and mid-career scientists who have already made exceptional contributions should be given full consideration for the award.

## DAY MEDAL

The Arthur L. Day Medal was established in 1948 through a donation by Arthur L. Day, founding director of the Geophysical Laboratory of the Carnegie Institution of Washington. It is awarded annually, or less frequently at the discretion of the Council, to recognize outstanding distinction in the application of physics and chemistry to the solution of geologic problems, with no restriction to the particular field of geologic research. It was Day's wish to provide an award to recognize outstanding achievement in research and to inspire further effort, rather than to reward a distinguished career, and so it has been the longstanding practice of the Society to award this medal to geoscientists actively pursuing a research career.

## YOUNG SCIENTIST AWARD (DONATH MEDAL)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 years or younger throughout the year in which the award is to be presented—*for 2014, only those candidates born* ***on or after 1 Jan. 1979*** *are eligible*) for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in the earth s
The award consists of a gold medal (the Donath Medal) an
honorarium.

### How to Nominate

To ensure thorough consideration by the respective committees, please follow these nomination instructions carefully; additional information supplied will not enhance the nomination. Paper submissions will still be accepted; however, we encourage electronic submission. For each candidate please submit the following:

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online or for hard-copy download to submit via post.
2. **Supporting documents,** to be submitted as e-mail attachments or via post; for Penrose, Day, and Young Scientist, the following supporting documents are required:
   - **Curriculum vitae;**
   - A summary (300 words or less) of the scientific contributions to geology that qualify the candidate for the award;
   - A selected bibliography of no more than 20 titles (for the Young Scientist Award, only 10 titles are required);
   - Letters from each of five GSA Fellows or members ***in addition*** to the person making the nomination. **For the Day Medal only:** at least three of the letters need to be from GSA Fellows or members and up to two from fellows or members of the Mineralogical Society of America, Geochemical Society, or American Geophysical Union.


The deadline for receipt of all GSA medal, award, and recognition nominations is 1 Feb. 2014.

CALL FOR NOMINATIONS

# 2014 GSA Medals & Awards

## GSA PUBLIC SERVICE AWARD

GSA Council established the GSA Public Service Award in 1998 in honor of Eugene and Carolyn Shoemaker. This annual award recognizes contributions that have materially enhanced the public's understanding of the earth sciences or have significantly served decision makers in the application of scientific and technical information to public affairs and earth science–related public policy. This may be accomplished by individual achievement in

- Authorship of education materials of high scientific quality that have enjoyed widespread use and acclaim among educators or the general public;
- Acclaimed presentations (books and other publications, mass and electronic media, or public presentations, including lectures) that have expanded public awareness of the earth sciences;
- Authorship of technical publications that have significantly advanced scientific concepts or techniques applicable to the resolution of earth-resource or environmental issues of public concern; and/or
- Other individual accomplishments that have advanced the earth sciences in the public interest.

The award will normally go to a GSA member, with exceptions approved by GSA Council, and may be presented posthumously to a descendant of the awardee.

### How to Nominate

Paper submissions will still be accepted; however, we encourage electronic submission.

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online or for hardcopy download to submit via post.
2. **Supporting documents,** to be submitted as e-mail attachments or via post.
   - **Curriculum vitae;**
   - Letter of nomination (300 words or less);
   - Brief biographical sketch that clearly demonstrates the applicability of the selection criteria; and
   - A selected bibliography of no more than 10 titles.

## THE BROMERY AWARD FOR THE MINORITIES

The Bromery Award for the Minorities should be given to any minority, preferably African Americans, who qualify under at least one of the following two categories:

1. Nominee has made significant contributions to research in the geological sciences, as exemplified by one or more of the following:
   - Publications that have had a measurable impact on the geosciences;
   - Outstanding original contributions or achievements that mark a major advance in the geosciences; and/or
   - An outstanding lifetime career that demonstrates leadership in geoscience research.
2. Nominee has been instrumental in opening the geoscience field to other minorities, as exemplified by one or more of the following:
   - Demonstrable contributions in teaching or mentoring that have enhanced the professional growth of minority geoscientists;
   - Outstanding lifetime career service in a role that has highlighted the contributions of minorities in advancing the geosciences; and/or
   - Authorship of educational materials of high scientific quality that have enjoyed widespread use and acclaim among educators or the general public.

### How to Nominate

Paper submissions will still be accepted; however, we encourage electronic submission.

1. **Nomination form:** Please go to www.geosociety.org/awards/nominations-Bromery.htm to submit the form online or for hardcopy download to submit via post.
2. **Supporting documents,** to be submitted as e-mail attachments or via post.
   - **Curriculum vitae;**
   - A letter of nomination (300 words or less);
   - Letters from three scientists with at least two from GSA Fellows or members and one from a member of another professional geoscience organization; and
   - An optional selected bibliography of no more than 10 titles.

The deadline for receipt of all GSA medal, award, and recognition nominations is 1 Feb. 2014.

CALL FOR NOMINATIONS

# 2014 GSA Medals & Awards

## GSA DISTINGUISHED SERVICE AWARD

GSA Council established the GSA Distinguished Service Award in 1988 to recognize individuals for their exceptional service to the Society. GSA members, Fellows, associates, and employees may be nominated for consideration, and any GSA member or employee may submit a nomination for the award. GSA's Executive Committee will select awardees, and GSA Council must ratify all selections. Awards may be made annually, or less frequently, at the discretion of Council.

### How to Nominate

Paper submissions will still be accepted; however, we encourage electronic submission.

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online or for hard-copy download to submit via post.
2. **Supporting documents,** to be submitted as e-mail attachments or via post.
   - **Curriculum vitae;**
   - A letter of nomination (300 words or less);
   - A brief biographical sketch that clearly demonstrates the applicability of the selection criteria; and
   - An optional selected bibliography of no more than 10 titles.

## SUBARU OUTSTANDING WOMAN IN SCIENCE AWARD

*Sponsored by* SUBARU Confidence in Motion

The Subaru Outstanding Woman in Science Award recognizes a woman who has had a major impact on the field of the geosciences based on her Ph.D. research. The generous support of Subaru of America, Inc., in conjunction with the Doris M. Curtis Fund, makes this award possible. GSA's 103rd president, Doris Curtis pioneered many new directions for geology, not the least of which was her tenure as GSA president after an unbroken chain of 102 men. Causes dear to her were women, public awareness, minorities, and education. Women are eligible for this award during the first three years following their Ph.D. degree.

### How to Nominate

Paper submissions will still be accepted; however, we encourage electronic submission.

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online or for hard-copy download to submit via post.
2. **Supporting documents,** to be submitted as e-mail attachments or via post.
   - **Curriculum vitae including** dissertation title and abstract;
   - A letter of nomination that clearly states how the Ph.D. research has impacted the geosciences in a major way;
   - A selected bibliography of no more than 10 titles; and
   - Three letters of support.

## AWARD NOTES

Candidates whose names are submitted by the respective award committees to GSA Council but who do not receive an award will remain under consideration by those committees for three years. For those still under consideration, it is recommended that an updated nomination letter be sent to GSA.

All nomination forms and submission instructions are online at **www.geosociety.org/awards/.** Nomination forms and instructions may also be obtained from GSA Grants, Awards, and Recognition, P.O. Box 9140, 3300 Penrose Place, Boulder, CO 80301-9140, USA, +1-303-357-1028, awards@geosociety.org.

The deadline for receipt of all GSA medal, award, and recognition nominations is 1 Feb. 2014.

CALL FOR NOMINATIONS

# 2014 GSA Medals & Awards

## GSA FELLOWSHIP

Fellowship is an honor that is bestowed on the best of our profession once per year at the GSA Spring Council meeting and is recognized at our yearly Annual Meeting. GSA members are elected to Fellowship in recognition of distinguished contributions to the geosciences. A **GSA Fellow** may support *only two* nominees per election cycle and only **one** as a primary nominator. A **GSA member** who is not a Fellow may not be a *primary* nominator, but may be a secondary nominator for no more than **two** nominees per election cycle.

The primary nominator is responsible for collecting the entire nomination packet (including letters of support) and must submit the nomination as one e-mail (with supporting documents as attachments) or as one package by via post. Letters of support sent separately will not be accepted.

### How to Nominate

Paper submissions will still be accepted; however, we encourage electronic submission.

1. **Nomination form:** Please go to www.geosociety.org/members/fellow.htm to submit the form online or for hardcopy download to submit via post.
2. **Supporting documents,** to be collected by the primary nominator and submitted as one package as e-mail attachments or via post:
   - A letter of nomination, including a summary of the nominee's significant contributions supporting the selected criteria for election (up to one page);
   - The nominee's curriculum vitae;
   - A paragraph stating the nominee's total number of publications and a selected bibliography (up to four pages); and
   - A supporting letter of nomination from each of the secondary nominators.

## JOHN C. FRYE ENVIRONMENTAL GEOLOGY AWARD

**Deadline:** 31 March 2014

*What's the best paper on environmental geology you've read lately?* You can nominate that paper for this award as long as it is a GSA or state geological survey publication and was published during the preceding three full calendar years. Your nomination must include a paragraph stating the pertinence of the paper.

Each nominated paper will be judged on its uniqueness or significance as a model of its type of work and its overall worthiness for the award. The paper must (1) establish an environmental problem or need; (2) provide substantive information on the basic geology or geologic process pertinent to the problem; (3) relate the geology to the problem or need; (4) suggest solutions or provide appropriate land-use recommendations based on the geology; (5) present the information in a manner that is understandable and directly usable by geologists; and (6) address the environmental need or resolve the problem. It is preferred that the paper be directly applicable to informed laypersons (e.g., planners, engineers). This award is made in cooperation with the Association of American State Geologists (AASG).

**Please send your nominations to** Program Officer, Grants, Awards & Recognition, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA.

### 2013 AWARD RECIPIENTS NAMED

The 2013 award will be presented at the GSA Annual Meeting in Denver, Colorado, USA, to **Elizabeth Meredith, John Wheaton, and Shawn Kuzara,** for "Coalbed Methane Basics: Ten years of lessons from the Powder River Basin, Montana," published in 2012 by the Montana Bureau of Mines and Geology as Information Pamphlet 6.

The deadline for receipt of all GSA medal, award, and recognition nominations is 1 Feb. 2014.


**Lone Star Rising Scholarship**

A national scholarship for women seeking to enter the workforce in a geoscience-related field, up to $3000. For more information, go to **www.awg.org/eas/scholarships.htm**

**Applications due:** Oct. 31, 2013.

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CALL FOR NOMINATIONS

# 2014 Medals & Awards

## 2014 NATIONAL AWARDS

GSA members are encouraged to nominate colleagues for the following awards:

The **William T. Pecora Award,** sponsored jointly by NASA and the U.S. Dept. of the Interior, recognizes outstanding contributions by individuals or groups toward understanding Earth by means of remote sensing. The award honors the work of those in the scientific and technical community as well as those involved in the practical application of remote sensing. Consideration will be given to sustained or single contributions of major importance to the art and/or science of understanding Earth through observations from space. Learn more at **http://remotesensing.usgs.gov/pecora.php.**

The **National Medal of Science** is awarded by the President of the United States to individuals "deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical, engineering, or social and behavioral sciences." The award committee gives special attention to younger U.S. scientists and engineers who may now be reaching a point at which their contributions merit recognition, as well as to outstanding women and minority scientists. Learn more at **www.nsf.gov/od/nms/medal.jsp.**

The **Vannevar Bush Award** is presented periodically to a senior statesperson of science and technology who, through public service in science and technology, has made an outstanding contribution toward the welfare of humankind and to the United States. Nominations should be accompanied by a complete biography and a brief citation summarizing the nominee's scientific or technological contributions to our national welfare in promotion of the progress of science. Learn more at **www.nsf.gov/nsb/awards/bush.jsp.**

The **Alan T. Waterman Award** is presented annually by the National Science Foundation (NSF) and the National Science Board to an outstanding young researcher in any field of science or engineering supported by the NSF. Candidates must be U.S. citizens or permanent residents 35 years of age or younger OR not more than five years beyond receipt of a Ph.D. by 31 Dec. of the year in which they are nominated. Candidates should have completed sufficient scientific or engineering research to have demonstrated outstanding capability and exceptional promise for significant future achievement through personal accomplishments. The Waterman Award complements the Vannevar Bush Award; both are designed to encourage individuals to seek the highest levels of achievement in science, engineering, and service to humanity. Learn more at **www.nsf.gov/od/waterman/waterman.jsp.**

The **G.K. Warren Prize** is awarded by the National Academy of Sciences for noteworthy and distinguished accomplishment in fluviatile geology and closely related aspects of the geological sciences. Learn more at **http://www.nasonline.org/about-nas/awards/g-k-warren-prize.html.**

## AGI MEDAL IN MEMORY OF IAN CAMPBELL

The AGI Medal in Memory of Ian Campbell recognizes singular performance in and contribution to the profession of geology. Candidates are measured against the distinguished career of Ian Campbell, whose service to the profession touched virtually every facet of the geosciences. Campbell was a most uncommon man of remarkable accomplishment and widespread influence, and in his career as a geologist, educator, administrator, and public servant, he was noted for his candor and integrity. To submit a nomination, go to **www.agiweb.org/direct/awards.html.**

## AGI MARCUS MILLING LEGENDARY GEOSCIENTIST MEDAL

The Marcus Milling Legendary Geoscientist Medal is awarded for consistent contributions of high-quality scientific achievements and service to the earth sciences having lasting, historic value. The recipient will have been recognized for accomplishments in his or her field(s) of expertise by professional societies, universities, or other organizations, and should be a senior scientist nearing completion or having completed full-time regular employment. To submit a nomination, go to **www.agiweb.org/direct/awards.html.**


# The Geological Society of London Celebrates GSA's 125th Anniversary

***George H. Davis,*** *Past GSA President, University of Arizona, Dept. of Geosciences, 1040 E. 4th Street, Tucson, Arizona 85721, USA, gdavis@u.arizona.edu*

The Geological Society of London celebrated GSA's 125th Anniversary through two five-day field trips in the Northwest Highlands of Scotland. These were held in May and June 2013. One trip explored "The Great British Tertiary Volcanoes" on Skye and Rum (Field Trip Leaders: Dougal Jerram, Kathryn Goodenough, and Val Troll), and the other explored the "Structure and Tectonics of the NW Highlands of Scotland" (Field Trip Leaders: Rob Butler and Rick Law).

As GSA's president, and as a devoted field-oriented structural geologist, I participated in the structure-tectonics Northwest Highlands trip, along with more than 25 international participants (Fig. 1; Australia, Austria, Hungary, Poland, Spain, UK, and U.S. all represented). Participants on a tectonics studies group field excursion, which was run by students, also joined in on the trip. This trip was impeccably designed and led. Day after day, Rob Butler and Rick Law served up dazzling, extraordinary outcrops, and they framed our field experience in an integrated context of structural geology, petrology, and tectonics.

Figure 1 (top and above): The participants. Photograph by Rob Butler. From left to right: 1. John Schneider; 2. Miroslaw Ludwiniak; 3. Hannah Watkins; 4. Elena Druguet; 5. Steven Johansen; 6. Bernard Skillerne de Bristowe; 7. Ioannis Tsiantis; 8. Richard McIntosh; 9. Steven Habesh; 10. Christine Hodgson; 11. Melvyn Jones; 12. Rick Law; 13. Clare Marshall; 14. Rod Holcombe; 15. Joseph Nievoll; 16. Julien Moreau; 17. Taija Torvela; 18. Robert Freer; 19. Brian Marshall; 20. Scott Paterson; 21. Thelma Thompson; 22. Rob Butler; 23. Valbone Memeti; 24. Peter Thompson; 25. Joanna Uroda; 26. Michal Wygladala; 27. Alice Gripp; 28. Gustavo Jose Guariguata Rojas; 29. Pedro Galindo; 30. Myriam Rada de Guariguata; 31. Alistair McCay; 32. George Davis; 33. Brigitte Vogt; and 34. John Spring.

Imagining that the trip would be all about the Moine Thrust, I had not anticipated the vast geological range of what we would cover in five days: Lewisian basement with its bizarre expressions of magmatism, migmatization, anatexis, and deformation; Scourie dykes, the margins of which we observed to be marked by localized shearing, pseudotachylite, and flanking folds; transposition and interference fold patterns in intensely deformed Moine rocks; the thrusting of Moine metasediments over Cambrian limestone; the thrusting of Lewisian basement over Cambrian quartzite; folded mylonites; intensely and systematically fractured pebbles within tectonically extended Permo-Triassic conglomerates; superb coastline expressions of the Great Unconformity between Devonian Old Red Sandstone and basement rocks below (Fig. 2); and thin, delicate extensional shear zone systems in Jurassic black shale and sandstone.

Added to the excellence of these outcrop relationships was the steady diet of "Butler-Law narratives" on the history of geological debate and discovery in the Highlands. Their stories reminded us of why we love extracting "truth" from "impossible" field relationships. A case in point was the afternoon we spent on the flank of Ben Arnaboll, where Rob and Rick quite literally led us to the hypocenter of the Highlands Controversy (Fig. 3). None other than Murchison himself concluded that the rock sequence in the Northwest Highlands was a simple homocline marked by dipping beds "younging" eastward. He stayed with this interpretation even

Figure 2. Great unconformity between Old Red Sandstone (above) and crystalline basement (below). Note topographic relief on this ancient erosion surface. Portskerra locale. Photograph by George Davis.

though the limestone and sedimentary quartzites within this package were interbedded with gneisses and schists (Murchison and Geikie, 1861). Later, both Callaway (1883) and Lapworth (1884) concluded that this sequence was laced with low-angle structural contacts that "repeated"' rock units. Morever, Lapworth (1885) recognized that foliation at these structural contacts was not bedding, but a deformational fabric that had formed during shearing. He named this fault rock "mylonite." Geikie realized that Lapworth and Callaway had it right, coined the term "thrust," and scrambled swiftly to publish (Geikie, 1884). Butler (2010) has archived this rich history in the "Blue Monster" (Law et al., 2010), as we came to know it. Personally, I cherish the afternoon we worked the classic Arnaboll thrust exposure while learning the saga from Rob and Rick. Though I had heard bits and pieces of this history in the classroom, it was on the flank of Ben Arnaboll that I actually *experienced* this history.

As we celebrate GSA's 125th Anniversary, I now realize that Lapworth's settling of the Highlands Controversy in 1885 does not seem so very long ago. He settled matters on the eve of the birth of the Geological Society of America (1888). I confess that I am no longer overawed by the concept of 125 years, for I attended my very first GSA Annual Meeting as a college junior in 1962, and thus have experienced 50 years (40%) of GSA's legacy. As I triangulate these several facts, I am left with an especially clear grasp of the youth of our science and our Society, as well as the promise of things to come—*on both fronts*—for they are intertwined.

Let me say that the set of field-trip gifts from our sister Society could not have been improved upon. The words of David Shilston, President of the Geological Society of London, capture the warmth of this initiative: "The field trips visited classic areas of British geology and it was a pleasure to provide these opportunities for a gathering of geologists with a wide range of interests. … Field work is the heart of much of what we do, and … it is always good to get together to talk about rocks in the field."

## REFERENCES CITED


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Figure 3. The Arnaboll Thrust in its type locality, with Lewisian gneisses (gray, upper plate) separated from Cambrian quartzites (orange, lower plate) by mylonitic Lewisian gneisses (dark gray). View is to the south. Tectonic transport direction is from east to west. Rob Butler points to "type" mylonite. Photograph by George Davis.

Preliminary Announcement and Call for Papers

# NORTHEASTERN SECTION

49th Annual Meeting of the Northeastern Section, GSA
Lancaster, Pennsylvania, USA

**23–25 March 2014**

**www.geosociety.org/Sections/ne/2014mtg/**

The Columbia-Wrightsville Bridge, officially the Veterans Memorial Bridge, spans the Susquehanna River. Photo courtesy www.discoverlancasterpa.com.

## *At the Junction of the Northern and Southern Appalachians*

### LOCATION

Situated between the classic Valley and Ridge province of the Appalachians and the geologically complex Piedmont, which is beginning to reveal more of its tectonic secrets, Lancaster is close to the Susquehanna River, by which it was historically accessible from Chesapeake Bay. Lancaster has lately become an important focus for studying the effects of climate change and human influence on its verdant and productive landscape.

### CALL FOR PAPERS

**Abstract deadline:** 10 Dec. 2013
Submit online at **www.geosociety.org/sections/ne/2014mtg/.**
**Abstract submission fee:** US$10 for students and US$15 for all others.

If you cannot submit an abstract online, please contact Nancy Wright, +1-303-357-1061, nwright@geosociety.org.

### Symposia

S1. **Tectonic Links between the Northern and Southern Appalachians.** Don Wise, Univ. Massachusetts–Amherst, dwise@geo.umass.edu; Hal Bosbyshell, West Chester Univ. of Pennsylvania, hbosbyshell@wcupa.edu; Gale Blackmer, Pennsylvania Topographic & Geologic Survey, gblackmer@pa.gov.

S2A. **Origin and Evolution of the Appalachian Critical Zone. I. Physical, Chemical, and Biological Processes.** Jason Price, Millersville Univ. Pennsylvania, jason.price@millersville.edu; Joel Moore, Towson Univ., moore@towson.edu.

S2B. **Origin and Evolution of the Appalachian Critical Zone. II. Anthropogenic Sediments and Their Impacts on Aquatic Ecosystems.** Robert C. Walter, Franklin & Marshall College, robert.walter@fandm.edu; Allen C. Gellis, USGS, agellis@usgs.gov; Jeffrey Niemitz, Dickinson College, niemitz@dickinson.edu.

### Theme Sessions

T1. **Karst Research and the Sustainable Use and Management of Karst Aquifers.** Malcolm Field, U.S. Environmental Protection Agency, field.malcolm@epa.gov; Neven Kresic, AMEC Environment & Infrastructure, Inc., neven.kresic@amec.com.

T2. **Interpreting Sedimentary Records of Past Changes in Climate and Ecology.** Kira Lawrence, Lafayette College, lawrenck@lafayette.edu; David Sunderlin, Lafayette College, sunderld@lafayette.edu.

T3. **Implementing Recent Innovations in Thermobarometry to Constrain Igneous and Metamorphic Evolution.** Kyle Ashley, Virginia Tech, ktashley@vt.edu; Victor Guevara, Virginia Tech, vguevara@vt.edu; Donald Stahr III, Virginia Tech, dstahr@vt.edu.

T4. **Gaining a Greater Understanding of Mars from Gale Crater and Beyond.** Rebecca Williams, Planetary Science Institute, williams@psi.edu.

T5. **Embracing Digital Technologies and the Geoweb: The Changing Philosophies and Practices of Geologic Mapping.** Joseph Kopera, Massachusetts Geological Survey, jkopera@geo.umass.edu; John Van-Hoesen, Green Mountain College, vanhoesenj@greenmtn.edu.

T6. **Service Learning in the Geosciences: Deep Learning through Critical, Reflective Thinking and Civic Responsibility.** Steve Winters, Holyoke Community College, swinters@hcc.edu; Lori Weeden, Univ. Massachusetts Lowell, lori_weeden@uml.edu.

T7. **EarthScope Arrives on the East Coast.** Charles Scharnberger, Millersville Univ. Pennsylvania, charles.scharnberger@millersville.edu.

T8. **Coastal Storms in the Mid-Atlantic: Research and Teaching Opportunities.** Marcus Key, Dickinson College, key@dickinson.edu; Sean Cornell, Shippensburg Univ. Pennsylvania, srcornell@ship.edu.

T9. **Acadian Paleoenvironments of the Appalachians: Mountains Carved by "Alpine" Glaciers, Forested Lowlands and Swamps, and a Marine Foreland Basin with Limited Circulation.** Alexander Bartholomew, SUNY New Paltz, barthola@newpaltz.edu; Edward B. Daeschler, Academy of Natural Sciences of Drexel Univ. of Philadelphia, daeschler@ansp.org; Frank R. Ettensohn, Univ. Kentucky, f.ettensohn@uky.edu; William E. Stein, Binghamton Univ., stein@binghamton.edu.

T10. **Paleoclimate Records of All Types and Ages.** John Rayburn, SUNY New Paltz, rayburnj@newpaltz.edu; David Barclay, SUNY Cortland, barclayd@cortland.edu; Tara Cutrin, Hobart & William Smith Colleges, curtin@hws.edu.

T11. **Examples of Next-Generation Science Standards Implemented in the K–12 Classroom by and for Teachers.** Tanya Furman, Penn State, furman@psu.edu; Laura Guertin, Penn State, Brandywine, guertin@psu.edu.

T12. **Geologizing in America: From Wilderness to Megalopolis.** Jeri L. Jones, Jones Geological Services, jonesgeo@comcast.net; Mary Ann Schlegel, Millersville Univ. of Pennsylvania, maryann.schlegel@millersville.edu; Nicholas G. McDonald, Westminster School, ngm@westminster-school.org.

T13. **Scratching the Surfaces: Advances in Continental and Marine Ichnology.** Ilya Buynevich, Temple Univ., coast@temple.edu; Logan Wiest, Temple Univ., logan.wiest@temple.edu.

T14. **An Interdisciplinary Approach to Taphonomy: The Impact of Morphological, Molecular, and Isotopic Changes on Environmental Proxies.** Qin Leng, Bryant Univ., qleng@bryant.edu; Chris Williams, Franklin & Marshall College, chris.williams@fandm.edu; Hong Yang, Bryant Univ., hyang@bryant.edu.

T15. **Significant 21st-Century Paleontological Discoveries in Northeastern North America.** Roger D.K. Thomas, Franklin & Marshall College, roger.thomas@fandm.edu; Roger Cuffey, Penn State, rcuffey@psu.edu.

T16. **Emerging Techniques and Applications in Paleolimnology.** Greg de Wet, Univ. of Massachusetts, Amherst, gdewet89@gmail.com.

T17. **Glaciers, Sediments, and Landforms of Northeast North America and Beyond.** Sarah Principato, Gettysburg College, sprincip@gettysburg.edu; Benjamin Laabs, SUNY Geneseo, laabs@geneseo.edu.

T18. **Using LiDAR Imagery to Map Features Generated by Quaternary Glacial, Periglacial, and Mass Movement Processes.** Duane Braun, Bloomsburg Univ. of Pennsylvania, DBraun9@roadrunner.com; Gary Fleeger, Pennsylvania Geologic & Topographic Survey, gfleeger@pa.gov.

T19. **Echoes of Exhumation: Comparing Exhumation Processes of the Ancient Appalachians to Those of Currently Active Orogens.** Craig Dietsch, Univ. of Cincinnati, dietscc@ucmail.uc.edu.

T20. **Groundwater Contamination and Remediation: Challenges and Innovative Solutions.** Martin Helmke, West Chester Univ. of Pennsylvania, mhelmke@wcupa.edu; Tripp Fischer, Brownfields Science and Technology, tfischer@bstiweb.com.

T21. **Abandoned Mine Drainage: Impacts, Treatment and Novel Uses.** Jennifer Whisner, Bloomsburg Univ. Pennsylvania, jwhisner@bloomu.edu; Cynthia Venn, Bloomsburg Univ. Pennsylvania, cvenn@bloomu.edu.

T22. **Marcellus and Utica Shales: Geology, Natural Gas Production, and Water Resources Issues.** Dru Germanoski, Lafayette College, germanod@lafayette.edu.

T23. **Dr. Allan M. Thompson: Honoring His Legacy as a Geologist and Educator.** John A. Conrad, Conrad Geoscience Corp., jconrad@conradgeo.com; Ralph R. Leon, ExxonMobil Corp., ralph.r.leon@exxonmobil.com.

T24. **Mineral Resource Geology of Northeastern North America.** Elizabeth A. Graybill, Magnesita Refractories, lizgraybill@gmail.com; G. Robert Ganis, consulting geologist, bobganis@mac.com.

### Field Trips

Descriptions for the following field trips are online; trip registration opens in January 2014. For additional information, please contact the Field Trip Chair, Andrew de Wet, at adewet@fandm.edu.

1. **Sources and Sinks of Anthropogenic Sediments in the Mid-Atlantic Region.** Robert C. Walter, Franklin & Marshall College, robert.walter@fandm.edu; Allen C. Gellis, USGS, agellis@usgs.gov; William B. Hilgartner, Johns Hopkins Univ. and Friends School, Baltimore, hilgartner@jhu.edu; Dorothy J. Merritts, Franklin & Marshall College, dorothy.merritts@fandm.edu.
2. **Tectonics of Southeastern Pennsylvania, West Grove Metamorphic Suite.** Howell Bosbyshell, West Chester Univ. of Pennsylvania, hbosbyshell@wcupa.edu; Gale Blackmer, Pennsylvania Geologic & Topographic Survey, gblackmer@pa.gov; Sandy Schenk, Delaware Geological Survey, rockman@udel.edu; LeeAnn Srogi, West Chester Univ. of Pennsylvania, esrogi@wcupa.edu.
3. **Geology of the Baltimore Mafic Complex Adjacent to the PA/MD State Line.** Stephen Shank, Pennsylvania Geologic & Topographic Survey, stshank@pa.gov; Lynn Marquez, Millersville Univ. of Pennsylvania, lynn.marquez@millersville.edu.
4. **Stratigraphy and Structure of the Chilhowee Group in Lancaster and York Counties.** Charles Scharnberger, Millersville Univ. of Pennsylvania, charles.scharnberger@millersville.edu; Joseph P. Smoot, USGS, jpsmoot@usgs.gov; Edward L. Simpson, Kutztown Univ. of Pennsylvania, simpson@kutztown.edu; Jeri L. Jones, Jones Geological Services, jonesgeo@comcast.net.
5. **Late Devonian Vertebrate Fossils from the Catskill Formation at Red Hill, Clinton County, Pennsylvania.** Edward B. Daeschler, Academy of Natural Sciences of Drexel Univ., daeschler@ansp.org; Walter L. Cressler, Westchester Univ. of Pennsylvania, wcressler@wcupa.edu.

## REGISTRATION

**Early registration deadline:** 18 Feb. 2014
**Cancellation deadline:** 24 Feb. 2014

Registration opens in January 2014. For further information or if you need special accommodations, please contact one of the general co-chairs, Roger Thomas, roger.thomas@fandm.edu, or Noel Potter, pottern@dickinson.edu.

## ACCOMMODATIONS

**Hotel registration deadline:** 28 Feb. 2014

A block of rooms has been reserved at the Marriott Hotel at Penn Square, 25 South Queen St., Lancaster, Pennsylvania 17603, USA, and the meeting rate is US$129 per night plus tax. Reservations should be made by calling Marriott at +1-800-228-9290 (toll free) or +1-717-239-1600 (local). Please be sure to mention that you are attending the GSA meeting.

Preliminary Announcement and Call for Papers

# SOUTHEASTERN SECTION

63rd Annual Meeting of the Southeastern Section, GSA
Blacksburg, Virginia, USA

**10–11 April 2014**

**www.geosociety.org/Sections/se/2014mtg/**

Duck Pond at Virginia Tech. Photo by Eric T. Gunther.

## *Elevating Geosciences in the Southeastern U.S.: New Ideas about Old Terranes*

### LOCATION

The 63rd Annual Meeting of GSA's Southeastern Section will take place in Blacksburg, Virginia, USA, at the Inn and Conference Center at Virginia Tech, which is located near the boundary of the Valley and Ridge geologic province to the west and the Blue Ridge to the east, with convenient access to a wide range of geologic features. We have developed a technical program and field trips that cover a diverse set of geologic topics and processes, including seismology; Cenozoic volcanism; Paleozoic sedimentation, magmatism, and metamorphism; surface and groundwater processes; and Paleozoic and Mesozoic geobiology. Our meeting is also at that magical time of Appalachian spring when the mountains of southwestern Virginia are at their best.

### CALL FOR PAPERS

**Abstract deadline:** 7 Jan. 2014
Submit online at **www.geosociety.org/Sections/se/2014mtg/**
**Abstract submission fee:** US$10 for students; US$15 for all others.
If you cannot submit an abstract online, please contact Nancy Wright, +1-303-357-1061, nwright@geosociety.org.

### Symposia

S1. **Contextualizing the Importance of the Newark Supergroup to Understanding the Biotic Change in the Early Mesozoic.** Sterling Nesbitt, Virginia Tech, sjn2104@gmail.com; Paul Olsen, Columbia Univ., polsen@ldeo.columbia.edu.

S2. **Adaptation and the Architects of Change: The Reciprocal Relationship between Life and the Environment through Time.** Mike Meyer, Western Carolina Univ., mike.meyer.geo@gmail.com; A. Drew Muscente, Virginia Tech, a.d.muscente@gmail.com.

S3. **A Symposium in Honor of the Career of Richard Bambach.** Shuhai Xiao, Virginia Tech, xiao@vt.edu; Gwen Dailey, Winthrop Univ., daleyg@winthrop.edu.

S4. **In Honor and Memory of Dr. Robert B. Neuman: New Directions in Southern Appalachian Geologic Research, Foreland to Hinterland.** Mark Carter, USGS, mcarter@usgs.gov; Arthur Merschat, USGS, amerschat@usgs.gov; Elizabeth McClellan, Radford Univ., emcclellan@radford.edu; Melissa Brett, Radford Univ., mcbrett@radford.edu.

### Theme Sessions

T1. **Modern and Ancient Sediment Routing Systems in the Southeastern United States.** William Craddock, USGS, wcraddock@usgs.gov; Kenneth Eriksson, Virginia Tech, kaeson@vt.edu.

T2. **Geologic Studies of the U.S. Atlantic Coastal Plain.** Christopher Swezey, USGS, cswezey@usgs.gov; William R. Doar III, South Carolina Geologic Survey, doarw@dnr.sc.gov.

T3. **Paleontologists of the Southeast: Characters Welcome!** Michael A. Gibson, Univ. of Tennessee–Martin, mgibson@utm.edu; Richard A. Laws, Univ. of North Carolina–Wilmington, laws@uncw.edu.

T4. **Revealing the Cenozoic Fossil Record in Eastern North America.** Michelle R. Stocker, Virginia Tech, mstocker@utexas.edu; Gregg F. Gunnell, Duke Univ., gregg.gunnell@duke.edu.

T5. **Ichnology in the Southeast USA.** Andrew K. Rindsberg, Univ. of West Alabama, arindsberg@uwa.edu.

T6. **EarthScope Targets in the Eastern United States.** John Hole, Virginia Tech, hole@vt.edu; Steven Whitmeyer, James Madison Univ., whitmesj@jmu.edu.

T7. **Lessons Learned from the 2011 Virginia Earthquake.** J. Wright Horton, USGS, whorton@usgs.gov; Martin Chapman, Virginia Tech, mcc@vt.edu; Russell Green, Virginia Tech, rugreen@vt.edu.

T8. **Geohazards: Methods for Mapping, Monitoring, and Mitigating.** C.F. (Skip) Watts, Radford Univ., cwatts@radford.edu; M.J. (Marty) Woodard, Haley and Aldrich, mwoodard@haleyaldrich.com.

T9. **Geologic Maps, Geophysical Maps, Digital Geologic Maps, and Derivatives from Geologic and Geophysical Maps (*Posters*).** Michael W. Higgins, mhiggins@mindspring.com; Ralph F. Crawford, The Geologic Mapping Institute, crawford@sprintmail.com.

T10. **Digital Devices and Online Resources for Geospatial Visualization.** Callan Bentley, Northern Virginia Community College, cbentley@nvcc.edu; Declan DePaor, Old Dominion Univ., ddepaor@odu.edu.

T11. **Hydrocarbon Recovery Using Fracking Technologies.** John Chermak, Virginia Tech, jchermak@vt.edu.

T12. **Virginia Uranium.** Robert J. Bodnar, Virginia Tech, rjb@vt.edu.

T13. **Evaluating Dust Contaminant Exposure and Impact on Human Health and Community Well-Being Associated with Coal Mining Activities**. Nicholas Basta, The Ohio State Univ., basta.4@osu.edu; John R. Craynon, Virginia Tech, jcraynon@vt.edu; Nancy E. Johnson, Kentucky College of Public Health; J. Buchanich, Univ. of Pittsburgh; E. Talbott, Univ. of Pittsburgh; Vladislav Kecojevic, West Virginia Univ.; Braden Lusk, Univ. of Kentucky; Susan L. Meacham, Virginia Tech; Michael E. Karmis, Virginia Tech.

T14. **Mineralogy and Geochemistry of Mine Wastes.** J. Donald Rimstidt, Virginia Tech, jdr02@vt.edu; Lee Daniels, Virginia Tech, wdaniels@vt.edu.

T15. **Melting Processes in the Eastern U.S.** Esteban Gazel, Virginia Tech, egazel@vt.edu; Elizabeth Johnson, James Madison Univ., johns2ea@jmu.edu.

T16. **The Next Generation Science Standards, Common Core, and STEM: Opportunities for Geoscience Education in K–12 and Beyond.** William Witherspoon, Fernbank Science Center, DeKalb County School District, witherspoonb@fc.dekalb.k12.ga.us; Denise Hills, Geological Survey of Alabama; Vladislav Kecojevic, West Virginia Univ., vlad.kecojevic@mail.wvu.edu; Braden Lusk, Univ. of Kentucky, lusk@engr.uky.edu; Susan L. Meacham, Virginia Tech; Michael E. Karmis, Virginia Tech, mkarmis@vt.edu.

T17. **Progress in Online Geoscience Education.** Jennifer Sliko, Western Carolina Univ., jsliko@gmail.com; Hannah Scherer, Virginia Tech, hscherer@vt.edu.

T18. **Earth-Science Instruction in 2013 and Beyond: How Teaching Practical Science Classes Will (and Must!) Adapt in a World of MOOCs and Social Media Options.** Douglas W. Haywick, Univ. of South Alabama, dhaywick@southalabama.edu; Ann E. Holmes, Univ. of Tennessee–Chattanooga, ann-holmes@utc.edu; David Kopaska-Merkel, Geological Survey of Alabama, davidkm@gsa.state.al.us.

T19. **Innovative, Multidisciplinary Approaches to Teaching Core Geoscience Courses.** Lynn Fichter, James Madison Univ., fichtels@jmu.edu; Lawrence Malinconico, Lafayette College, malincol@lafayette.edu; David Sunderlin, Lafayette College, sunderld@lafayette.edu; Steven Whitmeyer, James Madison Univ., whitmesj@jmu.edu.

T20. **Undergraduate Research as Teaching Practice in the Southeastern Section.** Jeff Ryan, Univ. of South Florida, ryan@mail.usf.edu; Weston Dripps, Furman Univ., weston.dripps@furman.edu; Lee Phillips, Univ. of North Carolina at Pembroke, lee.phillips@uncp.edu.

T21. **Karst and Caves.** Madeline Schreiber, Virginia Tech, mschreib@vt.edu; John Haynes, James Madison Univ., haynesjx@jmu.edu; Dorothy Vesper, West Virginia Univ., djvesper@mail.wvu.edu.

T22. **Hydrologic Characterization of Crystalline-Rock Aquifers of the Blue Ridge and Piedmont Provinces.** Tom Burbey, Virginia Tech, tjburbey@vt.edu; Larry Murdoch, Clemson Univ., lmurdoc@clemson.edu.

T23. **Water Quality Issues in the Southeast U.S.** Vijay Vulava, College of Charleston, vulavav@cofc.edu; Madeline Schreiber, Virginia Tech, mschreib@vt.edu.

T24. **Hidden Gems: Geological Collections and Museums in the Southeastern U.S.** Jim Beard, Virginia Museum of Natural History, jim.beard@vmnh.virginia.gov; Llyn Sharp, Virginia Tech Museum of Geosciences, llyn@vt.edu; Sarah Timm, Virginia Museum of Natural History, sarah.timm@vmnh.virginia.gov.

T25. **Watershed Processes.** Jeff Wilcox, Univ. of North Carolina–Asheville, jwilcox@unca.edu; Weston Dripps, Furman Univ., weston.dripps@furman.edu.

T26. **Hands-On Geoscience Activities for Complex Topics: A Marketplace of Ideas.** Denny Casey, Virginia Museum of Natural History, denny.casey@vmnh.virginia.gov; David Kopaska-Merkel, National Association of Geoscience Teachers, davidkm@gsa.state.al.us; Eric Pyle, James Madison Univ., pylee@jmu.edu; Llyn Sharp, Virginia Tech, llyn@vt.edu.

## FIELD TRIPS

Descriptions for the following trips are online; trip registration opens in January 2014. For additional information, please contact the Field Trip Co-Chairs: Chuck Bailey, cmbail@wm.edu, and Lorrie Coiner, lorrie.coiner@dmme.virginia.gov.

1. **Geology of the Valley and Ridge/Eocene Volcanics, Highland County, Virginia.** John Haynes, James Madison Univ., haynesjx@jmu.edu; Elizabeth Johnson, James Madison Univ., johns2ea@jmu.edu; Steven Whitmeyer, James Madison Univ., whitmesj@jmu.edu. Two days pre-meeting.
2. **Origin and Interaction of Ordovician Terranes in the Western Piedmont of Virginia: Geology between Lake Anna and Aquia Creek.** Stephen Hughes, North Carolina State Univ., kshughes@ncsu.edu; James Hibbard, North Carolina State Univ., jphibbar@ncsu.edu. Two days pre-meeting.
3. **Recent Seismic Activity, Landslides, Stream Capture, and Groundwater Flow along Reactivated Northwest-Trending Fracture Systems at the Northeast End of the Blue Ridge Plateau near Roanoke, Virginia.** Bill Henika, Virginia Tech, bhenika@vt.edu; Lorrie Coiner, Virginia Department of Mines, Minerals and Energy, lorrie.coiner@dmme.virginia.gov; Philip Prince, Virginia Tech, psprince@vt.edu. One day pre-meeting.
4. **Key Structural and Stratigraphic Relationships from the Northeast End of the Mountain City Window and the Mount Rogers Area, Virginia–North Carolina–Tennessee.** Arthur Merschat, USGS, amerschat@usgs.gov; Richard D. Tollo, George Washington Univ., rtollo@gwu.edu; Douglas W. Rankin, USGS, dwrankin@usgs.gov; C. Scott

Southworth, USGS, ssouthwo@usgs.gov; Samantha Bauer, George Washington Univ. Three days pre-meeting.

5. **Mesozoic Fauna from the Solite Quarry, Dan River Basin, Virginia.** Andy Heckert, Appalachian State Univ., heckertab@appstate.edu. One day pre-meeting.
6. **Marcellus/Millboro Shale, Valley and Ridge, Virginia and West Virginia.** Daniel Soeder, DOE/NETL, daniel.soeder@netl.doe.gov; John Chermak, Virginia Tech, jchermak@vt.edu. Two days pre-meeting.
7. **Geomorphology and Karst in the Shenandoah Valley, Virginia.** Daniel Doctor, USGS, dhdoctor@usgs.gov. Two days post-meeting.
8. **Tectonics and Stratigraphy of the Eastern Blue Ridge: Regional Correlations of the Ashe and Alligator Back Formation (Metamorphic Suites), Southern Virginia and Northwestern North Carolina.** Mark Carter, USGS, mcarter@usgs.gov; Arthur J. Merschat, USGS, amerschat@usgs.gov; C. Scott Southworth, USGS, ssouthwo@usgs.gov. Two days post-meeting.
9. **Geology and Tectonics of the Scottsville Mesozoic Basin, Virginia Piedmont.** Chuck Bailey, College of William and Mary, cmbail@wm.edu; Rob Weems, USGS, rweems@usgs.gov. Two days post-meeting.
10. **Geologic Setting of the August 2011 Central Virginia Earthquake.** David Spears, Virginia Dept. of Mines, Minerals and Energy, david.spears@dmme.virginia.gov; Bill Burton, USGS, bburton@usgs.gov. Two days post-meeting.
11. **Stratigraphy and Sedimentology of the Upper Mississippian Pride Shale.** Ty Buller, Virginia Tech, tybuller@vt.edu; Kenneth Eriksson, Virginia Tech, kaeson@vt.edu. One day post-meeting.
12. **Geology of the Coles Hill Uranium Deposit, Virginia Piedmont.** Joseph Aylor, Virginia Uranium, jaylor@vauinc.com; Stewart East, Virginia Uranium, seast@vauinc.com; Lorien Huemoeller, Virginia Uranium, lhuemoeller@vauinc.com; Norm Reynolds, Virginia Uranium, nreynolds@vauinc.com; Robert Bodnar, Virginia Tech, rjb@vt.edu. One day post-meeting.

## ACCOMMODATIONS

A block of rooms has been reserved at the **Inn at Virginia Tech,** 901 Prices Fork Road, Blacksburg, Virginia 24061, USA, adjacent to the Conference Center. Room rate: $144, plus tax. To make your reservation, please call +1-540-231-8000. Be sure to mention you are attending the GSA Southeastern Meeting.

## LOCAL COMMITTEE

**General Chairs:** Robert J. Tracy, rtracy@vt.edu; Kenneth A. Eriksson, kaeson@vt.edu

**Technical Program Chair:** Steven Whitmeyer, whitmesj@jmu.edu

**Field Trip Co-Chairs:** Chuck Bailey, cmbail@wm.edu; Lorrie Coiner, lorrie.coiner@dmme.virginia.gov

**Posters and Exhibits:** Esteban Gazel, egazel@vt.edu

**Sponsorships:** Chester (Skip) Watts, cwatts@radford.edu

# GSA MENTOR PROGRAMS

## STUDENTS

***—Interested in a career in the applied geosciences?***

Plan now to attend a Roy J. Shlemon Mentor Program in Applied Geoscience and/or a John Mann Mentors in Applied Hydrogeology Program at your 2014 Section Meeting to chat one-on-one with practicing geoscientists. These volunteers will answer your questions and share insights on how to get a job after graduation.

## PROFESSIONALS

***—Interested in sharing information about your applied geoscience career with students?***

Being a mentor is a rewarding experience. To learn more about serving as a mentor at one of GSA's Section Meetings, contact Jennifer Nocerino at **jnocerino@geosociety.org.**

# 2014 Section Meeting Calendar

**www.geosociety.org/Sections/**


**SOUTH-CENTRAL SECTION**
**Fayetteville, Arkansas, USA**
**17–18 March 2014**
University of Arkansas Global
Local Committee chair: Steve Boss
Abstracts deadline: 3 Dec. 2013
Early registration deadline: 10 Feb. 2014

**NORTHEASTERN SECTION**
**Lancaster, Pennsylvania, USA**
**23–25 March 2014**
Lancaster Marriott
Local Committee co-chairs: Noel Potter and Roger Thomas
Abstracts deadline: 10 Dec. 2013
Early registration deadline: 18 Feb. 2014



**SOUTHEASTERN SECTION**
**Blacksburg, Virginia, USA**
**10–11 April 2014**
Skelton Conference Center at Virginia Tech
Local Committee co-chairs: Robert Tracy and Kenneth Eriksson
Abstracts deadline: 7 Jan. 2014
Early registration deadline: 10 Mar. 2014

**NORTH-CENTRAL SECTION**
**Lincoln, Nebraska, USA**
**24–25 April 2014**
Cornhusker Marriott
Local Committee chair: Matt Joeckel
Abstracts deadline: 14 Jan. 2014
Early registration deadline: 24 Mar. 2014




**ROCKY MOUNTAIN/ CORDILLERAN SECTIONS**
**Bozeman, Montana, USA**
**19–21 May 2014**
Montana State University, Strand Union Building
Local Committee co-chairs: Dave Lageson and Jeff Vervoort
Abstracts deadline: 11 Feb. 2014
Early registration deadline: 14 Apr. 2014

Wilson Park, Fayetteville, Arkansas; used with permission of Wikimedia Commons.

Ohiopyle falls at Ohiopyle State Park, Ohiopyle, Pennsylvania; used with permission of Wikimedia Commons.

Blue Ridge Mountains, Shenandoah National Park, Virginia. Photo by Amrinder Arora; used with permission of Wikimedia Commons.

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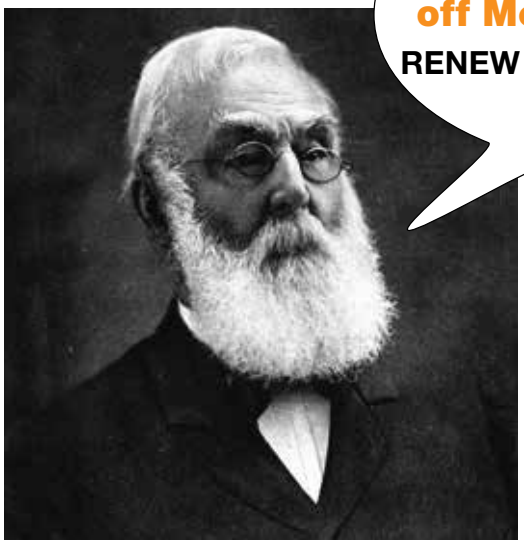

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A common scene during the trip. Photo by Justin Samuel.

# Rocky Mountain FIELD CAMP

## for K–12 Teachers

**Trip dates:** 21–26 June 2013

**Trip leaders:** Davida Buehler, Matthew Dawson, and Justin Samuel

Written by participant **Kathy Megivern,** Ankeny High School, Ankeny, Iowa, USA

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The descriptions and itinerary for the 2013 Rocky Mountain Field Camp (RMFC) sprouted hopeful images and expectations in my mind. Several items captured my attention and placed the course at the top of my summer must-do list:

1. Examining rocks that tell the story of Colorado's fascinating geological history;
2. Collecting rock, mineral, and fossil samples throughout the trip;
3. The description, "This trip includes many hikes … some will be long";
4. Destinations, including Eldorado Canyon, Garden of the Gods, Pikes Peak, Florissant Fossil Beds, and Henderson Mine; and
5. Presentation topics, including Bowen's Reaction Series, reading geologic maps, pegmatites, and mineral formation.

You won't read here the story told to us by Colorado's rocks. That is a story to be unraveled by future RMFC participants. My goal is to share the spirit of the field camp and how it merged the various facets of geology into one coherent course.

The pace of the course was all I'd hoped it would be. I need the schedules for my numerous trips to Colorado to be absolutely packed. And what a great start to this course! As soon as the last participant arrived, the leaders whisked us off to GSA Headquarters for a program and dinner. We were ushered to tables set with rock samples, Columbia fleeces and GSA tote bags of folders full of learning materials and a field journal. We began with lessons on the rock cycle and rock types.

In light of the nationwide drive for increased inquiry and relevance in science classes, some high school geology teachers avoid including rock identification in their courses. I've asked university professors and science education specialists at other workshops what research shows is the best approach to teaching rock identification, but it seems there is not yet a definitive answer. Recognizing its importance, I've been teaching it with as much inquiry and relevance as I can. RMFC's rock cycle activity and subsequent series of rock identification activities provided answers that made sense to me, even though I hadn't yet asked the "best approach" question here. Inquiry was abundant in these activities, and they prepared students for actual rock identifications at the end of the sequence. Additionally, the lessons included ties to plate tectonics, environments of formation, geologic time, and the relevance of geology. This lesson helped me validate what I've been doing and added elements and timing for an even more meaningful experience for students. These quality activities were typical of those we experienced throughout this course.

We continued our rock lessons outdoors and set out on the trails of Boulder to put our rock knowledge to use. At selected locations, we observed the rocks and recorded our observations in words and sketches in our field journals, interpreted the evidence in the rocks, then shared and discussed our observations and interpretations. Continuing this process from site to site, we pieced together the geologic history of this area. As we worked our way through the various ages of rock, Davida Buehler, GSA's Teacher Advocate Program Officer and our main trip leader, called this our "walk into the future."

With each new piece of the story added, Davida would remind us of what we had already determined and then build on it. I'd never experienced the power of review and reinforcement as

dramatically as I did here. Most teachers have limited time outdoors, so field geology tends to challenge us. We experienced what many students experience when they face challenges in their learning, whether it is in the field, in the lab, or when faced with the written word. We could look in our notes to review, but the quick verbal repetition was welcome, effective, and an excellent reminder for us as teachers.

Florissant Fossil Beds National Monument was inspiring. Instructed to avoid all interpretive signs, a ranger handed us each a simple outline diagram of a hillside cross section on which we could take notes as we stopped at various stations and elevations along the way to examine evidence of the geologic history in the rocks. We were to deduce the information presented on the signs for ourselves.

Once we learned of the geologic events in this area, we read the signs and watched the educational videos in the visitor center. We had an appreciation and understanding of the information there that we would never have had without the preceding learning experience. "Experience" is an important point, for this is what students need for deep, long-lasting learning. Limited to one field trip per year for my high school geology course, this camp made me excited to develop more simulations for students to complete at school. I plan to design one using samples we collected at nearby Florissant Quarry. At this quarry, we split shale of the same formation as in the national monument.

RMFC was well organized and well balanced, with stops to illustrate Colorado's geologic history and several other aspects of geology. Precipitous drop-offs and breathtaking views made the drive to the top of Pikes Peak a thrilling one. Observing the Pikes Peak Granite prompted discussion of the intriguing story of this granite and ways that granites form.

At Skyline Drive in Canon City, we viewed the rare underside of dinosaur trackways and worked through dinosaur lessons for the classroom. A chance meeting with an enthusiastic and knowledgeable University of Kansas Ph.D. student informed us about what ancient tales he was gleaning from fossil burrows and their ecology. That afternoon, we visited the Garden Park Fossil Area's Marsh Quarry, where Marshall Felch excavated fossils for Othniel C. Marsh, a key player in the renowned dinosaur wars of the late 1800s.

The next day, we reviewed our timeline of Colorado geologic history in preparation for studying Mount Princeton (and learning the secret of its Chalk Cliffs) and Sugarloaf Mountain. We also reviewed mineral formation in anticipation of our visit to Henderson Mine, which mines molybdenum. At the mine, we donned the safety equipment of miners and descended more than 2,000 feet to observe firsthand some of their advanced mining processes. We also learned of Henderson Mine's dedication to environmental responsibility.

Could it be possible that RMFC would include so many of my favorite things? Was it true that RMFC would meet my high expectations? Absolutely! This fall, I'll return to the classroom with increased content knowledge, improved field skills, and new online resources. I'll continue to draw on the expertise from GSA through its Connected Community and future field trips. I'll introduce my students to EarthCaching, and share what I've learned in working with Bureau of Land Management and National Park Service staff. Not bad for five and a half days at Rocky Mountain Field Camp.


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Photo by Bret Webster.

# GSA's Connected Community

This is the fifth and final article in our series about GSA's new Connected Community. You can find previous articles online at **www.geosociety.org/gsatoday/** that convey how to easily and securely log in through GSA's "single sign-on" system, set up your profile to make yourself visible in the Community, find contacts using a host of key variables, join or create interest groups, extend the Annual Meeting experience beyond October, and use discussion forums (e-Groups) in the Connected Community.

## *There's one more thing you should know:*

### Resource Libraries

Discussions often need to be supported—with data, charts, figures, photos, videos, animations, website links, manuscripts, or slide presentations—to make them expedient and valuable.

Resource Libraries answer that need for e-Groups and are a core element of GSA's Connected Community. Each community (e-Group) has been created with its own resource library—a repository in which users can share files, including multimedia, with their peers in a socially enriched environment.

Resource libraries can be populated in two ways. The first way is to upload documents directly by using the "add a new entry" link. The second way documents end up in a resource library is by including an attachment in a discussion post. The system automatically puts it into the library and sends out a link to everyone in the e-Group.

Multimedia library content can be viewed through Library Entry pages and embedded as content in other Web pages. Additionally, Creative Commons licensing notices can be added to library entries.

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**Committees:** Archive documents and make them searchable for new members;

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**Presenters:** Share your research and get feedback;

**Interest groups:** Build a community knowledge base of resources;

**Travelers:** Post pictures from your field trips; and

**Authors:** Release an abstract from your book to generate interest.

The possibilities are endless. Make resource libraries work for you. Join your colleagues today by typing community.geosociety.org into your web browser, then click on "Help" for instructions on how to log in.

## *Did You Know?*

If you are registered for GSA's 125th Annual Meeting, you are already a member of the Annual Meeting Attendees Community. Make the meeting friendlier. Find out who's coming and make a connection now. Post your profile picture so people will recognize you, and get a head start on remembering those names and faces at the meeting.

**We Believe in the Power of GSA's Connected Community!**

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# GSA Annual Meeting
# VANCOUVER 2014
## 19–22 October 2014

## *Now Accepting Technical Session, Field Trip, and Short Course Proposals*

The 2014 GSA Annual Meeting will take place in beautiful Vancouver, British Columbia, Canada. The primary host of the 2010 Winter Olympics, this green city is very walkable and offers many bike rentals and paths. A short train or bus/taxi ride takes you from Vancouver International Airport into town. The convention center, on the edge of Coal Harbor, is an architectural masterpiece, with Canada's largest living roof. This geologically active area will make for some unique field trips. Venture outside the city to visit the mountain town of Whistler or Capilano Suspension Bridge Park, where you can hike around a West Coast rainforest. We hope you will join us 19–22 October 2014 for this first annual meeting outside the United States in sixteen years. ***And make sure your passport is up to date!***

### TECHNICAL SESSIONS

**Proposals deadline:** 14 Jan. 2014
**Abstracts deadline:** 29 July 2014

**Help ensure that your area of research and expertise is represented in next year's technical program.** Any individual or geoscience organization is welcome to suggest topics and submit proposals for both Topical Sessions and Pardee Keynote Symposia. Pardee Symposia are high-profile sessions on significant scientific developments, with invited speakers only. Topical Sessions are a combination of invited and volunteered papers. Unique formats are allowed, but they must be outlined in the proposal along with the technical support needs. Sessions that promote discussion are encouraged.
**https://gsa.confex.com/gsa/2014AM/sessionproposals.epl**

### FIELD TRIPS

**Deadline:** 2 Dec. 2013
**Know of a great geoscience excursion in the Vancouver, British Columbia, Canada, area?** Teach your colleagues and peers about the wondrous scenery and ground-breaking research in this region. Trips can be a half-day to 5 days long. *Questions?* Please contact Beth Engle, bengle@geosociety.org.
**https://gsa.confex.com/gsa/2014AM/fieldtrip.htm**

### SHORT COURSES

**Deadline:** 1 Feb. 2014
**Enjoy Teaching? Lead a Short Course at the GSA Annual Meeting in Vancouver in 2014!** Extend your expertise to your peers and to the next generation. GSA Short Courses help develop professional, teaching, and research skills at all levels. *Questions?* Please contact Jennifer Nocerino, jnocerino@geosociety.org.
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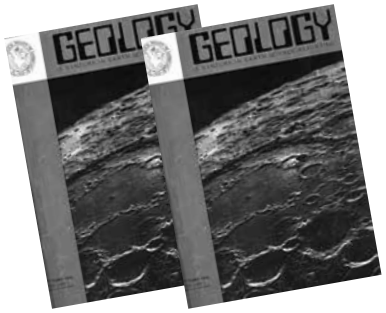
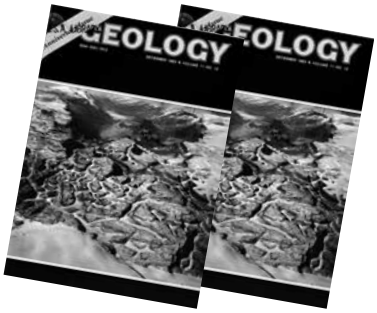
Aerial view of Vancouver with Stanley Park in the foreground. Image by Albert Normandin, 2009, courtesy Tourism Vancouver.



# Geology—Past & Future REVISITED



**Editor's note:** The following is the third installment of our encore presentation of articles highlighting the 10th anniversary of the first issue of *Geology*, as published in *Geology* in Dec. 1983 [v. 11, no. 12, p. 679–691, doi: 10.1130/0091-7613(1983)11<679:GAF>2.0.CO;2]. Each section was written by a different author (author affiliation notations are as originally published in 1983). See the August 2013 *GSA Today* (v. 23, no. 8, p. 18–19) for the first installment and table of contents. In this issue: article 6: "Plate motion in convergent plate boundaries" by Seiya Uyeda; and article 7: "Earthquake prediction" by Clarence R. Allen.

## Plate motion in convergent plate boundaries

***Seiya Uyeda,*** *Earthquake Research Institute, Tokyo, Japan*

In 1972 I was visiting MIT and running a seminar on the driving mechanism of plate tectonics. Obviously, we thought it was the new frontier. When we saw W.J. Morgan's map of absolute plate motions, we immediately realized that the most important driving force should be the pull of subducted slab, because all the plates attached to substantial amounts of downgoing slabs were shown to move much more rapidly than other plates. This simple idea was elaborated with Don Forsyth, who had participated in the seminar, when we found each other staying at Lamont-Doherty Geological Observatory in 1974. The results showed that our intuition was probably right. Subduction is not merely a part of the plate-tectonic machine but its main engine. To further deepen the theory, two paths were envisioned. One was to pursue mantle convection theory more rigorously, while the other was to infer plate motions in the geologic past and compare them with the predictions from the theory. These paths were followed by high-powered colleagues, with some important progress. However, in my judgment, their endeavors have not produced real breakthroughs in advancing the driving-mechanism study, although some unanticipated usefulness has been found—e.g., parameterized convection theory in Earth's thermal history and paleoreconstruction of plates in the now-fashionable collision-accretion tectonics. The basic reason why these paths have not led to real breakthroughs so far could be the paucity of reliable observational constraints to guide us out of the maze. Flow in the deep mantle is still difficult to measure, and the reliability of paleomotion determinations deteriorates as one goes back in time. It is instructive to remember that the phenomenal success of the concepts *seafloor spreading* and *plate tectonics* was achieved by the surge, in the late 1960s, of observational support from diverse disciplines.

When observational constraints had been exhausted, I went back to the problem of subduction-zone tectonics, which had been my own frontier for some time. In my view, subduction-zone tectonics was full of fascinating enigmas—e.g., back-arc spreading, thermal regime, sediment accretion, and arc volcanism, and there was a good possibility of a new supply of data through endeavors such as the DSDP active margin drilling, in which I was beginning to be involved. In 1976, I thought I found a breakthrough in understanding of subduction tectonics. It was the notion of two basic different modes of subduction, namely high-stress and low-stress modes. This notion, which explains the difference in tectonic stress regime in different subduction zones in terms of mechanical coupling between subducting and overriding plates, was worked out, with H. Kanamori, while I was visiting Caltech in 1977. Although there is much to improve—e.g., by taking fuller account of accretion and collision processes during subduction—the basic idea seems to be viable for some years to come.

In my view, a new frontier must not only concern fundamental problems but also be provided with influx of new observational data. With these in mind, I feel that the new frontier for the next decade lies in the nonrigidity or softness of lithosphere. Plate tectonics so far has established the "rigid" behavior of plates, but only for rifted plates and plates undergoing steady subduction. Evidence now is rapidly accumulating that plates behave not at all rigidly when collision and accretion take place. An important new type of information related to this problem is real-time monitoring of plate motions. This will be achieved by the space geodetic methods such as VLBI and laser ranging, and also by underwater acoustics. As soon as these technologies begin to work, "nonrigid" plate tectonics will take big steps forward in promoting understanding of the orogenic processes and also in predicting earthquakes.

## Earthquake prediction

***Clarence R. Allen,*** *Seismological Laboratory, California Institute of Technology, Pasadena, California 91125, USA*

Five to ten years ago, great optimism existed in the seismological community that routine short-term earthquake prediction was imminent, based mainly on reported successes in various parts of the world in identifying physical precursors to earthquakes. Especially significant was the successful Chinese prediction of the 1975 Haicheng earthquake, with considerable saving of lives. Within

Send brief comments to gsatoday@geosociety.org. Should this article spark a longer comment, please consider writing a *GSA Today* Groundwork or science article; learn more at www.geosociety.org/gsatoday/.

the past five years, however, research results have been sobering, and the problem turns out to be a more difficult one than we had thought. In no part of the world has a successful, routinely operating earthquake-prediction system yet been implemented.

Discouraging results during the past few years include (1) the apparent demise of the proposed Vp/Vs technique, (2) the failure to observe obvious precursors prior to two moderate-sized California earthquakes in 1979, both in areas of reasonably good instrumentation, (3) the realization that earthquakes are more different from each other in their mechanical parameters than we had previously thought, and (4) the recognition that most really large earthquakes are multiple events, thus complicating the prediction problem. On the other hand, encouraging results include (1) the successful scientific prediction of some earthquakes, (2) the recognition, even if only in retrospect, of demonstrable physical precursors to several large earthquakes, (3) the development of instruments and techniques to document major strain changes, such as that of the Southern California uplift, and (4) the verification time and again of the seismic-gap concept. The attitude among seismologists toward short-term prediction at this time seems to be one of very guarded optimism, as compared with the near-euphoria of a few years ago.

If our progress in short-term earthquake prediction has been slower than envisaged, certainly progress has been much faster than expected in long-term prediction, including hazard evaluation and probabilistic assessments. Particularly significant in this area has been the development of techniques for establishing earthquake recurrence intervals based on geologic field relationships, as exemplified by paleoseismicity studies of the southern San Andreas fault in California and the Wasatch fault in Utah. For long-term planning, engineering design, land-use planning, and the development of realistic building codes, these results may in fact be far more important than the development of a short-term prediction capability.

The next ten years will probably see several successful short-term predictions of significant earthquakes, accompanied by at least an equal number of failures and false alarms—which will create increasing public-relations problems. I doubt that in any part of the world will a highly reliable, routine prediction system be implemented within this short time interval, although Japanese scientists have a reasonable chance of being successful in the highly instrumented Tokai area. On the other hand, long-term predictions, and particularly probabilistic assessments, will become increasingly more accurate, more numerous, and more useful, as more and more active faults and other neotectonic features are studied in detail. Quantitative geomorphology, pedology, and radiometric dating will play increasingly important roles. Our improved understanding of the mechanics of the earthquake process will undoubtedly permit far better predictions of strong ground shaking and of artificially induced earthquakes. Progress in earthquake prediction will, of course, be critically dependent upon the level of government research funding in this field, which currently appears discouraging in the United States.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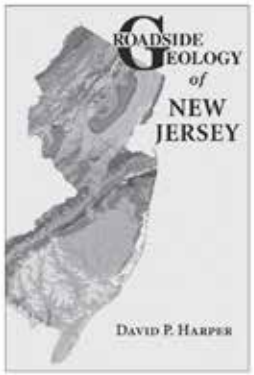


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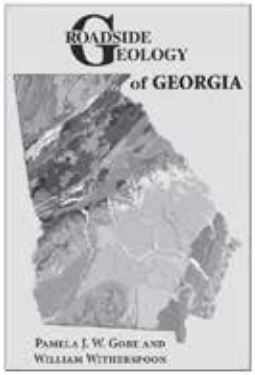


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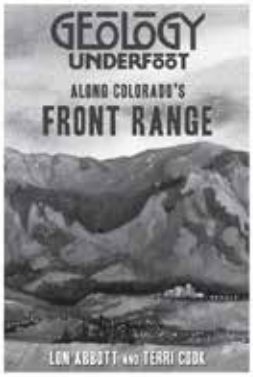


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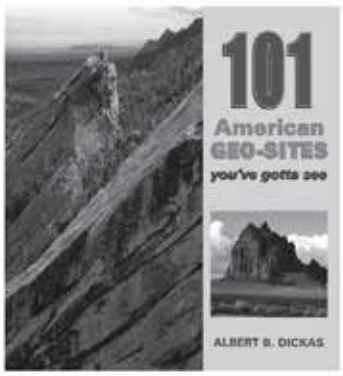


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# In Memoriam

The Society notes with regret the deaths of the following members (notifications received between 1 May and 31 July 2013).

**Lawrence B. Cline**
Albany, New York, USA
Notified 9 May 2013

**Norman Herz**
Athens, Georgia, USA
28 May 2013

**Donald L. Johnson**
Urbana, Illinois, USA
Notified 13 May 2013

**William R. Judd**
West Lafayette, Indiana
Notified 13 June 2013

**Klaus Felix Kaiser**
Wiesendangen, Switzerland
Notified 10 June 2013

**John S. King**
Tonawanda, New York, USA
Notified 24 June 2013

**John F. Lerbekmo**
Edmonton, Alberta, Canada
Notified 17 May 2013

**Wallace Ronald McCord**
Lexington, Kentucky, USA
14 May 2013

**John J. Prucha**
Syracuse, New York, USA
Notified 31 May 2013

**Lewis Rosenberg**
Tijeras, New Mexico, USA
23 July 2013

**Robert Gordon Schmidt**
Alexandria, Virginia, USA
12 May 2013

**Robert Schneider**
Springfield, Virginia, USA
1 March 2013

**John F. Sulik**
Corpus Christi, Texas, USA
Notified 3 June 2013

**Samuel B. Treves**
Lincoln, Nebraska, USA
10 June 2013

**Stephen I. Wareham**
Fullerton, California, USA
Notified 2 May 2013

**Todd Watkins**
Monroe, Georgia, USA
Notified 29 May 2013

**Robert M. Weidman**
Missoula, Montana, USA
1 Dec. 2012

*To honor a friend or colleague* with a GSA Memorial, please go to **www.geosociety.org/pubs/memorials/mmlGuid.htm** to learn how. Contact the GSA Foundation, **www.gsafweb.org,** if you would like to contribute to the Memorial Fund.

# About People

GSA Fellow **Martin P.A. Jackson** has been awarded the 2013 William Smith Medal by the Geological Society of London. The citation notes that Jackson's "fundamental research, in partnership with industry via the Applied Geodynamics Laboratory at Austin, which he founded 25 years ago, has revolutionised oil exploration and development in salt-bearing sedimentary basins."

GSA Fellow **An Yin** has been named a Fellow of the American Geophysical Union (AGU). The citation accompanying Yin's election notes that he is recognized "for outstanding unification of field observation and quantitative theory to achieve breakthrough insights into the evolution of mountain belts."

GSA Fellow **David Bottjer** has been named the Moore Medalist for outstanding contributions in paleontology by the SEPM (Society for Sedimentary Geology), and GSA member **Brian Romans** has been named the SEPM Wilson Medalist for outstanding contributions in sedimentary geology by a young geologist. These medals will be presented during the 2014 SEPM Annual Meeting in Houston, Texas, USA on Tues., 8 April 2014.

Learn more about the achievements of GSA members at **www.geosociety.org/news/memberNews.htm,** and send your stories to gsatoday@geosociety.org.

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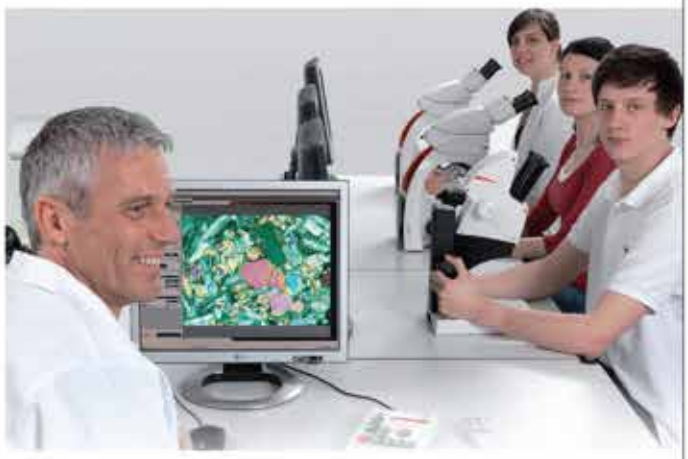

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**P. Geoffrey Feiss,** GSA Foundation President

# GSA Annual Meeting & Exposition

GSA Foundation staff members are busy preparing events and exhibits to inform donors about the GSA programs they help support and to celebrate their role in advancing the geosciences. The Foundation invites you to visit with our staff during the meeting to learn more about GSA programs and Foundation services for donors and to peruse the Silent Auction. Our booth will be easy to find—just look for the GSA Headquarters area.

**Booth Activities:** In addition to Foundation staff, GSA program officers and program participants will be at the booth to meet with you. Folks from **GeoCorps™ America,** which places more than 100 interns to work on public lands each year, and GSA's **Student Research Grants Program,** which awarded more than 300 grants, averaging US$1,800, to student members in 2012, will be available to talk. You can also learn more about participating in the GSA Annual Meeting **Mentor Luncheons.**

*New this year:* The Foundation will host the main information station for the **On To the Future** program. Members of the GSA Diversity Committee will be on-hand to assist On To the Future participants and answer questions from members about this new program.

The ever-popular **GSA Silent Auction** will feature rock and mineral specimens, books and geological reports, antique books and maps, field gear, wine, and more. Proceeds from your auction purchases will support On To the Future.

**The Penrose Circle lounge** offers Penrose Circle members a relaxing oasis amid the hustle and bustle of the meeting along with an array of services, including wireless and wired Internet access, printer access, and coat and luggage storage.

**Events:** The **Senior Fellows Reception** (by invitation) will be held on Monday evening this year so that senior Fellows and guests can attend the 125th Anniversary Gala the following evening. The **Pardee Coterie Breakfast** on Sunday morning welcomes members (by invitation) who have included GSA in their estate plans.

The **GSA Foundation Board of Trustees** will hold its semi-annual business meeting in the convention center on Saturday. GSA members interested in participating in and learning about the work of the Foundation on behalf of the Society are invited to attend.

**Donor Services:** The Foundation welcomes all inquiries about ways to financially support GSA. Staff members will be available to assist you with information about how to include GSA in your estate plans or other ways to make a gift to the Foundation. *Student donors* should stop by the booth to receive a special pin designating them as GSA Foundation supporters.

We look forward to seeing you at the Foundation Booth and Silent Auction!

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## 1 REGISTRATION

*If you haven't registered yet, there's still time!*

You can register online throughout the meeting or visit the onsite registration desk at the Colorado Convention Center. We look forward to welcoming you to Denver, Colorado, USA!

## 2 SUBARU OUTDOOR LIFE LECTURE

SUBARU
Confidence in Motion

Colorado Convention Center, Room 205

Mon., 28 Oct., 6:30–7:30 p.m.

In April 2010, Dottie Metcalf-Lindenburger served as a mission specialist on *Discovery* flight STS-131 to the International Space Station. She had the opportunity to see Earth from a very different perspective and will discuss what she saw and what personal connections she made from that vantage point. As part of the mission, *Discovery* delivered a module filled with science racks that were transferred to laboratories on the International Space Station. Metcalf-Lindenburger will give an overview of the earth-science research that is ongoing there. Additionally, she'll talk about the analog program, NASA Extreme Environment Missions Operations (NEEMO), for which she served as a commander in the summer of 2012, and how it ties into future exploration in the Solar System.

## 3 Lunchtime LECTURES

Join your colleagues for our annual Lunchtime Lectures, every day from noon to 1 p.m. in the Colorado Convention Center, Mile High Ballroom 2AB/3AB. Bring your lunch and listen and learn.

### SUNDAY

GSA Presidential Address and Presentation of the President's Medal

Please join us Sunday when GSA President **Suzanne Mahlburg Kay** gives her Presidential Address, "125th Anniversary of the Geological Society of America: Looking at the Past and into the Future." Following her address, Past President **George H. Davis** will present the President's Medal to **Edward Burtynsky,** photographer and artist, who is known for his large-format photographs of industrial landscapes. *All are welcome*; no reservations, tickets, or meeting registration are required to attend.

### MONDAY

GSA Awards Ceremony

Please join GSA President Suzanne Mahlburg Kay and GSA Vice President/President-Elect Harry (Hap) McSween to honor and greet the GSA medal and award recipients for 2013. Brief citations and responses for the 2013 recipients of the Penrose Medal, the Arthur L. Day Medal, the Young Scientist Award (Donath Medal), the GSA Public Service Award Medal, the GSA Distinguished Service Award, The Subaru Outstanding Woman in Science Awardee, The Bromery Award for the Minorities, and the American Geological Institute (AGI) Medal in Memory of Ian Campbell will be presented. The John C. Frye Environmental Geology awardees, the ExxonMobil Field Camp awardee, the GSA Division awardees, the International Section's Honorary Fellow, and the newly elected GSA Fellows will also be recognized. *All are welcome*; no reservations, tickets, or meeting registration are required to attend.

### TUESDAY

2013 Michel T. Halbouty Lecture

Colorado Governor **John Hickenlooper** will deliver a lecture on the topic of his choice. Hickenlooper was a petroleum geologist prior to opening the first microbrew pub in Denver, and he served two terms as mayor of Denver before becoming Colorado's governor in 2011.

### WEDNESDAY

Colorado River Management: The Economy, Environment and Science Disconnect

**Bradley Udall** is the Director of the Getches-Wilkinson Center for Natural Resources, Energy, and the Environment at the University of Colorado Law School. His expertise is in the science and policy of water and climate change with a focus on the American Southwest. Udall will speak on the enormously complicated arrangements needed to manage water among the seven states and 40 million people in the Colorado River basin. Known as the Law of the River, these management plans were designed for another century, another climate, and a vastly reduced number of people. Udall will also address the changes that are needed to fix what he calls an "enormous science-economy-environment disconnect."

## 4 *And there's more…*

### GSA GOLD MEDAL LECTURES

Mon., 28 Oct., 2–3:30 p.m.

Colorado Convention Center, Mile High Ballroom 2AB/3AB

GSA continues the celebration with up-close and personal lectures by our three gold medalists: **Steven M. Stanley,** Penrose Medal; **Richard W. Carlson,** Day Medal; and **Naomi E. Levin,** Donath Medal. Each will present a 20-minute talk reflecting their scientific careers:

**Stanley:** "Living in the Past for Half a Century: From Paleontology to Paleobiology to Geobiology"

**Carlson:** "Understanding Earth"

**Levin:** "Stories from the Field"

*All are welcome*; no reservations, tickets, or meeting registration required.

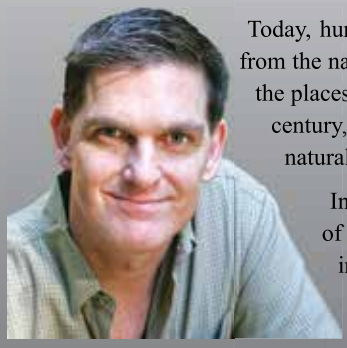
# PUBLIC LECTURE

## Dr. Scott Sampson: *For the Love of Nature:*

*Bridging the Human–Nature Divide in the 21st Century*

## Saturday, 26 October 2013

Colorado Convention Center, Mile High Ballroom 2AB/3AB at 2–3:30 p.m.



Today, humans are plugging into an increasingly electronic world while becoming more and more alienated from the nature that surrounds them. This rampant "de-naturing," which now threatens the health of people and the places in which they live, is one of the most pressing and overlooked crises of our time. In the twenty-first century, how do we broker a new human–nature relationship, one that embraces both technology and the natural world?

In this presentation, Scott Sampson, Vice President of Research and Collections at the Denver Museum of Nature & Science, charts a pathway toward a nature-rich future. Key elements of this journey include abundant, outdoor, multisensory experiences combined with nature literacy tied to local place. Sampson proposes that it is through the lens of place-based understanding that the earth sciences play an essential role, contributing to a deep time story that encompasses stars, planets, life, and us.

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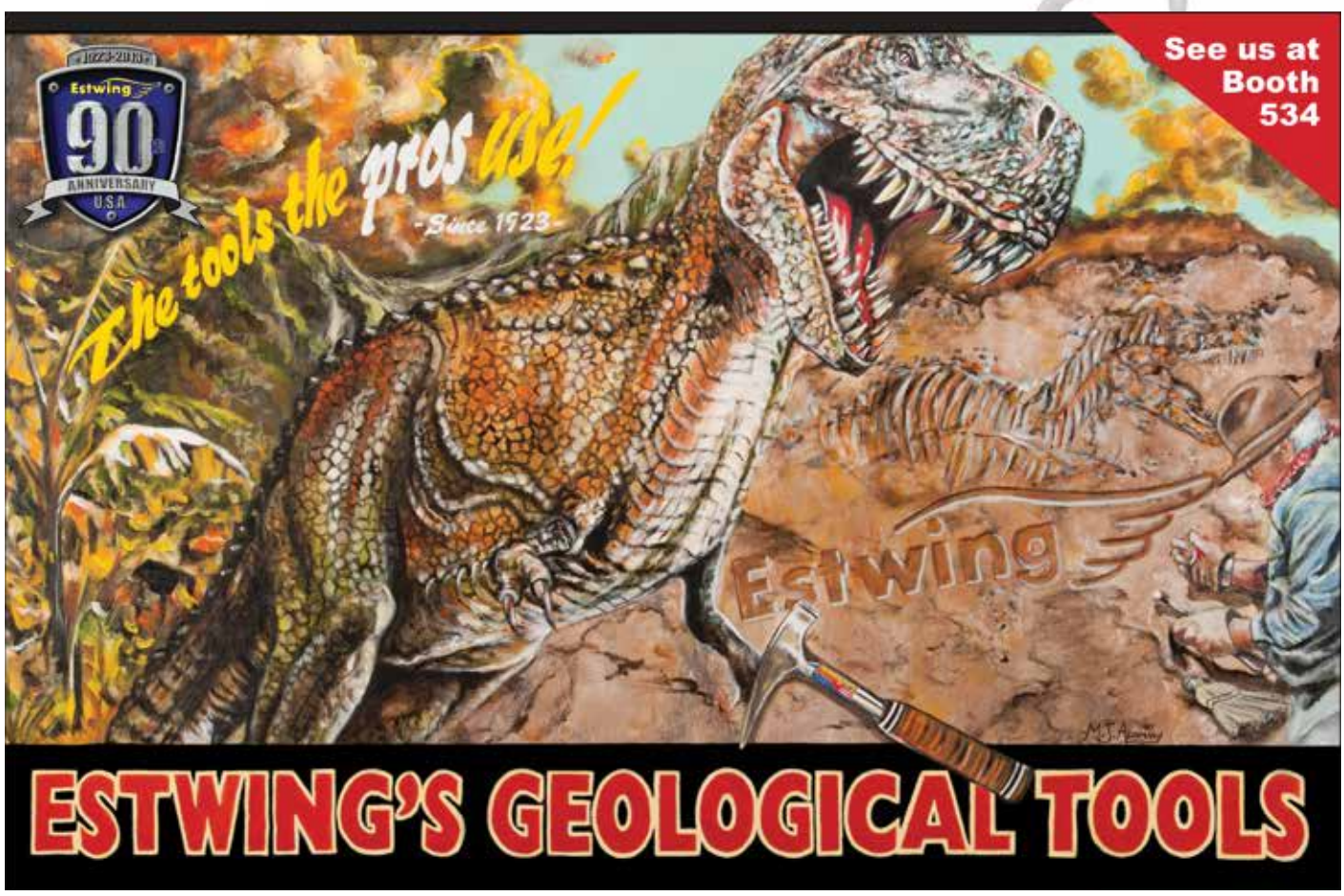

## Positions Open

**ASSISTANT PROFESSOR IN GEOPHYSICS**
**UNIVERSITY OF IOWA**

The Department of Earth & Environmental Sciences at the University of Iowa invites applications for a full-time tenure-track position in the broad area of geophysics. Requirements for this position are a Ph.D. in a geophysical discipline at the time of appointment and research interests that include the environmental and sustainability aspects of the geophysical sciences. The ideal candidate will have a significant record of publication and other achievements that demonstrate a strong potential to develop a nationally and internationally recognized, externally funded research program. Post-doctoral experience and demonstrated effectiveness in college-level teaching are desirable attributes. The successful candidate will be expected to attract and mentor graduate students as well as teach an introductory geophysics course and other undergraduate and graduate level courses.

Candidates should submit applications online at http://jobs.uiowa.edu/ (requisition #63146). In addition to curriculum vitae, the application should include a cover letter, a statement of teaching interests, evidence of teaching ability, and a statement that describes current and future research activities. Three letters of recommendation should be mailed to: Dr. Christopher Brochu, Search Committee Chair, Department of Earth & Environmental Sciences, University of Iowa, Iowa City, IA 52242, USA (phone: +1-319-353-1808; e-mail: chris-brochu@uiowa.edu). Screening of applications begins 15 Nov. 2013 and will continue until the position is filled. Questions regarding this position can be directed to Dr. Brochu or Dr. Mark Reagan (EES Department Chair, +1-319-353-1820, mark-reagan@uiowa.edu).

The Department and the College of Liberal Arts & Sciences are strongly committed to gender and ethnic diversity. Women and minorities are encouraged to apply. The University of Iowa is an affirmative action/equal opportunity employer.

**TENURE-TRACK ASSISTANT PROFESSOR**
**GEOSCIENCES DEPARTMENT**
**NORTH DAKOTA STATE UNIVERSITY**
**www.ndsu.edu/geosci/**

The Department of Geosciences at North Dakota State University (NDSU) invites applications for a tenure-track Assistant Professor position beginning 16 Aug. 2014 in the following areas: sedimentology, stratigraphy and/or paleontology. Teaching interest in all three fields is a plus.

A Ph.D. at the time of appointment is required. The successful candidate will teach introductory, advanced, and graduate level courses. For a complete description, application requirements and application portal, view the position announcement at jobs.ndsu.edu/postings/3627.

The Geosciences Department is a close-knit group of 60 to 70 majors and 9 faculty. We provide instruction for a B.S. geology degree and minors in geology and geography, but are also very active in advising M.S. and Ph.D. students in programs such as environmental and conservation sciences, biological sciences and physics. NDSU is a dynamic, growing institution. We are a land-grant research university, ranked in the Carnegie "Very High Research Activity" category. NDSU is an AA/EO institution, Committed to Diversity in Hiring.

Contact the search committee chair, Dr. Peter Oduor (Peter.Oduor@ndsu.edu, +1-701-231-7145), or the Dept. Chair, Dr. Donald Schwert (Donald.Schwert@ndsu.edu, +1-701-231-7496).

**ASSISTANT PROFESSOR**
**STRUCTURAL GEOLOGY**
**THE UNIVERSITY OF AKRON**

The University of Akron is searching for an Assistant Professor position that will focus on one of the following areas: structural geology, surface processes and/or tectonics. Teaching duties will include graduate courses in candidate's specialty, structural geology, introductory courses and summer field camp. Preferred qualifications include post-doctoral experience, a clear vision of future research endeavors and a plan for obtaining external funding. Candidate's specialty should enhance existing departmental core courses in geology. Additional information and the on-line application for job ID # 7749 are found at www.uakron.edu/jobs. Review of applications will begin 15 Nov. 2013. Questions about this position should be directed to Dr. LaVerne Friberg at lfribe1@uakron.edu. EEO/AA.

**ASSISTANT PROFESSOR**
**TENURE TRACK**
**ENVIRONMENTAL STUDIES**
**THE COLLEGE OF SAINT BENEDICT**
**SAINT JOHN'S UNIVERSITY**

The Environmental Studies Department at The College of Saint Benedict/Saint John's University invites applications for a tenure-track position at the rank of Assistant Professor to begin in fall 2014. Ph.D. in interdisciplinary environmental science, Earth system science, or a related field is preferred (ABD considered). Undergraduate teaching experience required. Preference will be given to candidates with expertise in applied, interdisciplinary environmental science emphasizing Earth systems, environmental geology, or a related geoscience field. For more information about the College of Saint Benedict and Saint John's University, please visit http://csbsju.edu.

To review the position and apply online, please visit http://employment.csbsju.edu. Review of applications will begin 15 Nov. 2013.

*Women, individuals of diverse racial and cultural backgrounds, and persons with disabilities are encouraged to apply. The College of Saint Benedict and Saint John's University are Affirmative Action/Equal Opportunity Employers.*

**TENURE-TRACK FACULTY POSITION**
**ECONOMIC GEOLOGY/STRUCTURAL GEOLOGY**
**UNIVERSITY OF WISCONSIN–EAU CLAIRE**

A Ph.D. in economic geology/structural geology or a closely related discipline is required at the time of appointment. All ranks will be considered. The department is seeking to expand its expertise in the area of metallic mining and to complement existing strengths. Experience with the genesis and exploration of ore deposits, field-based structural geology, field geology, and/or GIS will be considered an asset. Responsibilities include teaching, collaborative research with undergraduate students, advising, and service to the department and the University. Teaching responsibilities initially will include economic mineral deposits, structural geology, introductory geology courses, and a shared responsibility for field geology. The department has modern laboratory facilities well equipped to support a strong collaborative research program.

Only online applications are accepted (go to www.uwec.edu/Employment/uweccareers.htm to apply). For priority consideration, all application materials must be submitted by 15 Nov. 2013. For a complete position description, call +1-715-836-3732 or visit www.uwec.edu/geology/. UW-Eau Claire is an AA/EEO employer and encourages applications from women and minorities.

**ASSISTANT PROFESSOR**
**QUATERNARY GEOLOGY**
**WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY**

The Wisconsin Geological and Natural History Survey (WGNHS) invites applications for a tenure-track, Assistant Professor position in Quaternary geology. We seek candidates with outstanding research and outreach skills and the ability to establish a successful externally-funded research program. This is a 12-month renewable appointment beginning 1 July 2014.

The WGNHS, located near the University of Wisconsin–Madison campus and housed administratively within the University of Wisconsin-Extension, has established itself as a nationally recognized research institution through its innovative work relating to the geology of Wisconsin in collaboration with state and regional partners. We now seek to sustain and enhance our highly regarded programs relating to Quaternary geology. Particular interest will be paid to individuals with a strong background and research interests in the areas of glacial geology, paleoecology, paleoclimatology or geomorphology as applied to Quaternary deposits of Wisconsin. In addition to collaborating with academic institutions within Wisconsin and beyond, the successful candidate will collaborate with local, state, and federal agencies that have interests in geology, hydrogeology, and mineral resources. The successful candidate will benefit from access to our 20,000 square foot Research Collections and Education Center.

Our academic atmosphere, focus on research and outreach, and compact size sets the WGNHS apart from most geological research organizations. Take this opportunity to grow with us! For more information, please visit http://wisconsingeologicalsurvey.org. The application submission deadline is 17 Dec. 2013.

**ASSISTANT PROFESSOR OF GEOLOGY**
**MISSOURI STATE UNIVERSITY**

The Department of Geography, Geology and Planning invites applications for a tenure-track Assistant Professor of Geology to begin in August 2014 with an emphasis in **at least two of the following three areas: Structural Geology, Mineralogy, Petrology.** Ph.D. (or ABD) in geology or closely related field required at time of appointment. Requirements include a commitment to both undergraduate- and master's-level teaching and research interests and expertise at a level adequate to supervise master's-

level thesis projects. Post-doctoral research experience and evidence of teaching effectiveness would be advantageous. Must be able to facilitate a work environment that encourages knowledge of, respect for, and development of skills to engage with those of other cultures or backgrounds. Demonstrated knowledge and understanding of multicultural and diversity issues required.

The department grants undergraduate degrees in Geology, Geography, Planning, Geospatial Science, and Earth Science Education and an M.S. in Geospatial Science in Geography and Geology. The successful applicant would have the opportunity to teach and advise in the undergraduate program in Geology and in the department's graduate program.

Apply online at www.missouristate.edu/academicopenings. Attach a letter of application, current curriculum vitae, detailed research plan, and contact information for 3–5 professional references to the electronic employment application. The evaluation of applications will begin 4 Nov. 2013 and will continue until a successful candidate is found. Further information can be obtained at +1-417-836-5800, or fax to +1-417-836-6006, or visit our web site at http://geosciences.missouristate.edu. Missouri State University is an affirmative action/equal opportunity institution. The University is dedicated to the goal of building a culturally diverse and inclusive faculty and staff committed to teaching and working in a multicultural environment and strongly encourages applications from women, persons for underrepresented ethnic and racial groups, individuals with disabilities and covered veterans. Employment will require a criminal background check at University expense.

**TENURE-TRACK FACULTY POSITION**
**LOW-TEMPERATURE GEOCHEMISTRY**
**DEPT. OF GEOLOGICAL AND**
**ATMOSPHERIC SCIENCES**
**IOWA STATE UNIVERSITY**

The Department of Geological and Atmospheric Sciences at Iowa State University invites applications for a tenure-track faculty position at the assistant professor level to begin in August of 2014. The position will be in low-temperature geochemistry, with emphasis on research relevant to environmental geochemistry or contaminant hydrogeology. The selected candidate is expected to establish a successful, externally funded research program. This program would complement some existing strengths in the department, which include groundwater and surface-water hydrology, paleoclimatology, isotope geochemistry, sedimentary geology, economic geology, weather and climate modeling, glacial and Quaternary geology, geophysics, tectonics, and geoscience education. We also encourage interactions with researchers and faculty in other units on campus, such as Agricultural and Biosystems Engineering; Agronomy; Bioeconomy Institute; Chemistry; Civil, Construction and Environmental Engineering; Ecology and Evolutionary Biology; Natural Resource Ecology and Management; the Iowa Water Center; the Leopold Center for Sustainable Agriculture; and the National Laboratory for Agriculture and the Environment. In addition, this faculty member will teach at the undergraduate and graduate levels. Information about the Department appears at www.ge-at.iastate.edu.

Candidates must hold a Ph.D. by the time of appointment. All applications must be submitted electronically at www.iastatejobs.com (search vacancy ID#: 130853). Please be prepared to attach a letter of application, including concise teaching and research statements, curriculum vitae, and the names, addresses, e-mail addresses, and phone and fax numbers of at least three references.

The positions will remain open until filled. Full consideration will be given to applications received by 8 Nov. 2013. We encourage applications from minorities, women, veterans, and persons with disabilities. Iowa State University is an equal opportunity/affirmative action employer

**FACULTY POSITIONS**
**DEPARTMENT OF GEOSCIENCES**
**NATIONAL TAIWAN UNIVERSITY**

The Department of Geosciences at NTU is seeking active scientists to fill faculty positions starting 1 Aug. 2014. The positions are open to all fields in geosciences, but those who have strong background in the fields of geology (paleontology, stratigraphy, sedimentology, geo-resources, mineralogy and petrology, structural geology), geochemistry, geophysics, and applied geology will receive more favored consideration. Applicants are requested to submit the following documents: CV, list of publications, three to five reprints of refereed publications (one of which shall be designated as representative paper and must be published after 1 Aug. 2009), plans for teaching and research in WORD or PDF files, and names of three potential referees. Application materials are sent to Professor Kuo-Yen Wei, the Chairman of the Searching Committee, by post or e-mails at weiky@ntu.edu.tw.

Deadline for application: 15 Jan. 2014. Web site: www.gl.ntu.edu.tw/. Department of Geosciences, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 106, Taiwan.

**CHAIR, DEPARTMENT OF GEOLOGY**
**STEPHEN F. AUSTIN STATE UNIVERSITY**

The Department of Geology at Stephen F. Austin State University (SFA) invites applications for the department chair position. We seek an individual with strong management, communication, and interpersonal skills to provide innovative and energetic leadership. Duties include managing curricula, budgets, student enrollment, personnel, program and unit assessment, and developing strong, mutually beneficial relationships with industry and alumni. The incumbent will teach a reduced load of courses and develop a research program in his/her area of expertise. Applicants must have credentials for appointment at the associate or professor rank.

Submit a letter of application, CV, and a list of three references online at https://careers.sfasu.edu (posting 0602535). Also submit all official transcripts by mail to Dr. Kenneth Farrish, Search Committee Chair, (936-468-3701), Department of Geology, Stephen F. Austin State University, Box 13011 SFA, Nacogdoches, TX 75962. Review of applications will begin on 1 Dec. 2013 and will continue until the position is filled. Equal Opportunity Employer; Security-sensitive position; this position will be subject to a criminal history check.

**LSU**

**ASSOCIATE/FULL PROFESSOR**

**(ENDOWED CHAIR – JOHN FRANKS CHAIR/TENURED/TENURE-TRACK)**
**DEPARTMENT OF GEOLOGY AND GEOPHYSICS**

The Department of Geology and Geophysics at Louisiana State University seeks an outstanding individual to fill the endowed position of the John Franks Chair at the rank of Associate or Full Professor in a field that will support, and strengthen the mission of the department. Candidates should have internationally recognized scientific reputations and are expected to maintain a high-level, externally funded research programs, and provide leadership both on campus and beyond.

LSU is designated a Carnegie Research I University and one of a handful of distinguished universities to enjoy Land, Sea, and Space Grant status. The Department of Geology and Geophysics currently consists of 15 tenure-track faculty members having a wide range of geoscience expertise covering field, experimental, analytical and theoretical components and offers B.S., M.S., and Ph.D. degrees in geology. The Department has a strong record of success in research and graduate training, synergistic interactions with other academic units at LSU, federal and industry-funded research and teaching programs, and a large and active alumni base. (See **http://geology.lsu.edu** for more information.) Opportunities for a broad range of research interactions are available within the Department and throughout the University. The University actively promotes interdisciplinary research clusters including materials science and engineering, coastal sustainability and environment, conventional and renewable energy, biological, biotechnology and biomedical, and high performance computing. (See: **http://research.lsu.edu** for more information).

The successful candidate will be expected to lead a research team, supervise graduate student research, publish in highly ranked journals, and teach undergraduate and graduate courses in his/her area of specialization. Chair appointments would normally be made at the rank of Full Professor. However, exceptional candidates at the Associate Professor level will be considered. We encourage applications from underrepresented groups.

**Required Qualifications**: Ph.D. or equivalent degree in geological sciences or other relevant disciplines; a strong record of published research, and demonstrated ability to attract funding.

**Additional Qualifications Desired**: Internationally recognized scientific reputation. An offer of employment is contingent on a satisfactory pre-employment background check. The review process will begin December 13, 2013 and continue until a candidate is selected. Nominations or inquiries should be directed to Endowed Chair Search Committee, at 225-578-3353 or **geology@lsu.edu**. Apply online and view a more detailed ad at: **www.lsusystemcareers.lsu.edu**. Position #002395.

Quick link to ad URL: **https://lsusystemcareers.lsu.edu/applicants/Central?quickFind=56203**

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**TENURE-TRACK FACULTY POSITION**
**STABLE ISOTOPE GEOCHEMISTRY/**
**PALEOCLIMATOLOGY, DEPT. OF**
**EARTH AND ENVIRONMENTAL SCIENCES**
**UNIVERSITY OF KENTUCKY**

The Department of Earth and Environmental Sciences at the University of Kentucky invites applications for this tenure-track faculty position with an anticipated start date of August 2014. Exceptional candidates at all ranks will be considered. We seek candidates with expertise in light, stable isotope geochemistry, in particular as applied to research questions in the field of paleoclimatology. The Dept. of Earth and Environmental Sciences has recently completed the establishment of a fully equipped, state-of-the-art stable isotope geochemistry facility (three IRMS and full set of peripherals) for analysis of HCNO in virtually any substance. In addition to maintaining a productive externally funded research program, the new faculty member will teach and mentor at the introductory, major, and graduate levels. The successful individual will have a demonstrated publication record, and will have developed, or show the potential for developing, a nationally recognized research program; relevant experience beyond the Ph.D. is essential. Interested applicants should submit a merged .pdf document to Stable Isotope Geochemistry Search Committee, c/o Dr. Kevin Yeager (kevin.yeager@uky.edu). The document should include: cover letter, curriculum vitae, brief statements of research and teaching interests, copies of relevant research publications, and contact information for at least three references. We will begin review of applications on 1 Dec. 2013; however, applications will be accepted until the position is filled. The University of Kentucky is an Affirmative Action/Equal Opportunity university that values diversity and is located in an increasingly diverse geographical region. Women, persons with disabilities, and members of other under-represented groups are encouraged to apply. The University also supports family-friendly policies. Additional details of the Dept. of Earth and Environmental Sciences (faculty, research clusters, and facilities) and the University of Kentucky may be viewed at our web pages: www.as.uky.edu/ees and www.uky.edu.

**FACULTY POSITION**
**EARTH SURFACE PROCESSES/**
**GEOMORPHOLOGY**
**NANYANG TECHNOLOGICAL UNIVERSITY**

The Division of Earth Sciences and the Earth Observatory of Singapore at Nanyang Technological University, Singapore invites applications for a tenure-track position in geomorphology/Earth surface processes with emphasis on the geomorphic response to climate and/or anthropogenic change. Specific areas of interest include (but are not limited to) **physical, chemical, and/or biological aspects of Earth-surface dynamics and evolution** or **changes in the Earth's surface** as a result of human and natural impacts. Research approaches should encompass some combination of field, laboratory, and modeling. We seek an individual with research interests that augment our existing strengths in Earth systems science and surficial processes. This position is part of the continued expansion of the Division of Earth Sciences with the Earth Observatory of Singapore.

We invite candidates who have developed an internationally recognized, externally funded, multidisciplinary research program to apply at the assistant, associate or full professor level. Successful candidates will also be required to actively participate in our core undergraduate and graduate teaching and in the administration of the Division of Earth Sciences.

To apply, please submit the following materials to eos_humanresources@ntu.edu.sg:

- Statement of research and teaching interests;
- Curriculum vitae;
- A copy of three relevant publications; and
- The names of three references who are familiar with your work.

Further information about the Division of Earth Sciences and the Earth Observatory of Singapore is available at www.earthobservatory.sg, and to contact cmrubin@ntu.edu.sg for job specific information. Review of applications will begin on 1 Feb. 2014 and will continue until the position is filled.

**RESEARCH POSITION**
**COASTAL PALEOSEISMOLOGY/**
**QUATERNARY ENVIRONMENTAL CHANGE**
**NANYANG TECHNOLOGICAL UNIVERSITY**

The Earth Observatory of Singapore, Nanyang Technological University, invites applications for a Research Fellow (post-doctoral level) in Coastal Paleoseismology/Quaternary Environmental change.

This project is part of an on-going program to recover stratigraphic records of past earthquakes and tsunamis, and sea-level change in Indonesia. Skills in quantitative micropaleontology/palaeoenvironmental reconstructions and/or sedimentology of coastal systems are highly desirable. The candidate is required to have a Ph.D. in coastal geomorphology/geology.

The coastal paleoseismic project is led by Charles Rubin and Ben Horton and supported by the Earth Observatory of Singapore. All applicants should demonstrate a clear desire for adventurous fieldwork and exceptional science. Further details may be obtained from the Earth Observatory of Singapore, Nanyang Technological University cmrubin@ntu.edu.sg.

Initially the contract duration will be two years, although a longer period (up to 4 years) can be negotiated. Excellent knowledge of English, both in speaking and writing, is a requirement.

International candidates are highly encouraged to apply. Applications should include a CV, list of publications, a short (1-page) synopsis of previous research achievements and research plans, and the names of at least two referees.

Applications and inquiries should be sent electronically to eos_humanresources@ntu.edu.sg.

We will begin reviewing applications 1 Feb. 2014; however, applications will be reviewed until the position is filled.

**TENURE-TRACK FACULTY POSITION**
**PETROLOGY/MINERAL RESOURCES**
**CALIFORNIA STATE POLYTECHNIC**
**UNIVERSITY, POMONA**

The Geological Sciences Dept. invites applications for an Assistant Professor tenure-track appointment beginning September 2014. Applicants must hold a Ph.D. in geology or a related field by August 2014. The ideal candidate will have teaching and research interests in areas of "hard-rock geology" that emphasize practical applications of petrologic field and laboratory studies to structural, tectonic and/or mineral resource problems. We seek an enthusiastic instructor for undergraduate courses in Igneous/Metamorphic Petrology, Field Methods/Field Modules, Mineralogy, Megascopic Petrography, willing to co-teach Optical Mineralogy. Preferred areas of specialization include but are not limited to Geochronology, Economic Geology, Igneous or Metamorphic Petrology, High Temperature/Isotope Geochemistry, Volcanology. The successful candidate is expected to ensure that our curriculum in their specialty area remains current, engage students in research and supervise M.S. and senior theses. He/she must have experience with field studies and data collection using modern instrumentation and ability to manage our Petrology/XRF/XRD analytical laboratory. Preferred qualifications include demonstrated success with external funding, established ties to research institutions, mining industry or government agencies and interest in developing intradepartmental and cross-campus collaborations. Applicants must submit a signed application form (http://academic.csupomona.edu/faculty/docs/application.pdf), letter of interest, CV, statement of teaching and research interests, and contact information for five professional references. A campus interview, three formal reference letters and official confirmation of degree transcripts are required of all finalists. Initial screening begins 6 Jan. 2014. Mail application materials to Petrology Search Chair, Geological Sciences Department, California State Polytechnic University, Pomona, CA 91768. Cal Poly Pomona is an affirmative action, equal opportunity employer. Full Position Description: http://geology.csupomona.edu/employment.htm.

**MULTIPLE TENURE-TRACK**
**FACULTY POSITIONS**
**DEPT. OF GEOLOGICAL SCIENCES**
**CALIFORNIA STATE UNIVERSITY,**
**FULLERTON**

The Department of Geological Sciences at California State University, Fullerton (http://geology.fullerton.edu/), invites applications for two tenure-track Assistant Professorships to begin 18 Aug. 2014. The successful candidates: (1) will be key members in establishing a College of Natural Sciences and Mathematics center for the environment, resources, and sustainability; (2) will be expected to develop active, field-based, externally funded research programs involving undergraduate and master's students in the candidates' field of study; (3) be committed to excellence in teaching at the undergraduate and master's levels; and (4) will have the ability to communicate effectively with an ethnically and culturally diverse campus community.

**Resource Geology:** Research interests may include mineralogy, petrology, ore deposit/economic resource geology, or volcanology as they pertain to the environment, resources, and sustainability. The successful candidate must demonstrate interest and ability to teach Earth Materials (Mineralogy) and introductory-level geosciences and upper-division/graduate courses in the candidate's area of specialization. Preference will be given to candidates who also demonstrate the interest and ability to teach field geology. For a complete position description, see http://diversity.fullerton.edu/jobs/ft/resource_geology.asp.

**Coastal Sedimentology:** Research interests may include the study of coastal processes or modern coastal marine systems as analogs for ancient environments and/or petroleum geology, as they pertain to the environment, resources, and sustainability. The successful candidate must demonstrate interest and ability to teach marine geology and oceanography. Preference will be given to applicants who have the ability to teach sedimentology/stratigraphy and/or field geology classes, introductory-level geosciences courses, and upper-division/graduate courses in the candidate's area of specialization. For a complete position description, see http://diversity.fullerton.edu/jobs/ft/coastal_sedimentology.asp.

**Application Procedures:** For both searches, a Ph.D. in Geological Sciences or related field is required at the time of appointment. Send a single pdf document containing: (1) a detailed curriculum vita; (2) a letter of application; (3) a teaching statement that includes: a discussion of relevant course work and/or experience in preparation for teaching, a list of courses you are qualified to teach, and a statement of your teaching philosophy; and (4) a statement of your future research plans and goals. Letters of recommendation from at least three referees familiar with your teaching and research background should be sent separately. For the Coastal Sedimentology search, applicants and referees should email materials directly to Dr. Matthew Kirby at coastal_search@fullerton.edu. For the Resource Geology search, applicants and referees should email materials directly to Dr. David Bowman at resource_search@fullerton.edu.

Applications will be accepted until the position is filled. To ensure full consideration, submit all application materials by 15 Nov. 2013. Cal State Fullerton is an Equal Opportunity/Title IX/503/504/VEVRA/ADA Employer.

**TENURE TRACK FACULTY POSITION**
**GEOMORPHOLOGY/SURFICIAL PROCESSES**
**DEPT. OF GEOLOGY AND GEOGRAPHY**
**AUBURN UNIVERSITY**

The Department of Geology and Geography at Auburn University invites applications for a tenure-track Assistant Professor position in the field of Geomorphology/Surficial Processes to begin Fall Semester 2014. Opportunities exist for collaboration with related on-campus programs including units in the College of Sciences and Mathematics, College of Agriculture, College of Engineering, and School of Forestry and Wildlife Sciences.

The successful candidate will be expected to teach at the undergraduate and graduate levels including a geomorphology/surficial processes course as well as general education classes such as Physical Geography, Physical Geology, and/or World Regional Geography and to establish a productive record of independent research, extramural funding, and publication. A PhD in Geography or related field is required at the time of appointment. Desired qualifications include training in both geology and geography. The candidate selected for this position, which begins August 2014, must meet eligibility requirements to work in the United States on the date the appointment is scheduled to begin and to continue working legally for the term of employment; excellent communication skills are required.

Applicants should submit a letter of application (1–2 pages) describing professional experience, research and teaching interests; a curriculum vitae; copies of all transcripts; and the names and contact information of at least three references.

In order to apply for this position and view full details, please visit our online website at https://aufacultypositions.peopleadmin.com/postings/173.

Applicants are encouraged to visit the AU website to learn more about Auburn University and the Department of Geology and Geography (www.auburn.edu/academic/cosam/departments/geology/). Review of applications will begin 4 Nov. 2013, and will continue until the position is filled.

In support of our strategic plan, Auburn University will maintain its strong commitment to diversity with standards to help ensure faculty, staff, and student diversity through recruitment and retention efforts. Auburn University is an Affirmative Action/Equal Opportunity Employer. Women and minorities are encouraged to apply.

**GEODYNAMICS**
**DEPT. OF EARTH SCIENCE**
**UNIV. OF CALIFORNIA, SANTA BARBARA**

The Department of Earth Science at the University of California, Santa Barbara, invites applications for a tenure-track Assistant Professor position in the broad area of geodynamics, starting 1 July 2014. We seek an innovative geophysicist who investigates solid earth processes with modern geophysical data and simulation methods. Areas of technical expertise might be in geodesy, seismology, and numerical modeling, but are not limited to them. We particularly seek candidates who both complement our current research program and integrate across tectonics and geophysics.

The successful candidate is expected to develop a vigorous, externally funded research program, and supervise research by graduate and undergraduate students. A Ph.D. or an equivalent degree is required at the time of appointment.

Applicants should submit a PDF containing a letter of application; their curriculum vitae; a description of teaching and research objectives and accomplishments; and the contact information of three referees who will provide letters. Applicants should request three referees to send letters of evaluation by 1 Nov. 2013. The application file and letters of reference should be submitted to https://recruit.ap.ucsb.edu.

Review of applications will begin 1 Nov. 2013. The position will remain open until filled, but to ensure full consideration, application materials should be submitted by this date.

The department is especially interested in candidates who contribute to the diversity and excellence of the academic community through research, teaching, and service.

UCSB is an Equal Opportunity/Affirmative Action employer.

**FACULTY POSITION IN PETROLOGY**
**DEPT. OF EARTH AND**
**ENVIRONMENTAL SCIENCES**
**BOSTON COLLEGE**

The Department of Earth and Environmental Sciences at Boston College invites applications for a tenure-track position in the field of Petrology to start in Fall 2014. The successful candidate will be


*Call for Applications*

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Bring your science and technology expertise to Capitol Hill to work directly with national leaders at the interface between geoscience and public policy. The GSA-USGS Congressional Science Fellowship provides a rare opportunity for a geoscientist to spend a year working for a Member of Congress or congressional committee. If you are an earth scientist with a broad geologic background, experience applying scientific knowledge to societal challenges, and a passion for helping shape the future of the geoscience profession, GSA and the USGS invite your application. The fellowship is open to GSA members who are U.S. citizens or permanent residents, with a minimum requirement of a master's degree with at least five years professional experience or a Ph.D. at the time of appointment. Learn more at www.geosociety.org/csf or by contacting Susan Lofton, +1-303-357-1040, slofton@geosociety.org.

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expected to develop an externally funded research program integrated with excellence in teaching within the geological sciences and environmental geoscience curriculum at both the undergraduate and graduate levels. Teaching responsibilities will include Mineralogy, Igneous and Metamorphic Petrology, and other courses in the candidate's area of research expertise. The successful candidate should have a commitment to integrate with existing department research expertise in structural geology, sedimentary geology, igneous and metamorphic terrane analysis, and geochronology/geochemistry. Candidates with a strong field emphasis in research and teaching are particularly desired. This is an open-rank position, and applications at all levels are invited. The Department is equipped with a range of modern research instrumentation listed on our website (www.bc.edu/content/bc/schools/cas/geo/instrumentation-and-facilities.html). Information on the Department, its faculty and research strengths can be viewed on the Department's web page at www.bc.edu/eesciences. Applicants should submit a curriculum vitae, statements of teaching and research interests, and at least three references online at https://secure.interfolio.com/apply/21996. Review of applications will begin on 11 Nov. 2013. Department faculty will be available at the GSA and AGU fall meetings to meet with applicants. Boston College is an academic community whose doors are open to all students and employees without regard to race, religion, age, sex, marital or parental status, national origin, veteran status, or handicap.

**PEVEHOUSE CHAIR IN GEOSCIENCES**
**TEXAS TECH UNIVERSITY**

The Department of Geosciences at Texas Tech University invites applications for the Pevehouse Chair in Geosciences. The purpose of this endowed position is to support innovative research and education that are broadly aligned with petroleum geosciences and may include geophysics, structural geology, geomechanics, sedimentology, petrophysics, and organic geochemistry. A Ph.D. in geosciences or closely allied field is required, as is a record of research as demonstrated by professional publications. The chair holder will conduct a vigorous, externally-funded research program, direct graduate student research, and teach undergraduate and graduate courses in his/her specialty. The position is expected to be filled at the tenured Full Professor level.

Texas Tech is a state-supported, graduate research-oriented university with over 32,000 students. The Department of Geosciences consists of twenty-four tenured/tenure-track faculty, with teaching and research emphases in solid earth geosciences, atmospheric science, and geography. It offers degree programs in solid earth geosciences at the BS, MS, and Ph.D. levels. The chairholder will join a dynamic, growing Department with more than 200 undergraduate majors and more than 60 graduate students. Texas Tech is committed to growth in disciplines aligned with hydrocarbon geology through addition of at least one junior faculty position.

The Department computer labs are equipped with GIS, geologic mapping/modeling, and seismic processing/interpretation software packages. Available experimental/analytical facilities include a stable isotope laboratory, XRD, XRF, analytical SEM, TEM, laser ablation ICP-MS, a heat flow lab, and remote sensing spectroradiometers In addition, the Department of Petroleum Engineering maintains experimental and analytical facilities in petrophysics, drill fluids, cement, enhanced recovery, and reservoir simulation, as well as X-ray CT/nuclear magnetic resonance imaging lab.

Lubbock is located on the Southern High Plains in close proximity to the Permian Basin. The city has a population of over 225,000 and the semi-arid climate is conducive to outdoor activities. Cultural amenities include musical, theatrical, and sports events, and the city offers numerous options for shopping and dining. The city also offers the best healthcare facilities in the region, including the university's Health Sciences Center. The cost of living is low compared to national norms.

Applicants must first go to the employment website of the university at http://jobs.texastech.edu. There, go to "Search Postings", search for requisition number 87107, and fill out necessary forms in applying for the position online. Then, applicants should submit a letter of application, curriculum vitae, a statement of teaching and research interest, names and contact information (including e-mail address) of at least 3 professional references. These documents should be uploaded to the employment website and we request that copies by emailed or sent directly to: Dr. Calvin Barnes, Pevehouse Chair Search Committee, Department of Geosciences, Texas Tech University, MS 1053, Lubbock, TX 79409-1053.

Additional information on the department can be found at website www.depts.ttu.edu/gesc/. E-mail questions regarding the position are received at cal.barnes@ttu.edu. Review of applicants will begin immediately and continue until the position is filled.

Texas Tech University is an affirmative action/equal opportunity employer, committed to excellence through diversity. Texas Tech welcomes applications from minorities, women, veterans and persons with disabilities.

**ASSISTANT PROFESSOR**
**CENTRAL MICHIGAN UNIVERSITY**

The Department of Earth and Atmospheric Sciences, Central Michigan University, invites applications for a tenure-track Assistant Professor position in hydrogeology beginning August 2014 or earlier. A state-supported university with an on-campus enrollment of more than 20,000 students, CMU is a Doctoral/Research Intensive institution recognized for strong undergraduate education and a range of focused graduate programs and research. The Department of Earth and Atmospheric Sciences consists of ten full-time faculty and about 100 undergraduate majors. The department has a very strong record of incorporating research into the undergraduate curriculum and has a variety of well-equipped teaching and research facilities. Applicants must have demonstrated research expertise in hydrogeology and be committed to teaching excellence. The successful candidate will be appointed at the Assistant Professor level and will be expected to (1) effectively teach and develop courses related to the candidate's area of expertise; (2) develop an active research program that merits external funding; (3) contribute towards the development of an Environmental Science program within the department. Required qualifications include a Ph.D. in Geology or related field. You must submit an online application at https://www.jobs.cmich.edu/ to be considered an applicant for this position. Interested persons must submit a letter of application, curriculum vitae, a statement of proposed research agenda, a statement of prior teaching experience and philosophy, and names and email addresses of three references. All applications and materials received by 1 Nov. 2013 or until filled. CMU, an AA/EO institution, strongly and actively strives to increase diversity within its community (see www.cmich.edu/aaeo/).

## Fellowship Opportunities

**NASA POSTDOCTORAL FELLOWSHIPS**

The NASA Postdoctoral Fellowships Program offers scientists and engineers unique opportunities to conduct research in space science, earth science, aeronautics, exploration systems, lunar science, astrobiology, and astrophysics. U.S. citizens, Lawful Permanent Residents, and foreign nationals eligible for J-1 status as a Research Scholar may apply. **Applications are accepted March 1, July 1, and November 1 each year.** Stipends start at $53,500 per year, with supplements for high cost-of-living areas and for certain academic specialties. Financial assistance is available for relocation and health insurance, and $8,000 per year is provided for professional travel.

**For further information and to apply, visit: http://nasa.orau.org/postdoc.**

## Opportunities for Students

**Graduate Fellowships at the University of Kentucky.** Pioneer Natural Resources Fellowships are available at the University of Kentucky. Pioneer Fellowships are open to M.S. and Ph.D. candidates with research interests in stratigraphy, sedimentology, and petroleum geology. These positions include salary, tuition, research support and health insurance. Field sites for research include the western United States and the East African Rift Valley. Students with interdisciplinary geoscience backgrounds (including coursework/research in sedimentary geology, exploration seismology, petroleum geochemistry, and micropaleontology) are particularly encouraged to apply. Experience in conducting remote fieldwork is a plus. Please contact Prof. Michael McGlue (michael.mcglue@uky.edu) for more information. Further details on the Department of Earth and Environmental Sciences at the University of Kentucky can be found at http://ees.as.uky.edu/. The department maintains world-class facilities and an active, student-centered research program. Review of applications for Fall 2014 admission will begin 1 Feb. 2014.

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### Comment:

**Comment to "Open-source archive of active faults for northwest South America" by Gabriel Veloza, Richard Styron, Michael Taylor, and Andres Mora in *GSA Today***
Laurence Audin and 12 others, doi: 10.1130/GSATG169C.1, pages e24–e25.

### Reply:

**Reply to comment to "Open source archive of active faults for northwest South America" by Laurence Audin et al., 2013**
Gabriel Veloza, Richard Styron, and Michael Taylor, doi: 10.1130/GSATG193Y.1; pages e26–e27.

### Original Article:

**Open-source archive of active faults for northwest South America,** GSA Today, v. 22, no. 10, p. 4–10, doi: 10.1130/GSAST-G156A.1, http://www.geosociety.org/gsatoday/archive/22/10/article/i1052-5173-22-10-4.htm.

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GROUNDWORK
Furthering the Influence of Earth Science

# Literature searches with Google Scholar: Knowing what you are and are not getting

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## ABSTRACT

Whether you are a student developing a senior thesis or a geoscientist preparing a research proposal, finding relevant concepts, data, and information produced by other geoscientists is a crucial step to eventual success. The quote, "If I have seen farther it is by standing on the shoulders of giants," attributed to Sir Isaac Newton, acknowledges this fact. Our expanding knowledge base, increasing professional specialization, and greater involvement in interdisciplinary studies make it less and less likely we will know all the useful information important to any study we may consider undertaking. For this reason, we turn to scholarly literature to remedy any important deficiencies. For both students and researchers, this has increasingly meant employing Google Scholar.

## SEARCHING LITERATURE IN THE DIGITAL AGE

Some of the same technological changes that enhance our ability to collect relevant data also facilitate our ability to search scholarly literature. Abstracting and indexing of published literature is now provided in computerized, searchable bibliographic databases. These include both discipline-specific databases, such as GeoRef, produced by the American Geological Institute, and multidisciplinary ones, such as Web of Science from Thomson Reuters and Scopus from Elsevier (Walters, 2011). Internet-based platforms are available for accessing these databases.

In November 2007, Google Scholar was introduced as another means for geoscientists to conduct a computer-based literature search. It is an Internet search engine rather than a computerized bibliographic database. Access is through the widely used Google Internet portal. Like all new methods and ideas, thoroughly examining the strengths and limitations of Google Scholar ensures we understand what it does or does not actually deliver.

Before looking closely at Google Scholar's use in literature searches, it is important to understand how searching differs between Google and Google Scholar. Both are search engines owned by Google Inc. and both use proprietary software to identify Web-based links relevant to the search terms entered by the user. The terms entered into a Google search initiate a hunt through all publically accessible files on Web servers connected to the Internet that match those words. The Google Scholar search engine utilizes a variant of this software that searches for the user's terms within only scholarly publications as defined by the source servers; e.g., universities and scientific publishers (Walters, 2011).

How the results obtained can differ is demonstrated by a search we conducted on 27 Jan. 2013 using the search term "Indian ocean tsunami." The Google search returned 6.8 million results with the ten listed on the first screen page including an entry about the 2004 event on Wikipedia, a news item on National Geographic's website, and reports from six major national and international news organizations. Some news items related to the 2004 event and others to the tsunami watch that occurred after the 11 Apr. 2012 earthquake. The remaining two entries consisted of collected still images and videos about the tsunami.

In contrast, Google Scholar returned a comparatively modest 28,000 results. Except for four of the ten entries, the first page provided links to articles in scholarly journals ranging from *Nature* to the *International Journal of Hospitality Management* (Elsevier). The other entries were technical pages on a university website and technical reports on websites established by international donors for relief efforts and a government disaster response agency. This illustrates the very different search algorithms employed by Google and Google Scholar in terms of result numbers, content, and sources. It is worth noting that searches using this term over time returned widely differing result numbers for Google but not for Google Scholar. This reflects the more dynamic nature of Internet content as a whole compared to that part defined as scholarly content by Google Scholar.

## MECHANICS OF BIBLIOGRAPHIC DATABASES AND GOOGLE SCHOLAR

To fully explore any advantages or disadvantages of Google Scholar requires understanding how a search engine differs from a computerized bibliographic database. The content of bibliographic databases is developed through indexing done by the organization producing them. Indexed entries are added to these databases by organizations' employees based on a set of criteria related to specific sources and standards. The GeoRef thesaurus is

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[1]GSA Supplemental Data item 2013316, GeoRef and Google Scholar search results for "wildfire-related debris flows," is available online at http://www.geosociety.org/pubs/ft2013.htm. You may also obtain a copy by writing to gsatoday@geosociety.org.

an example of an indexing standard used in compiling that particular database. This compilation approach ensures the scholarly content and quality of these databases (Gray et al., 2012). Available bibliographic databases with content in the geological sciences are offered via subscriptions. Many students and researchers access these databases via subscriptions paid for by their libraries or organizations.

GeoRef is a bibliographic database familiar to most geoscientists because it is specifically targeted to our professional needs. This traditional abstracting and indexing service assumes its audience is informed geoscientists familiar with the defined vocabulary used by GeoRef to describe the subject content of the database (Tahirkheli, 2009). Available through various interfaces, GeoRef searches can be limited by various parameters such as date, journal articles, source language, or recent database updates. As Tahirkheli (2009) points out, a searcher can examine indexes providing the author name, journal name, and publication type before choosing a specific entry. Authors found in a search may then be searched separately using associated live links. Similarly, citations found during the search may have links to the full-text article (Tahirkheli, 2009).

Google Scholar is designed for use by many different disciplines including the geosciences. It is accessed via the Google Internet portal. Retrieval via Google Scholar requires that the article be in digital format on the Internet. Gray et al. (2012) and the inclusion guidelines provided by Google Scholar (http://scholar.google.com/intl/en/scholar/inclusion.html) highlight that effectively finding documents depends partly on the quality of the metadata for these electronic documents. Users enter their search terms, such as article title, author, or key words in a manner similar to the familiar Google search (Tahirkheli, 2009). The search algorithm will return those links that most closely match the terms entered where the full text is available (Tahirkheli, 2009). Where there are many articles found, it will provide those having the most links to other Internet pages first and then others following in descending order. Thus, papers with similar key words or titles would be represented with the one most often cited being listed first. Because this may place more recent relevant articles farther down the list, a user interested in primarily recent articles can limit the search by a year range or publication after a particular year.

The search term "wildfire-related debris flows" was recently used to illustrate differences between GeoRef and Google Scholar (see GSA Supplemental Data[1] for more information) GeoRef returned 127 citations compared to 276 from Google Scholar. Google Scholar included 85% of the GeoRef citations with the missing ones being limited to conference proceedings, government reports, technical publications, foreign language journals, and theses. Both GeoRef and Google Scholar distinguished abstracts from full articles. Retrieving full-text articles for citations returned by GeoRef and Google Scholar may require payment to the publisher. However, free articles were available in PDF format for 88% of citations returned by Google Scholar. They were available from open-access journals or via links to organizational sites where authors had posted their publications.

Repeated evaluations of Google Scholar for both simple and advanced searches have demonstrated its ability to deliver results equivalent to those provided by traditional computerized bibliographic methods (Hightower and Caldwell, 2010; Walters, 2011; Gray et al., 2012). Given its generally high precision and recall compared to other databases, it is a valuable tool for literature research (Walters, 2011).

## DISCUSSION

Literature research is done by undergraduate and graduate students as part of their learning process and by academic or institutional researchers as part of their work. Applied geoscientists in government organizations and private industry conducting scholarly research find Google Scholar attractive because it is accessible outside academic institutions or research organizations holding subscriptions to traditional bibliographic services. Also, using Google Scholar is free to anyone with an Internet connection and can achieve useable results without knowledge of sophisticated search functions or familiarity with the vagaries of different interfaces (Gray et al., 2012).

Equally attractive is the ability to quickly access full-text articles via the link associated with the citation found through Google Scholar (Tahirkheli, 2009; Walters, 2011). Continued growth in the number of open-access journals and institutional repositories will increase the number of articles readily available for free via Google Scholar. This trend especially benefits geoscientists unaffiliated with organizations that provide access to journal subscriptions. It will also help students from other countries who became accustomed to ready access to journal articles while obtaining their degrees at universities and colleges in the United States. A number of publishers are digitizing past issues of journals, too.

Google Scholar users should recognize that this technology continues to change. Just as many negative reactions to the beta version initially released are no longer relevant to the current version, tomorrow's version will be different and may include new positive and negative elements. Recognizing that Google search retrieval remains based on software, it may return some material that is not vetted for the quality, accuracy, and authority expected from traditional bibliographic services (Gray et al., 2012). Consequently, geoscientists should stay informed on changes to ensure that the results they are getting conform to their standards and expectations. When possible, it will continue to be a good practice to conduct literature searches utilizing the specific advantages offered by both Google Scholar and traditional bibliographic databases.

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## Geology

Wiley has more geology journals than any other publisher *, including 4 in the top 10. The 6 Wiley journals published 256 articles which were cited 12,867 times in 2012.


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**Reviews of Geophysics**
IF 13.906
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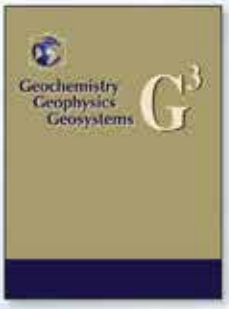
**Tectonics**
IF 3.487




**Geochemistry Geophysics Geosystems**
IF 2.939

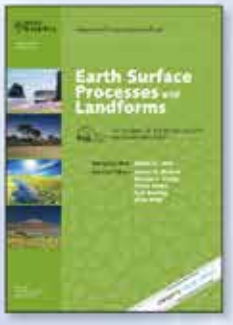

**Meteoritics & Planetary Science**
IF 2.800

## Physical Geography

Seven Wiley journals are in Physical Geography category *, including 5 in the top 20. The journals published 568 articles which were cited 26,999 times in 2012.


**Global Ecology and Biogeography**
IF 7.223
Ranked number 1


**Journal of Biogeography**
IF 4.863
Ranked number 2




**Earth Surface Processes and Landforms**
IF 2.49


**Boreas**
IF 2.457

## Geosciences, Multidisciplinary

21 Wiley journals ranked in the Geosciences, Multidisciplinary category*. The journals published 4,992 articles and with 273,923 cites, Wiley journals had the highest number of cites in 2012.


**Geophysical Research Letters**
IF 3.982


**Geobiology**
IF 3.042


**Journal of Geophysical Research**
IF 3.174


**Basin Research**
IF 2.912

## Palaeontology

Five Wiley journals are ranked in the Palaeontology category *, including 3 in the top 5. The journals published 303 articles which were cited 13,924 times in 2012.


**Paleoceanography**
IF 3.296
Ranked number 1


**Journal of Quaternary Science**
IF 2.939
Ranked number 2

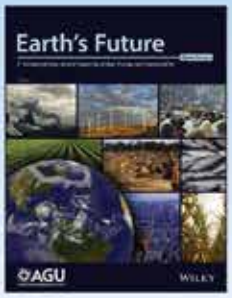
## Astronomy and Astrophysics

Three Wiley journals are ranked in the Astronomy and Astrophysics category *. The journals published 303 articles which were cited more than 5610 times in 2012.


**Space Weather**
IF 1.370


**Radio Science**
IF 1.000

*ISI Subject Category, 2012 Journal Citation Reports® (Thomson Reuters, 2013)

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