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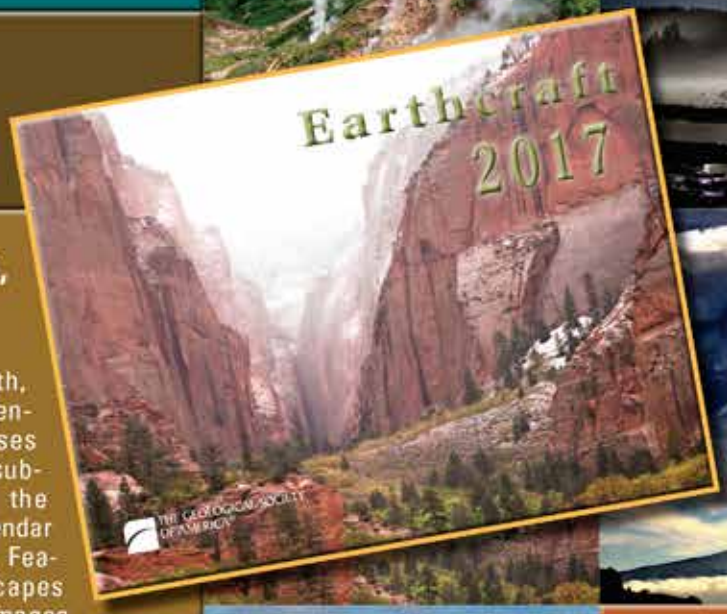

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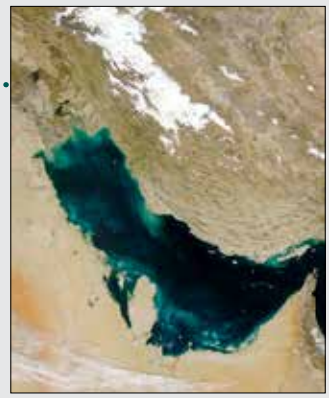

SCIENCE

Cover: NASA satellite photo of the Persian Gulf area with the Ghawar Oil Field in the lower left of the picture. See related article, p. 4–10.

GROUNDWORK

GSA News

A Novel Plate Tectonic Scenario for the Genesis and Sealing of Some Major Mesozoic Oil Fields

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ABSTRACT

Recent research reveals evidence of a major event of global plate motion during the Jurassic, with a magnitude and tempo hitherto not fully appreciated. Yet, its legacy persists today as the potent Jurassic source-reservoir-seal oil systems in the Persian Gulf region. We suggest that these formed as a consequence of a sweeping tectonic movement whereby Arabia drifted rapidly from the oil-forming Intertropical Convergence Zone along the equator to the arid tropics of the southern hemisphere with rapid deposition of relatively uncemented carbonate reservoirs and anhydrite seals, all during as little as 15 m.y. in the Late Jurassic. The Ghawar supergiant oil field of Saudi Arabia was one of the results. Rapid latitudinal change may have influenced the development of some source-reservoir-seal oil systems elsewhere as well.

INTRODUCTION

Ghawar is the world's largest oil field, a supergiant that accounts for ~60% of Saudi Arabia's crude production (Al-Anazi, 2007). The source rocks at Ghawar are marine muds and carbonates of the Tuwaiq Mountain and Hanifa formations (Alsharhan and Nairn, 1997) deposited in the Callovian-Oxfordian stages of the Late Jurassic (Al-Husseini, 2009) between 166 and 157 Ma (time scale of Cohen et al., 2013). The reservoirs are located in overlying bioclastic limestones of the Kimmeridgian (Late Jurassic; 157–151 Ma) Arab Formation that are sealed by anhydrites of the Tithonian (Late Jurassic; 152–145 Ma) Hith Formation (Alsharhan and Nairn, 1997; Al-Husseini, 2009).

This closely packed layercake stratigraphy with source and reservoir rocks sealed upsection with anhydrites makes Ghawar and similar supergiant oil fields of the Persian Gulf a dreamland for oil exploitation essentially because it minimizes the variables associated with oil maturation and migration that are by far the most difficult to forecast in oil assessment protocols. At the same time, these hydrocarbon provinces constitute a paleogeographic conundrum. Organic matter that eventually transforms into oil and gas with burial and maturation can originate in abundance in sedimentary basins along the Intertropical Convergence Zone (ITCZ), which straddles about ±5° from the equator (Manabe and Bryan, 1985; Kent and Muttoni, 2013; McGee et al., 2014) due to high levels of nutrients upwelled from deep waters or in run-off from adjoining continents onto shelf areas. And indeed, protracted residence along the equator is the commonly accepted explanation for the origin of the shelf-facies Jurassic oil in the Persian Gulf (Al-Awwad and Collins, 2013). However, carbonate sands for a reservoir and especially an anhydritic seal are more likely formed at tropical latitudes (~5–30°) where evaporation exceeds precipitation even under highly variable atmospheric pCO_2 levels (Manabe and Bryan, 1985). So it seems that to form a winning temporal sequence of source-reservoir-seal rock units, Arabia (= Persian Gulf region) needs to cross the ITCZ (deposition of Callovian-Oxfordian source rocks) and into the tropical arid belt (deposition of Kimmeridgian reservoir and especially Tithonian seal) in less than 15 m.y. within the Late Jurassic.

Recent research shows the existence of a major event of global plate (or even whole-mantle) motion during the Jurassic that was hitherto unknown to the earth science community and can be referred to as the Jurassic polar shift (Kent and Irving, 2010; Muttoni et al., 2013; Kent et al., 2015). When the Jurassic polar shift is taken into account to describe global paleogeography, the rapid trans-zonal plate motion that produced the source-reservoir-seal sequence at Ghawar and elsewhere in the world can be adequately explained.

JURASSIC POLAR SHIFT

The recent discovery of the Jurassic polar shift was made from paleomagnetic studies that provide a means to track the motion of tectonic plates relative to Earth's spin axis. Under favorable conditions, the remanent magnetization of rocks records ancient geomagnetic field directions, which when averaged over several thousands of years, closely correspond to those of a geocentric axial dipole (GAD). According to the GAD hypothesis, paleomagnetic directions of similar age from localities on a rigid tectonic plate should give the same paleomagnetic pole and hence the location of that plate with respect to the geographic axis or, equivalently, parallels of latitude. A temporal sequence of paleopoles or an apparent polar wander (APW) path is a convenient way to represent the motion of a tectonic plate with respect to the rotation axis (e.g., Creer and Irving, 2012). Relative motions between tectonic plates (usually their continental proxies) are detected by systematic differences in their respective APW paths (e.g., Van der Voo, 1990). It is also possible that Earth's entire crust and mantle rotated with respect to the spin axis, a still poorly understood phenomenon referred to as True Polar Wander (TPW) (e.g., Goldreich and Toomre, 1969). In either case—APW or TPW—the included continents experience an effective rotation about a Euler pole that involves a systematic change in latitude according to the GAD hypothesis.

The Jurassic polar shift largely derives from the recognition of a distinct set of paleomagnetic poles deemed reliable from three

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different continents and centered on ca. 145 Ma (Kent and Irving, 2010). The mean location of these three poles plots as the apex or cusp of a novel APW path when reconstructed to common coordinates using standard relative plate reconstructions. The APW path was constructed from published paleomagnetic poles from well-dated magmatic units and only those sedimentary units corrected for inclination flattening (Tauxe and Kent, 2004; Kent and Tauxe, 2005). The poles range in age from 230 to 50 Ma (Triassic to Eocene) from all the major continents that could be closely linked by plate circuits (see Fig. 4 in Kent and Irving, 2010). The resulting global composite APW path shows the presence of a previously undetected yet major polar shift of ~30° separating the 160 Ma (Oxfordian, Late Jurassic) mean paleopole from the mean cusp paleopole at 145 Ma, close in age to the Jurassic-Cretaceous boundary.

Whether the 1–2°/m.y. of Jurassic polar shift represents an episode of fast whole mantle rotation (TPW) or only rotation of the reconstructed continental lithosphere (APW), the main continents in either case rotated in unison clockwise by up to ~30° about a Euler pole centered on the equator (Fig. 1; Kent et al., 2015). As a result, Arabia drifted southward from straddling the ITCZ at ca. 160 Ma to plunging at up to 1–2°/m.y. (up to ~20 cm/yr) into the tropical arid belt of the southern hemisphere by 145 Ma. The main continents then rotated in unison anticlockwise about virtually the same Euler pole so that Arabia drifted northward back across the ITCZ and into the boreal arid belt by 120 Ma. Such a rapid polar shift and the backtrack at the 145 Ma cusp are not precluded either by any speed limit on plates (Meert et al., 1993) coupled with their negligible momentum (Forsyth and Uyeda, 1975) nor by models of whole-mantle motions for TPW (Tsai and Stevenson, 2007; Greff-Lefftz and Besse, 2014).

The critical 145 Ma apex paleopole of Kent and Irving (2010) is based on an average of three individual entries from radiometrically dated igneous units:

1. The Ithaca kimberlite paleopole from New York State in North America, based on high-temperature magnetic component directions bearing dual (normal and reverse) polarity from seven sites sampled in dikes intruding flat-lying Devonian platform carbonates, giving a positive baked contact test and with a geometry that precludes significant post-emplacement tectonic disturbances (Van Fossen and Kent, 1993); the Ithaca kimberlites are now provided with a U/Pb perovskite date of 146.4 ± 1.4 Ma (Kent et al., 2015).
2. The ca. 145 Ma combined Bumbeni-Swartruggens paleopole from South Africa, comprised of the Bumbeni syenite complex dated with Ar/Ar at 145.8 ± 1.3 Ma, which yielded bipolar paleomagnetic results from four sites, and the kimberlite fissures at Swartruggens dated with K-Ar and Ar/Ar to a mean of 142 ± 4 Ma, which also yielded bipolar paleomagnetic results from two sites (Main and Male kimberlites; Hargraves et al., 1997, and references therein).
3. The Hinlopenstretet paleopole from Svalbard, based on high-temperature magnetic component directions from 17 sites sampled in dikes dated with K-Ar to a mean age of 144 ± 5 Ma (Halvorsen, 1989).

The Bumbeni-Swartruggens and Hinlopenstretet paleopoles, when transferred into North American coordinates using rotation parameters to account for seafloor spreading in the Atlantic, fall at only 6° and 8°, respectively, from the cratonic Ithaca paleopole; this congruence of results from three continents allows erecting a mean paleopole at ca. 145 Ma with a 95% confidence circle (A95) of 9° (Kent and Irving, 2010).

The position of the ca. 145 Ma apex paleopole is confirmed by entirely independent data from magneto-biostratigraphically dated sections from Adria—the African promontory. These data have been successfully correlated to the marine magnetic anomaly M-sequence and corrected for sedimentary inclination shallowing (Muttoni et al., 2013). Two mean paleomagnetic poles for Adria-Africa are of particular interest for our discussion: a mean paleopole based on three stratigraphic sections straddling magnetic polarity chron CM22 at 151 ± 1 Ma in the Early Tithonian, and a mean paleopole at 145 ± 2 Ma in the mid-Tithonian–Berriasian (across the Jurassic-Cretaceous boundary) based on six sections altogether from polarity chron CM17 to CM21 (Muttoni et al., 2013). These two paleopoles at ca. 151 and ca. 145 Ma lie at only 1° and 7°, respectively, from the ca. 145 Ma paleopole of Kent and Irving (2010) rotated into African coordinates (Muttoni et al., 2013). Finally, a mean kimberlite paleopole from Ontario, Canada, dated with state-of-the-art U/Pb on perovskite to 156 ± 1.6 Ma, neatly plots in the middle of the Jurassic polar shift and provides additional independent support for it (Kent et al., 2015).

Acknowledging the limitations of our small subset of nonetheless well-dated and inclination flattening-free Late Jurassic paleopoles from stable regions of different plates (North America, Europe, Africa), the overall coherent progression they depict once restored to a common reference frame, confirmed by magneto-

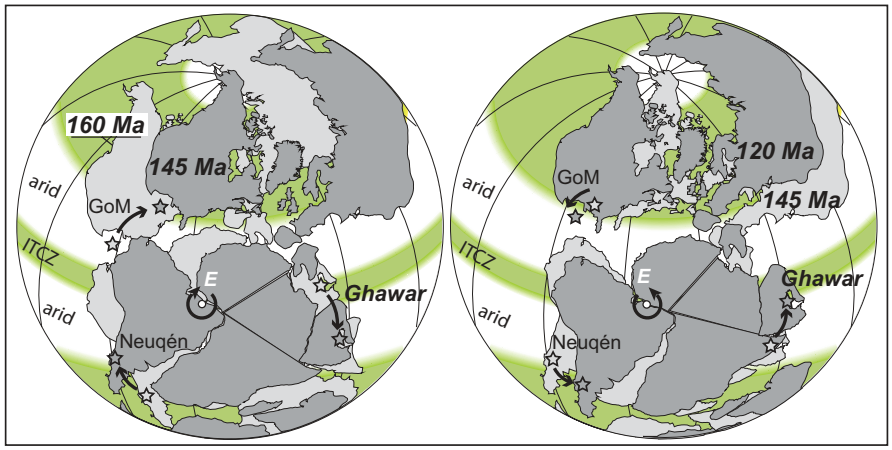

Figure 1. Paleocontinental reconstructions bracketing the Jurassic polar shift: in left panel, reconstructions at 160 Ma (light gray shading) and 145 Ma (dark gray shading); in right panel, reconstructions at 145 Ma (light gray shading; same as in left panel) and 120 Ma (dark gray shading). The Euler pole (*E*) for rotating the continental assemblage clockwise from 160 to 145 Ma and counterclockwise from 145 to 120 Ma is located on the equator in the vicinity of the Bight of Benin of western Africa. The stars connected by arrows indicate the sites discussed in the text: Ghawar in Saudi Arabia, Neuqén in Argentina, and the Gulf of Mexico (GoM). Green latitudinal belts represent the Intertropical Convergence Zone (ITCZ) within ±5° equator and the temperate humid belts, whereas the arid belts encompass the tropics up to ±30° latitude (modified from Kent et al., 2015).

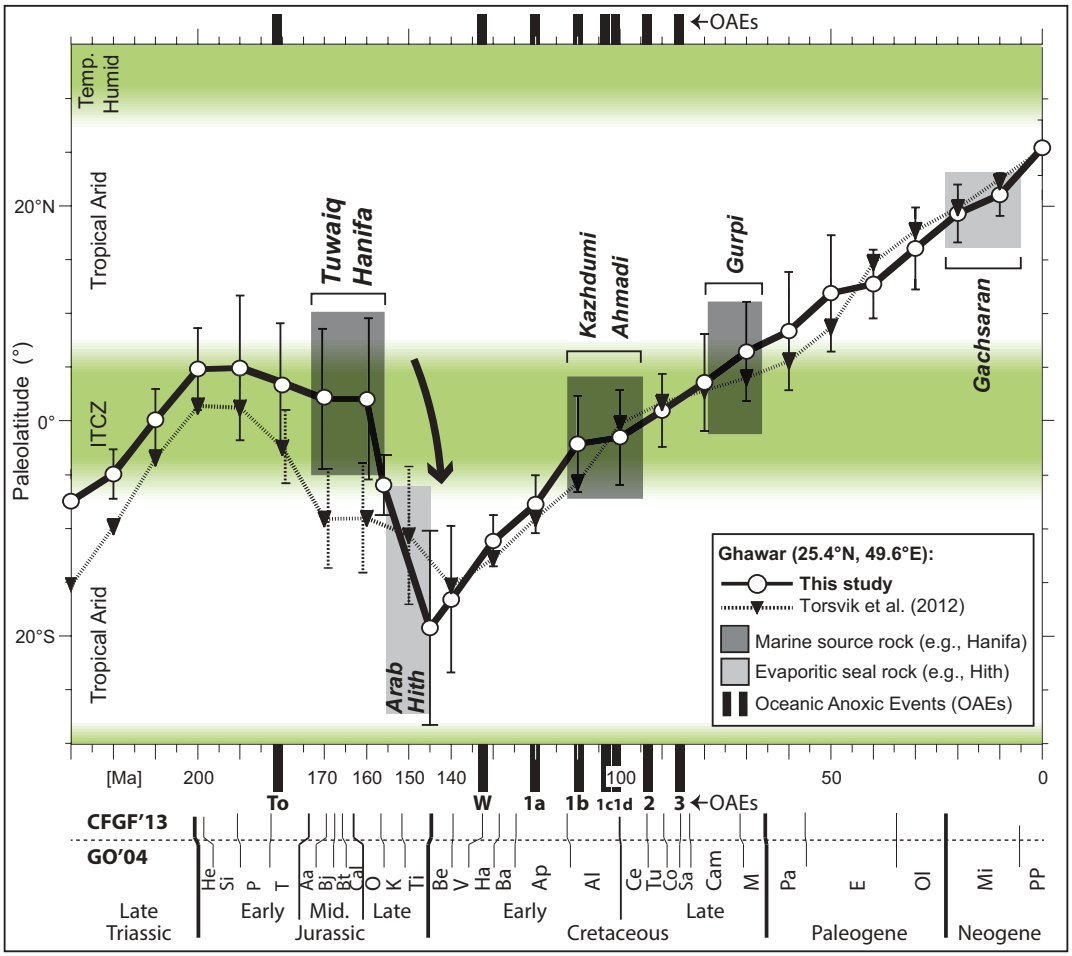

Figure 2. The paleolatitudinal evolution curve (white circles) of Ghawar (25.4°N, 49.6°E) in the Persian Gulf of Saudi Arabia calculated from the inclination flattening-free apparent polar wander (APW) path of Table 1 (in Arabian coordinates) that incorporates the Jurassic polar shift; errors in age (not shown to enhance visual clarity of diagram) are ± 10 m.y. except for paleolatitudes at 145 and 156 Ma with errors of ± 5 and ± 1.6 m.y., respectively; errors in paleolatitude (shown as vertical bars) are equal to ± A95 (cone of 95% confidence of mean paleomagnetic pole). The black arrow highlights the latitudinal drift associated with the Jurassic polar shift. Paleolatitudes computed for Ghawar using the Torsvik et al. (2012) APW path are also reported for comparison (black triangles, with error bars at 180, 170, 160, 150 Ma). The names of main source and seal rock formations/members discussed in the text are also reported (e.g., Hanifa, Hith) together with the temporal distribution of main Oceanic Anoxic Events: To—"Posidonienschiefer" (Toarcian); W—"Weissert" (Valanginian–Hauterivian); 1a—"Selli" (Early Aptian); 1b—"Paquier" (Late Aptian–Early Albian); 1c—"Toolebuc" (Late Albian); 1d—"Breistroffer" (Late Albian); 2—"Bonarelli" (Cenomanian–Turonian boundary); and 3 (Coniacian–Santonian) (Cronin, 2010). CFGF'13—time scale of Cohen et al. (2013); GO'04—time scale of Gradstein and Ogg (2004). ITCZ—Intertropical Convergence Zone; He—Hettangian; Si—Sinemurian; P—Pliensbachian; T—Toarcian; Aa—Aalenian; Bj—Bajocian; Bt—Bathonian; Cal—Callovian; O—Oxfordian; K—Kimmeridgian; Ti—Tithonian; Be—Berriasian; V—Valanginian; Ha—Hauterivian; Ba—Barremian; Ap—Aptian; Al—Albian; Ce—Cenomanian; Tu—Turonian; Co—Coniacian; Sa—Santonian; Cam—Campanian; M—Maastrichtian; Pa—Paleocene; E—Eocene; Ol—Oligocene; Mi—Miocene; PP—Pliocene–Pleistocene.

biostratigraphically calibrated data from Adria, is taken as evidence that the Jurassic shift constitutes a real feature of polar wander occurring between 160 and 145 Ma (Kent and Irving, 2010; Muttoni et al., 2013; see also Muttoni et al., 2005). This feature is largely underestimated in other APW paths from the literature essentially because of the inclusion of paleopoles poorly constrained in age and inclination flattening degree.

COUPLED OIL SOURCE-SEAL FORMATION DURING THE JURASSIC POLAR SHIFT

We computed a paleolatitude curve for Ghawar (Fig. 2, white circles with vertical error bars) using an APW path incorporating the Jurassic polar shift using the aforementioned paleopoles from Kent and Irving (2010) and Kent et al. (2015) (Table 1). According to this curve, Ghawar was located well within the ITCZ during virtually the entire Early, Middle and early-Late Jurassic, but by 145 Ma, it rapidly drifted to ~20° in the southern hemisphere. In other words, Ghawar traveled within 15 million years from the oil-forming productive ITCZ to the seal-forming arid tropics of the southern hemisphere.

This drift history neatly explains the Late Jurassic stratigraphy of the area. The Callovian–Oxfordian (166–157 Ma) Tuwaiq Mountain and Hanifa formations (Al-Husseini, 2009), which represent the main source rocks of Jurassic oil at Ghawar (Alsharhan and Nairn, 1997) were deposited when eastern Saudi Arabia resided on the ITCZ while the overlying Tithonian (152–145 Ma) Hith Formation anhydrites (Al-Husseini, 2009), representing the main seal cap (Alsharhan and Nairn, 1997), were

Table 1. Composite APW path used to calculate paleolatitudes at Ghawar

Central Age (Ma)	Mean Age (Ma)	*N*	A95 (°)	Plat NAM	Plong NAM	Plat SAM	Plong SAM	Plat AF	Plong AF	Plat AR	Plong AR	Paleolat Ghawar	Paleolat Neuqén	Paleolat GoM
10	8.3	54	2.0	85.0	168.1	85.9	151.0	85.3	173.5	85.6	221.6	21.1	–41.0	24.9
20	18.9	38	2.7	83.3	164.2	84.7	133.8	83.9	175.9	83.9	229.9	19.3	–42.8	24.0
30	29.5	23	3.8	81.5	169.2	83.7	132.6	81.8	190.7	80.6	235.3	16.1	–43.8	24.1
40	40.0	24	3.2	79.5	174.4	82.6	139.2	79.0	201.1	77.3	234.2	12.8	–44.4	24.5
50	49.4	9	5.4	79.4	171.8	82.5	130.0	78.5	206.0	76.4	236.9	11.9	–45.0	24.0
60	59.1	7	5.5	77.0	189.8	83.0	153.5	75.6	220.0	72.5	243.2	8.4	–42.9	27.5
70	68.9	7	4.6	75.9	204.7	84.5	181.7	73.8	234.7	69.6	253.0	6.5	–39.5	31.1
80	77.4	7	4.5	75.2	195.0	82.9	170.2	70.9	232.6	67.0	249.3	3.6	–41.2	28.9
90	89.7	8	3.4	75.5	190.6	84.2	158.6	68.0	237.8	63.8	252.1	1.0	–41.7	27.8
100	96.7	8	4.4	77.0	194.1	87.2	177.2	64.4	248.8	59.5	260.0	–1.5	–39.0	28.5
110	107.9	6	4.5	78.6	190.2	89.3	359.1	62.5	255.7	57.2	265.4	–2.1	–37.7	27.5
120	121.4	9	2.7	74.2	192.2	86.5	255.2	54.7	260.8	49.2	268.5	–7.7	–35.1	28.3
130	127.3	8	2.4	71.7	193.4	83.1	245.2	49.5	264.2	43.8	271.0	–11.1	–33.0	28.8
140	139.8	5	6.8	64.7	197.3	79.8	234.4	42.8	264.4	37.1	270.6	–16.5	–31.8	30.7
145	143.7	3	9.0	61.2	200.2	75.4	236.0	38.6	266.2	32.8	271.9	–19.2	–28.6	32.3
156	156.0	1	2.8	75.5	189.5	83.1	310.9	52.4	271.9	46.4	278.0	–5.9	–31.5	27.5
160	165.3	4	7.5	78.5	112.5	76.2	40.9	66.4	259.1	60.9	269.1	2.1	–41.7	15.3
170	170.8	4	6.5	76.3	105.9	76.1	41.6	66.5	258.7	61.0	268.8	2.1	–41.9	12.8
180	182.3	8	5.5	79.9	100.4	76.4	22.1	65.4	269.7	59.5	277.5	3.6	–37.2	16.1
190	184.6	8	6.7	79.7	91.6	75.0	23.6	66.9	270.3	61.0	278.3	5.0	–37.4	15.7
200	201.7	7	3.8	67.8	81.8	68.4	57.2	71.9	238.1	67.6	254.4	4.9	–48.4	4.0
210	207.7	11	2.9	64.2	91.2	68.9	71.8	67.5	229.5	63.9	244.9	0.1	–52.9	0.2
220	217.5	8	2.3	59.3	98.8	67.7	87.7	62.3	222.4	59.5	236.4	–4.9	–57.8	–4.4
230	223.0	3	5.7	57.8	102.8	67.7	94.6	59.7	222.0	57.0	235.1	–7.4	–59.1	–5.5

Note: Mean paleomagnetic poles (paleopoles) from 10 to 40 Ma are from Besse and Courtillot (2003); paleopoles from 50 to 230 Ma are from Kent and Irving (2010); and paleopole at 156 Ma is from Kent et al. (2015). Central age (Ma) of sliding window used to calculate the mean paleopole; uncertainties in paleopoles are ± 10 m.y., except for paleopole at 145 Ma, with an error of ± 5 m.y., and paleopole at 156 Ma, with an error of ± 1.6 m.y. Mean age (Ma)—mean age of paleopoles falling in sliding window centered on Central Age. *N*—number of paleopoles falling in window of Central Age and corresponding Mean Age. A95—cone of 95% confidence (°) of mean paleopoles; Plat NA, Plong NA—latitude (°N), longitude (°E) of mean paleopoles in North American coordinates; Plat SAM, Plong SAM, and Plat AF, Plong AF—latitude (°N) and longitude (°E) of mean paleopoles in South American (SAM) and African (AF) coordinates obtained by rotating North American paleopoles using rotation parameters of Müller et al. (1993) and Kent and Irving (2010); Plat AR and Plong AR—latitude (°N) and longitude (°E) of mean paleopoles in Arabian coordinates obtained by rotating paleopoles from African coordinates using rotation parameters of Besse and Courtillot (2002); Paleolat Ghawar—paleolatitude of Ghawar (25.4°N, 49.6°E) calculated from Plat AR and Plong AR. Paleolat Neuqén = Paleolatitude of Neuqén basin (38°S, 290°E) calculated from Plat SAM and Plong SAM. Paleolat GoM—paleolatitude of Gulf of Mexico (26°N, 270°E) calculated from Plat NAM and Plong NAM.

deposited as Saudi Arabia rapidly drifted to the arid southern tropics (Fig. 2). This rapid source-to-seal succession allowed the actual reservoirs to be located in the intervening porous bioclastic limestones of the Arab Formation (Daraei et al., 2014). Similar scenarios can be envisaged for other correlative systems involving the Tuwaiq-Hanifa sources and Hith anhydrite seal in neighboring Bahrain, Quatar, and the UAE (Alsharhan and Nairn, 1997; Alsharhan and Magara, 1994; Al-Suwaidi et al., 2000), whereas more to the north in central Iran, sedimentation switched from mid-latitude coal-bearing to tropical evaporitic during the Jurassic polar shift (Mattei et al., 2014).

The ensuing progression of paleolatitudes after the Jurassic polar shift that culminated at the 145 Ma cusp shows that Ghawar drifted back, albeit more slowly, across the ITCZ from the arid tropics of the southern hemisphere to the arid tropics of the northern hemisphere during the Cretaceous–Paleogene (Fig. 2). This provided a second time window in the Cretaceous for the formation of oil that is indeed also widespread in the Persian Gulf region. For example, most of Iran's oil reserves situated in the Persian Gulf (within ~400 km from Ghawar) are also sourced in Cretaceous rocks (e.g., Albian Kazhdumi Formation, Cenomanian Ahmadi Member of the Sarvak Formation, Late Cretaceous Gurpi Formation; Bordenave and Burwood, 1995; Mashhadi and Rabbani, 2015) that formed at or close to the ITCZ and were sealed by the Miocene Gachsaran evaporites (Soleimani and Bahadori, 2015).

At approximately similar distances from the equatorial Euler pole but on the other side of Gondwana, the oil-producing Neuqén Basin of Argentina provides an example of a source-reservoir-seal plate-motion stratigraphy involving transits across the boundary between the (austral) temperate humid belt and the tropical arid belt (Fig. 1). There, Early–Middle Jurassic and latest Jurassic–earliest Cretaceous marine shale source rocks (Los Molles and Vaca Muerta formations) are separated by an intervening evaporitic unit (Auquilco Formation) of Oxfordian–Kimmeridgian (Late Jurassic) age, whereas the overlying Cretaceous rocks are mainly continental (e.g., Howell et al., 2005; Palma et al., 2007; Boyer et al., 2011). A paleolatitude curve calculated for the Neuqén Basin (Fig. 3, upper panel; Table 1) shows that the Neuqén Basin dwelled at paleolatitudes higher than ~35°S (temperate humid belt) during practically the entire Mesozoic and Cenozoic except for a single northward incursion to ~30°S at 145 Ma, the culminating cusp of the Jurassic polar shift. This brief incursion toward a presumably more arid environment broadly coincided (within the error resolution of the available biostratigraphic dating of the Neuqén Basin sequence) with deposition of the Auquilco evaporites that seal the underlying Los Molles marine shales (Fig. 3, upper panel).

When our plate-motion stratigraphy operates in reverse mode—the transit occurring from the arid tropics into productive equatorial or mid-latitude humid belts—the resulting layercake sequence does not conspire positively for sealing oil. In these

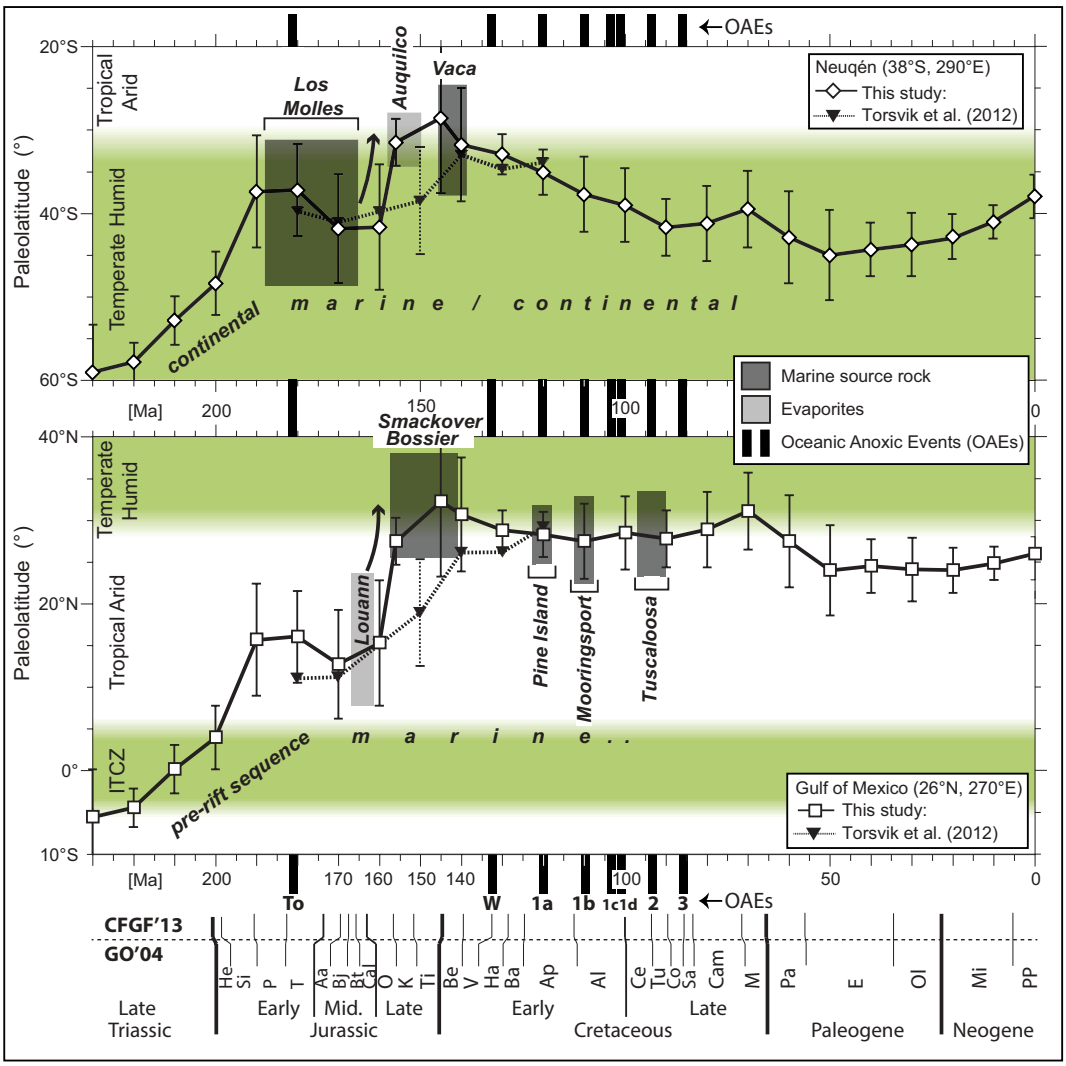

Figure 3. In upper panel, the paleolatitudinal evolution of the Neuqén Basin in Argentina (38°S, 290°E) and in lower panel of the Gulf of Mexico offshore Texas (26°N, 270°E) calculated from the APW path of Table 1 (in South American and North American coordinates, respectively). Errors in age (not shown to enhance visual clarity of diagram) are ±10 m.y. except for paleolatitudes at 145 and 156 Ma with errors of ±5 and ±1.6 m.y., respectively; errors in paleolatitude (shown as vertical bars) are equal to ± A95 (cone of 95% confidence of mean paleomagnetic pole). The black arrows highlight the latitudinal drift associated with the Jurassic polar shift. Included in both diagrams are the paleolatitudes predicted from the Torsvik et al. (2012) APW path for 180–120 Ma (black triangles) with vertical error bar at 150 Ma. The names of main source and seal rock formations discussed in the text are also reported (e.g., Los Molles, Auquilco, Vaca [= Vaca Muerta], Louann, Smackover). Continental, marine—continental or marine sedimentation. Oceanic Anoxic Events (OAEs): To—"Posidonienschiefer" (Toarcian); W—"Weissert" (Valanginian–Hauterivian); 1a—"Selli" (Early Aptian); 1b—"Paquier" (Late Aptian–Early Albian); 1c—"Toolebuc" (Late Albian); 1d—"Breistroffer" (Late Albian); 2—"Bonarelli" (Cenomanian–Turonian boundary); and 3 (Coniacian–Santonian) (Cronin, 2010). CFGF'13—time scale of Cohen et al. (2013); GO'04—time scale of Gradstein and Ogg (2004). ITCZ—Intertropical Convergence Zone; He—Hettangian; Si—Sinemurian; P—Pliensbachian; T—Toarcian; Aa—Aalenian; Bj—Bajocian; Bt—Bathonian; Cal—Callovian; O—Oxfordian; K—Kimmeridgian; Ti—Tithonian; Be—Berriasian; V—Valanginian; Ha—Hauterivian; Ba—Barremian; Ap—Aptian; Al—Albian; Ce—Cenomanian; Tu—Turonian; Co—Coniacian; Sa—Santonian; Cam—Campanian; M—Maastrichtian; Pa—Paleocene; E—Eocene; Ol—Oligocene; Mi—Miocene; PP—Pliocene–Pleistocene.

cases, the development of diapirs from the underlying evaporites and/or other tectonic or salt-related features can, however, provide traps for oil. A prominent example is the Gulf of Mexico (Fig. 1) where the Louann Salt, an important source of oil-trapping salt domes in the Gulf region (Mancini et al., 2008), formed as the Gulf dwelled at arid tropical latitudes of 10–15°N in the Middle Jurassic (Fig. 3, lower panel; Table 1). As the Gulf drifted to 30–32°N into the presumed temperate belt during the Jurassic polar shift, the Late Jurassic Smackover and Bossier source rocks were deposited (Mancini et al., 2008). Subsequently, during the Cretacous, the Gulf was stationed at around 30°N and was the locus of formation of additional source rocks (Pine Island, Moorigsport, Tuscaloosa; Mancini et al., 2008), some of which appear to often coincide with Cretaceous ocean anoxic events (OAEs) (Fig. 3, lower panel). We note, however, that there is a gap in OAEs between the Toarcian and early Aptian, a time interval that includes the Late Jurassic polar shift and the development of the source-reservoir-seal system at Ghawar (Fig. 2).

DISCUSSION

The Jurassic polar shift, whether it represented a generalized event of continental drift or a whole mantle rotation, constitutes a novelty of global plate motion. APW paths published before Kent and Irving (2010) do not show the Jurassic polar shift in its full

extent, only a very subdued hairpin around the Jurassic–Cretaceous boundary. For example, according to paleolatitudes computed using the widely cited Torsvik et al. (2012) APW path (Fig. 2, black triangles with vertical error bars across critical interval 180–150 Ma), Ghawar was located in the center of the ITCZ only during the Late Triassic and Early Jurassic; a transit from the oil-generating ITCZ to the seal-generating austral tropical arid belt is evident, but according to their APW path, it would have occurred in the Early–Middle Jurassic and therefore cannot readily explain the observed source-to-seal systems of the Persian Gulf. However, soon afterward in the Cretaceous, paleolatitudes from virtually all modern APW paths come into close agreement and can equally explain the Cretaceous source-to-seal oil systems in the Persian Gulf region (Fig. 2).

Torsvik et al. (2012) recognized that the Jurassic "spike" and associated features seen in the Kent and Irving (2010) APW path differ strongly from their and other published APW paths (e.g., Besse and Courtillot, 2002). They attributed the differences as largely an artifact of aliasing from the low number of input poles deemed reliable by Kent and Irving (2010). We believe that the retention of often poorly dated (±10 m.y. or more) or otherwise potentially biased paleomagnetic data, especially of earlier vintage for which, moreover, no direct assessment of sedimentary inclination error is available (e.g., Jura Blue Limestone sediments of Switzerland, Sub-Tatric and Krakow Upland sediments of Poland, Tunisia Upper Jurassic sediments, Rio Grande do Norte dikes of Brazil), is likely to attenuate the full expression of important features of APW, such as the Jurassic polar shift (see Kent and Irving, 2010, for a discussion).

CONCLUSIONS

In this paper, we show how APW paths based on stricter acceptance criteria can lead to an interesting reconciliation between paleolatitudes, generalized zonal climate belts, and the generation and sealing of the Late Jurassic Persian Gulf oil. Of course, not all oil formed and was sealed in the plate-motion–mediated manner we describe for Ghawar, as a notable example. Other oil systems like Neuqén and the Gulf of Mexico, where Jurassic latitudinal changes were smaller, may be controlled by other factors operating at more local basin scales (orography, coastal upwelling, high riverine nutrient supply) or more strongly depend on the different levels of details of the climate models adopted (e.g., Manabe and Bryan, 1985; Sellwood and Valdes, 2006; Huber and Caballero, 2011). Nevertheless, relevant aspects of the basic zonal climate model we adopted, which assumes a simple geography and very different pCO_2 levels (Manabe and Bryan, 1985), seems to be confirmed by more comprehensive analyses of Hadley circulation showing that since the Last Glacial Maximum, mean ITCZ shifts are likely to be within 1° latitude from the equator (McGee et al., 2014). And local basin controls must still operate in the context of latitudinal-dependent factors that paleomagnetic poles are well-suited to constrain.

We acknowledge that there could exist specific (and thus inevitably rare) combinations of local variables that could explain the occurrence of organic matter-rich deposits at tropical latitudes, where aridity would be normally expected, or marine evaporites on the equator, where precipitation exceeding evaporation is the (zonal) norm, but in general, it is hard to deny that the most potent venues to generate extensive and persistent marine evaporites are the arid tropics (e.g., present day Red Sea, Abu Dhabi) rather than the humid equator. Orography is known to perturb zonal circulation patterns, but considering the wide spatial distribution and tight temporal coupling between source and seal rock formation in the Late Jurassic of the Persian Gulf, one would expect a major orographic perturbation to rise (or disappear) in a few million years, shifting the paradigm from rapid horizontal plate motion, for which we have direct paleomagnetic evidence, to rapid vertical crustal motion, for which there is no evidence at least in the Persian Gulf.

Our plate-motion scenario of the Arabian passive continental margin (where organic matter could be efficiently buried in sediments) crossing the ITCZ of high nutrient availability and organic matter productivity and rapidly drifting into the anhydritic seal-forming tropics seems to explain some of the key factors that contributed to the world's Jurassic hydrocarbon richness, especially in the Persian Gulf, home of the world's largest oil field at Ghawar (Alsharhan and Nairn, 1997; Sorkhabi, 2010). Notably, a reduced timing between source and seal formation as predicted by our plate stratigraphy model reduces the uncertainties related to oil maturation and migration relative to timing of trap formation: Oil can migrate virtually any time after organic matter deposition and maturation and still be efficiently trapped by the early-in-place evaporitic seal lying immediately above.

In conclusion, our plate tectonic model for the genesis and sealing of Late Jurassic oil, especially in the Persian Gulf, should be considered a promising first-order model that will require further tests and elaboration by means of finely dated, global plate-motion scenarios. These will in turn be obtained by means of a further improved inventory of well-dated and inclination flattening-free paleomagnetic data as well as paleoclimate models of paleogeographies cast in the appropriate latitudinal reference frame according to the geocentric axial dipole model.

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GSA 2016

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- **Attendees:** ~7,100
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- **Short Courses:** 18
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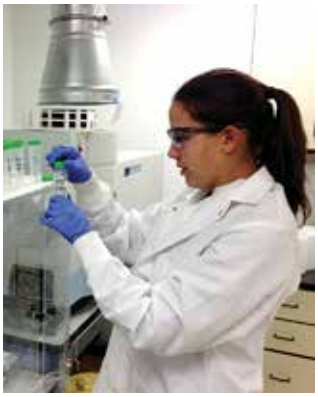

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San Antonio, Texas, USA
Shlemon Mentor Luncheon Program: Mon., 13 March
Mann Mentors in Applied Hydrology Luncheon: Tues., 14 March

Northeastern/North-Central Joint Meeting
Pittsburgh, Pennsylvania, USA
Shlemon Mentor Luncheon Program: Mon., 20 March
Mann Mentors in Applied Hydrology Luncheon: Tues., 21 March

Southeastern Section Meeting
Richmond, Virginia, USA
Shlemon Mentor Luncheon Program: Thurs., 30 March
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Cordilleran Section Meeting
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Kayaking on Llano River, southwest of Mason, Texas. Photo provided by Tony Plutino.

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Rooms have been reserved at the Omni Hotel at the Colonnade, 9821 Colonnade Blvd., San Antonio, Texas, 78230, USA. Reservations should be made by calling Omni Hotels and Resorts at +1-800-843-6664 (toll free) or +1-210-691-8888 (local). Please be sure to mention that you are attending the GSA meeting. Rate: US$165 plus tax. The Omni Hotel at the Colonnade adjoins the meeting Conference Center and offers a limited number of rooms at the conference rate.

TECHNICAL PROGRAM

In addition to the following sessions, there will also be discipline sessions and poster sessions. Please direct questions on these sessions to the technical program chair: David Turner, dturner2@stmarytx.edu.

Theme Sessions

T1. **Advances in Understanding Precambrian to Cenozoic Magmatic and Metamorphic Processes and their Bearing on Lithospheric Evolution of Southern Laurentia.** Principal organizer: Elizabeth Catlos, Univ. of Texas at Austin, ejcatlos@gmail.com.

T2. **Advances in the Application and Development of Terrestrial Paleoclimate Proxies.** *Cosponsored by Soils and Soil Processes Interdisciplinary Interest Group; GSA Geobiology & Geomicrobiology Division; GSA Karst Division.* Principal Organizer: Marina Suarez, Univ. of Texas at San Antonio, Marina.Suarezatutsa.edu.

T3. **Advances in Sedimentology, Stratigraphy, and Geochemistry of Carbonates and Mixed Carbonate Clastic Systems.** *Cosponsored by GSA Karst Division; GSA Sedimentary Geology Division.* Principal organizer: Dan Lehrmann, Trinity Univ., dlehrmann@trinity.edu.

T4. **The Impact of Oceanographic Conditions, OAES, and Volcanism on an Unconventional Reservoir System: The Late Cretaceous Eagle Ford and Austin Chalk Groups of the Gulf Coast.** *Cosponsored by GSA Sedimentary Geology Division.* Principal organizer: Alexis Godet, Univ. of Texas at San Antonio, alexis.godet@utsa.edu.

T5. **Micro- to Macroscopic Evidence of Life and its Implications for the Evolution and Interpretation of the Biosphere in Earth Systems.** *Cosponsored by GSA Geobiology and Geomicrobiology Division; GSA Karst Division.* Principal organizer: Stephen Hasiotis, Univ. of Kansas, hasiotis@ku.edu.

T6. **Karst: From Sinkholes to Springs and Everything in between.** *Cosponsored by GSA Karst Division.* Principal organizer: Geary Schindel, Edwards Aquifer Authority, gschindel@edwardsaquifer.org.

T7. **Planetary Geology.** *Cosponsored by GSA Karst Division.* Principal organizer: Danielle Wyrick, Southwest Research Institute, danielle.wyrick@swri.org.

T8. **Subsurface Exploration Techniques in the South-Central U.S.** *Cosponsored by GSA Archaeology Geology Division; GSA Geophysics Division.* Principal organizer: Evelynn Mitchell, Saint Mary's Univ., emitchell1@stmarytx.edu.

T9. **Fostering Cultures of Deliberate Inclusion in Geosciences.** *Cosponsored by GSA Geoscience Education Division; International Association for Geoscience Diversity.* Principal organizer: Stephen K. Boss, Univ. of Arkansas, sboss@uark.edu.

T10. **Late Paleozoic Tectonic Framework of the South-Central Region and Evolution of the Permian Basin.** *Cosponsored by GSA Structural Geology and Tectonics Division.* Principal organizer: Robert Stern, Univ. of Texas at Dallas, rjstern@utdallas.edu.

T11. **Petroleum and Water Interactions in Mexico's South-Central Region.** *Cosponsored by GSA International Interdisciplinary Interest Group.* Principal organizer: Antonio Cardona, Oklahoma State Univ., antonio.cardona_benavides@okstate.edu.

T12. **Upper Crustal Deformation across Continental Interiors from the Mesozoic to the Present.** *Cosponsored by GSA Structural Geology and Tectonics Division.* Principal organizer: Keith Gray, Wichita State Univ., k.grayatwichita.edu.

T13. **Texas Water Research Network: A Statewide Initiative to Integrate and Advance Water Research from Inception to Application.** *Cosponsored by GSA Hydrogeology Division; GSA Karst Division.* Principal organizer: Suzanne A. Pierce, Texas Advanced Computing Center, spierceattacc.utexas.edu.

T14. **Groundwater Availability in Texas: Rule of Capture and Sustainable to Consensus Yield.** *Cosponsored by GSA Hydrogeology Division; GSA Karst Division.* Principal organizer: Brian Hunt, Barton Springs Edwards Aquifer Conservation District, brianh@bseacd.org.

T15. **Undergraduate Students (Posters).** *Cosponsored by Council on Undergraduate Research Geosciences Division.* Principal organizer: Elizabeth A. Heise, School of Earth, Environmental and Marine Sciences, Univ. of Texas at Rio Grande Valley, elizabeth.heise@utrgv.edu.

FIELD TRIPS

For additional information, please contact the field trip chair, Dan Lehrmann, dlehrmann@trinity.edu; contact the trip leaders; or check the meeting website. All trips depart from the Omni Hotel at the Colonnade unless otherwise noted.

1. **The Edwards Aquifer—A Groundwater System Under Stress.** Sat., 11 March, 8:30 a.m.–5 p.m. Cost: $66; includes transportation, lunch, and guidebook. *Cosponsored by GSA Karst Division.* Principal organizer: Geary Schindel, Edwards Aquifer Authority, gschindel@edwardsaquifer.org.
2. **South-Central Texas Underground.** Sun., 12 March, 11:30 a.m.–5 p.m. Cost: $20; includes transportation and all lights, helmets, gloves, and kneepads for the trip. *Cosponsored by GSA Karst Division.* Principal organizer: Geary Schindel, Edwards Aquifer Authority, gschindeledwardsaquifer.org.
3. **Hydrogeology of Major Trinity Aquifer Springs in the Blanco River Basin.** Sun., 12 March, 8 a.m.–5 p.m. Cost: $95; includes guidebook, transportation, refreshments, and lunch. *Cosponsored by GSA Karst Division.* Principal organizer: Marcus Gary, Edwards Aquifer Authority, mgary@edwardsaquifer.org.
4. **The Eagle Ford and Austin Chalk Groups in and around San Antonio.** Sun., 12 March, 8 a.m.–4:45 p.m. Cost: $116; includes transportation in minibuses, field guidebook, breakfast, lunch box, and refreshments (water, soda). *Cosponsored by GSA Sedimentary Geology Division.* Principal organizers: Alexis Godet, Univ. of Texas at San Antonio, alexis.godet@utsa.edu; John Cooper, Univ. of Texas at San Antonio, jcgolf.cooper@gmail.com.
5. **Cretaceous Sedimentary Succession, Dinosaur Tracksites, and Structural Geology of the Canyon Lake Gorge and Heritage Museum of the Hill Country.** Sun., 12 March, 7 a.m.–5 p.m. Cost: $110; includes guidebook, transportation, lunch, and entry fees. *Cosponsored by GSA Sedimentary Geology Division.* Principal organizer: Marina Suarez, Univ. of Texas at San Antonio, Marina.Suarez@utsa.edu.
6. **Precambrian Geology of the Western Llano Uplift.** Sat., 11 March, 8 a.m. to Sun., 12 March, 5 p.m. Cost: $250; includes guidebook, transportation, lunch, and one night lodging. Principal organizer: Mark Helper, University of Texas at Austin, helper@jsg.utexas.edu.
7. **Cambrian Microbialites and Associated Marine Facies, Llano River, Mason County.** Fri.–Sun., 10–12 March, depart 5:30 p.m. on Fri.; return 5 p.m. on Sun. Cost: $380; includes transportation, refreshments, guidebook, kayak rental, and lodging at the Honey Creek Ranch on the Llano River. Meals are covered by participants at local restaurants. *Cosponsored by GSA Sedimentary Geology Division.* Principal organizer: Andre Droxler, Rice Univ., andre@rice.edu.

OPPORTUNITIES FOR STUDENTS

Presentation Awards

Awards for the best student posters and papers are supported by the *GSA South-Central Section*. To be eligible, students must be lead authors and presenters, and should be capable of answering detailed questions about their research. These awards will be announced during the Tuesday afternoon reception.

Student Travel Grants

Deadline: 13 Feb. 2017

Students who are GSA members and who register for the meeting are eligible to apply for student travel grants. For further information see **www.geosociety.org/gsa/sections/sc/grants.aspx#travel.**

Mentor Programs

For more information, go to www.geosociety.org/mentors, or contact Jennifer Nocerino at jnocerino@geosociety.org.

Roy J. Shlemon Mentor Program in Applied Geoscience Luncheon. Mon., 13 March, noon–1:30 p.m. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch.

John Mann Mentors in Applied Hydrogeology Program Luncheon. Tues., 14 March, noon–1:30 p.m. Students interested in applied hydrogeology or hydrology as a career will have the opportunity to network with professionals in these fields over a FREE lunch.

Geoscience Career Workshops

For more information, contact Jennifer Nocerino at jnocerino@geosociety.org.

Geoscience Career Workshop Part 1: Career Planning and Informational Interviewing. Your job-hunting process should begin with career planning, not when you apply for jobs. This workshop will help you begin this process and will introduce you to informational interviewing.

Geoscience Career Workshop Part 2: Geoscience Career Exploration. What do geologists in various sectors earn? What do they do? What are the pros and cons?

Geoscience Career Workshop Part 3: Cover Letters, Résumés, and CVs. How do you prepare a cover letter? Does your résumé need a good edit? Learn how to prepare the best résumé possible and avoid typical pitfalls.

Early Career Professional Focus Group

Have you graduated in the last five years and are either a working professional or still looking for a job? GSA would like to support you in pursuing your professional goals. During this 45-minute session participants will be asked a series of questions regarding potential programming and activities that GSA could offer to help you reach your goals. For more information, contact Tahlia Bear at tbear@geosociety.org.

LOCAL COMMITTEE

General Chair: Ben Surpless, bsurples@trinity.edu

Technical Chair: David Turner, dturner2@stmarytx.edu

Field Trip and Workshop Chair: Dan Lehrmann, dlehrmann@trinity.edu

Exhibits: Ben Surpless, bsurples@trinity.edu

Sponsorship: Bob Stern, rjstern@utdallas.edu

2015–2016 GSA-USGS Congressional Science Fellow Final Report

Geoscience COMPETES

Karen Paczkowski

The America COMPETES Act (Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science) was introduced in 2007 in response to the National Academies of Science report, "Rising Above the Gathering Storm: Engaging and Employing America for a Brighter Economic Future." The report warned that the U.S. was falling behind other countries in federal science, technology, engineering, and mathematics (STEM) investment, and that America's position as a global leader in discovery and innovation was eroding.

The America COMPETES Act set visionary goals for STEM research and education, recognizing that U.S. leadership in discovery and innovation depends on robust support for basic science research. The act set in motion a plan to double the funding for the National Science Foundation (NSF), National Institute of Standards and Technology (NIST), and Department of Energy (DOE) Office of Science by 2017. COMPETES passed with overwhelming bipartisan support in both the U.S. Senate and the House of Representatives. However, actual funding levels have fallen far short of the act's original visionary trajectory, and since the law's expiration in 2013, Congress has been deeply divided on a new authorization bill.

One particular sticking point has been the proposal to give Congress more direct control over funding of NSF directorates. A new version of COMPETES introduced in 2015 in the House would reduce funding for the geosciences and social sciences, while other sciences would see funding increases. In response, the Senate instead drafted a bill to recapture the original vision of the 2007 COMPETES Act. A bipartisan Innovation and Competitiveness Working Group held a series of stakeholder roundtables to explore federal research and development policy priorities. The working group was led by Senators Cory Gardner (R-CO) and Gary Peters (D-MI), both members of the Senate Committee on Commerce, Science, and Transportation, which is the Committee responsible for reauthorizing funding levels and policy directions for the federal agencies covered by COMPETES.

U.S. STEM research and education has been a key cause of mine since my earliest forays into policy as a graduate student, and Senator Edward J. Markey's (D-MA) office, where I served as the GSA-USGS Congressional Science Fellow, has contributed to the creation of this new bill. In my role as a Fellow I had the opportunity to work on this legislation and draft the Senator's statements for hearings.

During a hearing on 11 May 2016, Senator Markey stated, "Our funding decisions for basic science research should be guided by the possibilities promised by science and technology, and not by politics. A recent version of COMPETES, released and passed by Republicans over in the House, has singled out certain sciences as winners and other sciences as losers, authorizing funding increases for the former and decreases for the later. This narrow view of the scientific process ignores how advances in one area of science drive breakthroughs in seemingly unrelated fields. Science operates in a complex research ecosystem, and legislation should support the full range of scientific inquiry." Senator Markey also entered two letters into the congressional record. The first letter, signed by 100 universities, research institutions, and scientific professional societies, and the second letter written by 19 geoscience organizations including GSA, the American Geophysical Union, and the American Association of Petroleum Geologists, both provide concrete examples of how geoscience plays an essential role in tackling national challenges in water and mineral resources, energy independence, environmental issues, Earth's climate and ocean system, and mitigation of natural hazards. By entering these letters into the congressional record during the hearing, Senator Markey highlighted the important role geoscience plays in the U.S. innovation ecosystem and economic health.

On 22 June 2016, the Senate revision of COMPETES was released. The bill, renamed the American Innovation and Competitiveness Act (S. 3084), took the findings the Senate had gathered from the STEM research, education, and industry communities and laid out a bipartisan vision for U.S. STEM research and education. It authorizes a 4% annual funding increase for basic STEM research, in alignment with the American Innovation Imperative, a call to action led by nine large U.S. corporations and signed by more than 500 leading organizations from American industry, higher education, and science and engineering organizations. The bill also defends the NSF peer review process as a gold standard and authorizes programs to improve tech-to-market transfer and manufacturing practices to get more American discoveries out of the lab and into people's lives.

Working with Massachusetts' constituents like the Museum of Science in Boston, Senator Markey's office noticed that although the bill supported STEM education in university settings, it lacked a section highlighting the importance of informal STEM education. Informal STEM education is an important gateway for inspiring individuals to pursue careers in STEM fields, and is especially important for the geosciences. My own dedication to understanding the natural world began at a young age with visits to museums and parks, and exploring the outdoors. Through Senator Markey's office, I worked closely with the Museum of Science, committee staff, and legislative counsel to draft an amendment to the American Innovation and Competitiveness Act. The amendment allows NSF to support programs like the National Informal STEM Education (NISE) Network, a successful, decade-long program that has connected over 500 organizations by pairing informal STEM education organizations with cutting-edge research institutions to ensure the public gets the most

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up-to-date science. We garnered support for the amendment among the Senate offices by explaining the importance of informal STEM education and by detailing for each Senator on the Commerce Committee how their state has benefitted from the NISE Network. The amendment was passed on to the bill in the managers' package during the committee markup on 29 June 2016. The bill is now making its way through the legislative process with a vote possible this fall.

This article will be my final GSA-USGS Congressional Science Fellow Report. As my fellowship comes to a close, I would like to thank both GSA and the USGS for supporting my year in the Senate. It has truly been a privilege to advance the importance of geoscience, and to help bring the wonder of discovery and innovation to all citizens. Please feel free to contact me if you have any questions. I'm always happy to talk about the intersection between science and policy, and am eager to help scientists enter the science policy world.

The manuscript is submitted for publication by Karen Paczkowski, 2015–2016 GSA-USGS Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and the U.S. Geological Survey, Department of the Interior, under Assistance Award No. G15AP00128. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government.
Paczkowski works in the office of Senator Edward J. Markey (D-MA) and can be contacted by e-mail at karen.paczkowski@gmail.com.

Leadership Opportunities

Volunteer or nominate a colleague to serve on a GSA Committee, and help advance the impact of geoscience and geoscientists. Students and early career professionals are encouraged to bring their unique points of view to GSA leadership.

www.geosociety.org/committees

2016–2017 GSA-USGS Congressional Science Fellow Named

Kirstin L. Neff

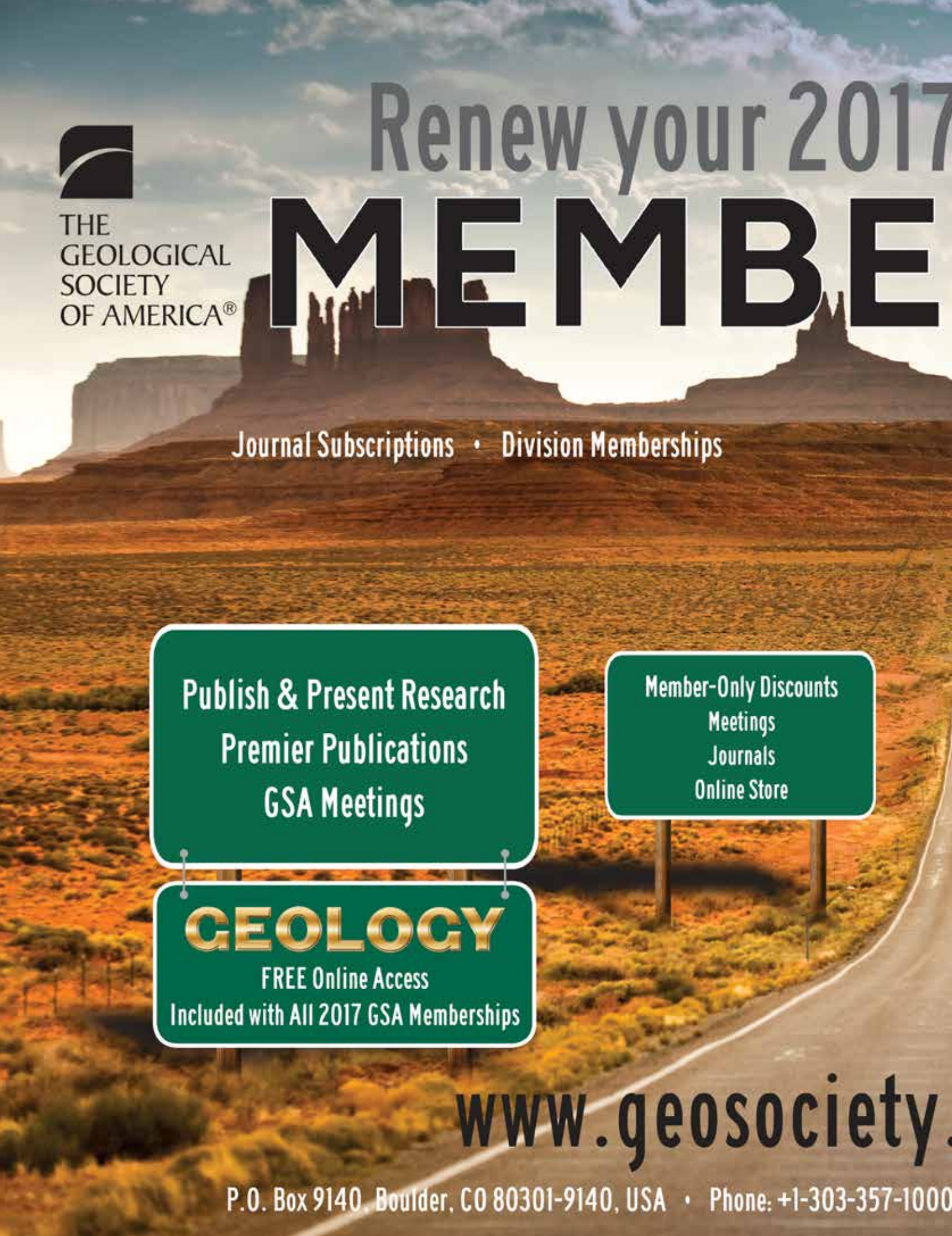
Kirstin L. Neff is thrilled to serve as the 2016–2017 GSA-USGS Congressional Science Fellow. She has accepted a placement in the office of Senator Martin Heinrich (D-NM), where she will be working on water and public lands issues.

Kirstin earned a B.A. *cum laude* from Wellesley College in 2008, with majors in political science and Russian language and literature. She wrote a senior honors thesis on U.S. immigration policy and received an award from the economics department for her paper on tariffs in the cement industry. She conducted ecological research on Lake Baikal in Siberia and studied abroad in St. Petersburg and Moscow, Russia. While at Wellesley, she was a managing editor of the *International Relations Council Journal*, a student-run peer-reviewed publication, and co-president of the College Democrats.

Kirstin received an M.S. (2013) and Ph.D. (2015) in hydrology from the University of Arizona in her hometown of Tucson. She was awarded a U.S. Environmental Protection Agency Science to Achieve Results (EPA STAR) Fellowship to support her doctoral research, which used stable water isotopes to characterize the seasonality of groundwater recharge across the Basin and Range Province of western North America. Her research has implications for climate change and development impacts to aquifers. Most recently, she was a postdoctoral scholar at NASA's Jet Propulsion Laboratory, working on satellite radar measurements of subsidence in California's Central Valley.

Kirstin has expertise in hydrologic modeling, water policy, remote sensing and spatial analysis, K–12 science outreach, and international relations. She has extensive experience in communicating scientific and technical information, having worked as a technical writer in the engineering sector and as a mentor scientist for several outdoor education programs. She speaks Spanish and Russian.

She is passionate about building a scientifically literate workforce through STEM education and conserving natural resources through public outreach and scientifically sound policymaking. In her fellowship year, she is looking forward to learning about the legislative process and further developing her science communication skills while contributing her scientific expertise to the policymaking process.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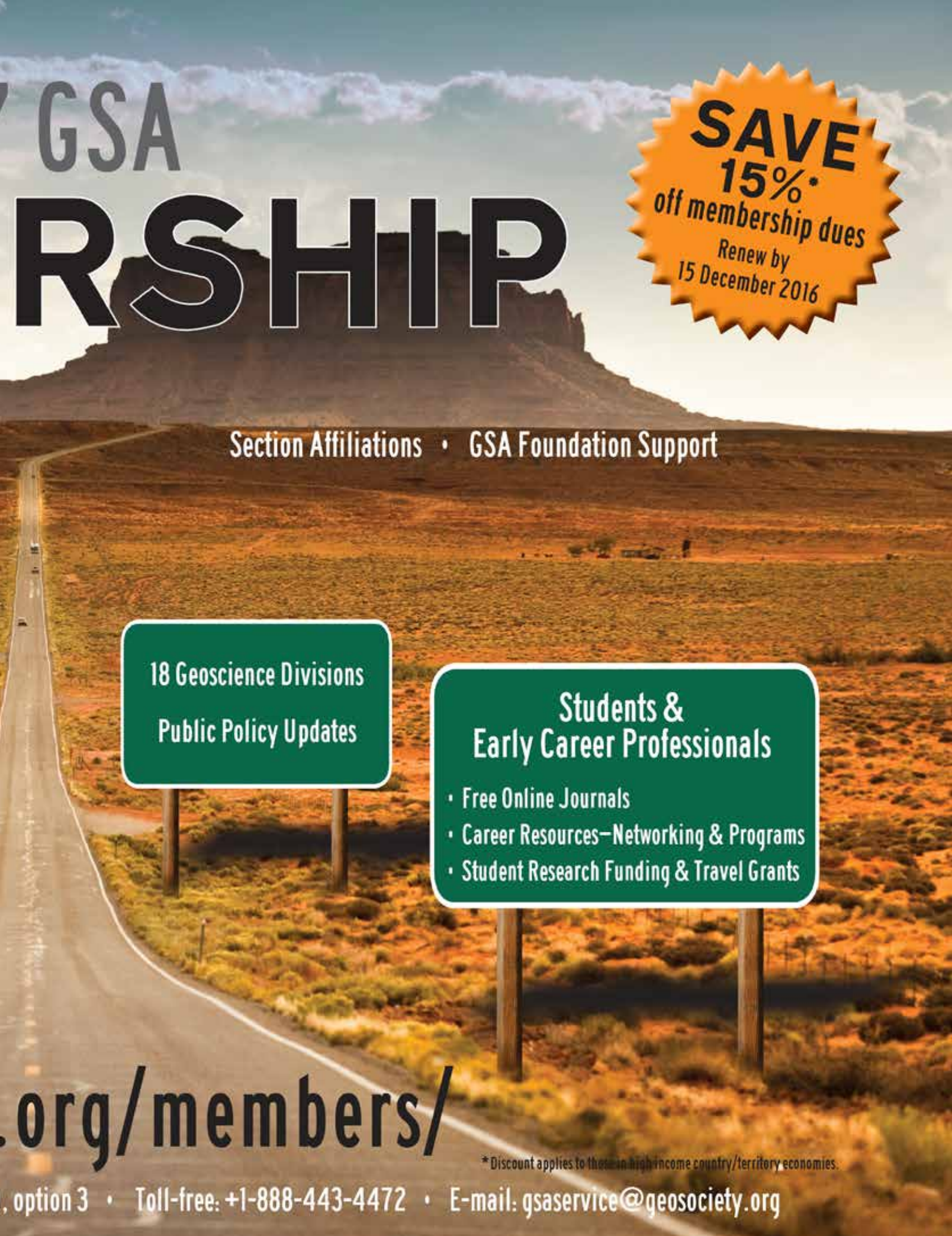
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Upcoming Award Deadlines

For details, see the October *GSA Today* or go to **www.geosociety.org/gsa/awards/about_GSA_awards.aspx.**

Award nominations: **www.geosociety.org/gsa/awards/nominate.aspx.**

Fellowship nominations: **http://rock.geosociety.org/members/fellow.asp.**

You can also email GSA Grants and Awards at **awards@geosociety.org.**

2017 GSA Medals and Awards

Nomination deadline: 1 Feb. 2017

- Penrose Medal
- Day Medal
- Young Scientist Award (Donath Medal)
- GSA Public Service Award
- Randolph W. "Bill" and Cecile T. Bromery Award for Minorities
- GSA Distinguished Service Award
- Doris M. Curtis Outstanding Woman in Science Award
- Geologic Mapping Award in Honor of Florence Bascom
- Honorary Fellow

GSA Fellowship

Nomination deadline: 1 Feb. 2017

Elevation to GSA Fellowship is an honor bestowed on the best of our profession at each spring GSA Council meeting. For a list of current GSA Fellows, go to **www.geosociety.org/GSA/About/awards/GSA_Fellows/GSA/Awards/Fellowship.aspx.** Nominate a deserving colleague for the honor of GSA Fellowship at **http://rock.geosociety.org/members/fellows.asp.**

For a list of other national awards and nomination forms, go to **www.geosociety.org/gsa/awards/national.aspx**. If you know of an award not listed, please send the details to awards@geosociety.org.

John C. Frye Environmental Geology Award

Nomination deadline: 31 Mar. 2017

In cooperation with the Association of American State Geologists and supported by endowment income from the GSA Foundation's John C. Frye Memorial Fund, GSA makes an annual award for the best paper on environmental geology published either by GSA or by a state geological survey.

2017 Post-Doctoral Research Awards

Application deadline: 1 Feb. 2017

- The **Gladys W. Cole Memorial Research Award** for research on the geomorphology of semiarid and arid terrains in the United States and Mexico is awarded annually to a GSA member or Fellow between 30 and 65 years of age who has published one or more significant papers on geomorphology.
- The **W. Storrs Cole Memorial Research Award** for research on invertebrate micropaleontology is awarded annually to a GSA member or Fellow between 30 and 65 years of age who has published one or more significant papers on micropaleontology.

Learn more about these post-doc research awards at **www.geosociety.org/gsa/grants/postdoc.aspx.**

OTHER AWARDS

Nomination deadline: 1 Feb. 2017

Submit nominations for the following awards at **www.agiweb.org/direct/awards.html.**

- **AGI Medal in Memory of Ian Campbell for Superlative Service to the Geosciences** recognizes singular performance in and contribution to the profession of geology.
- **The AGI Marcus Milling Legendary Geoscientist Medal** is given to a recipient with consistent contributions of high-quality scientific achievements and service to the Earth sciences having lasting, historic value; who has been recognized for accomplishments in field(s) of expertise by professional societies, universities, or other organizations; and is a senior scientist nearing completion or has completed full-time regular employment.

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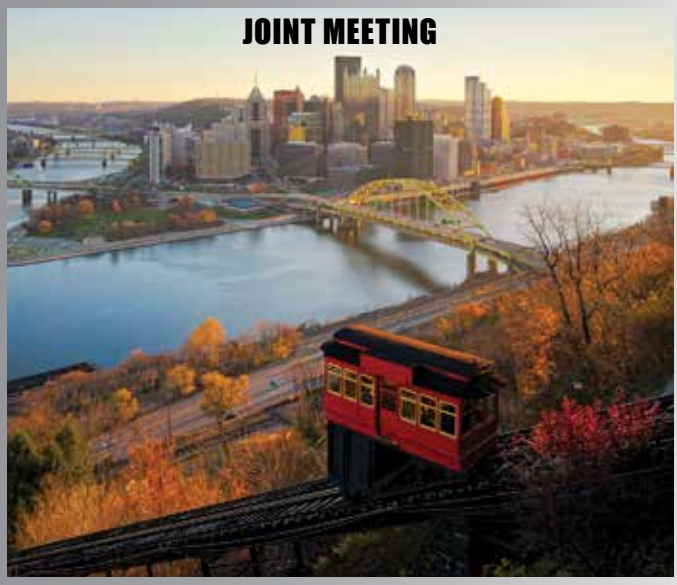
2017 GSA Section Meetings

Aerial overview of the Canyon Lake spillway of south-central Texas. Photo by Larry Walther.

South-Central Section
Location: San Antonio, Texas, USA
Dates: 13–14 March
Meeting Chair: Benjamin Surpless, bsurples@trinity.edu
www.geosociety.org/sc-mtg



Downtown Pittsburgh from Duquesne Incline.

Northeastern Section
(Joint with North-Central Section)
Location: Pittsburgh, Pennsylvania, USA
Dates: 19–21 March
Meeting Chair: Patrick Burkhart, patrick.burkhart@sru.edu
www.geosociety.org/ne-mtg

North-Central Section
(Joint with Northeastern Section)
Location: Pittsburgh, Pennsylvania, USA
Dates: 19–21 March
Meeting Chair: Timothy G. Fisher, timothy.fisher@utoledo.edu
www.geosociety.org/nc-mtg

Midlothian Mines. Photo used with permission from Richmond Region Tourism.

Southeastern Section
Location: Richmond, Virginia, USA
Dates: 30–31 March
Meeting Co-Chairs: David Spears, david.spears@dmme.virginia.gov; Karen Layou, klayou@reynolds.edu
www.geosociety.org/se-mtg

Used with permission from Hawai'i Tourism Authority. Photo by Tor Johnson.

Cordilleran Section
Location: Honolulu, Hawaii, USA
Dates: 23–25 May
Meeting Chair: Craig R. Glenn, glenn@soest.hawaii.edu
www.geosociety.org/cd-mtg

Dinosaur Provincial Park. Photo by Jenni Scott.

Rocky Mountain Section
Location: Calgary, Alberta, Canada
Dates: 9–10 June
Meeting Chair: Katherine Boggs, kboggs@mtroyal.ca
www.geosociety.org/rm-mtg

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You're invited to an open house, or an upcoming webinar, at the Museum. Complete details are available at **amnh.org/mat**

With deepest appreciation, the Museum acknowledges Kathryn W. Davis for her generous founding support of the MAT Program.

Leadership support for the MAT program is provided by The Shelby Cullom Davis Charitable Fund.

The MAT program is supported in part by the National Science Foundation under Grant Numbers DRL-1119444 and DUE-1340006, and the U.S. Department of Education under Grant Number U336S140026.

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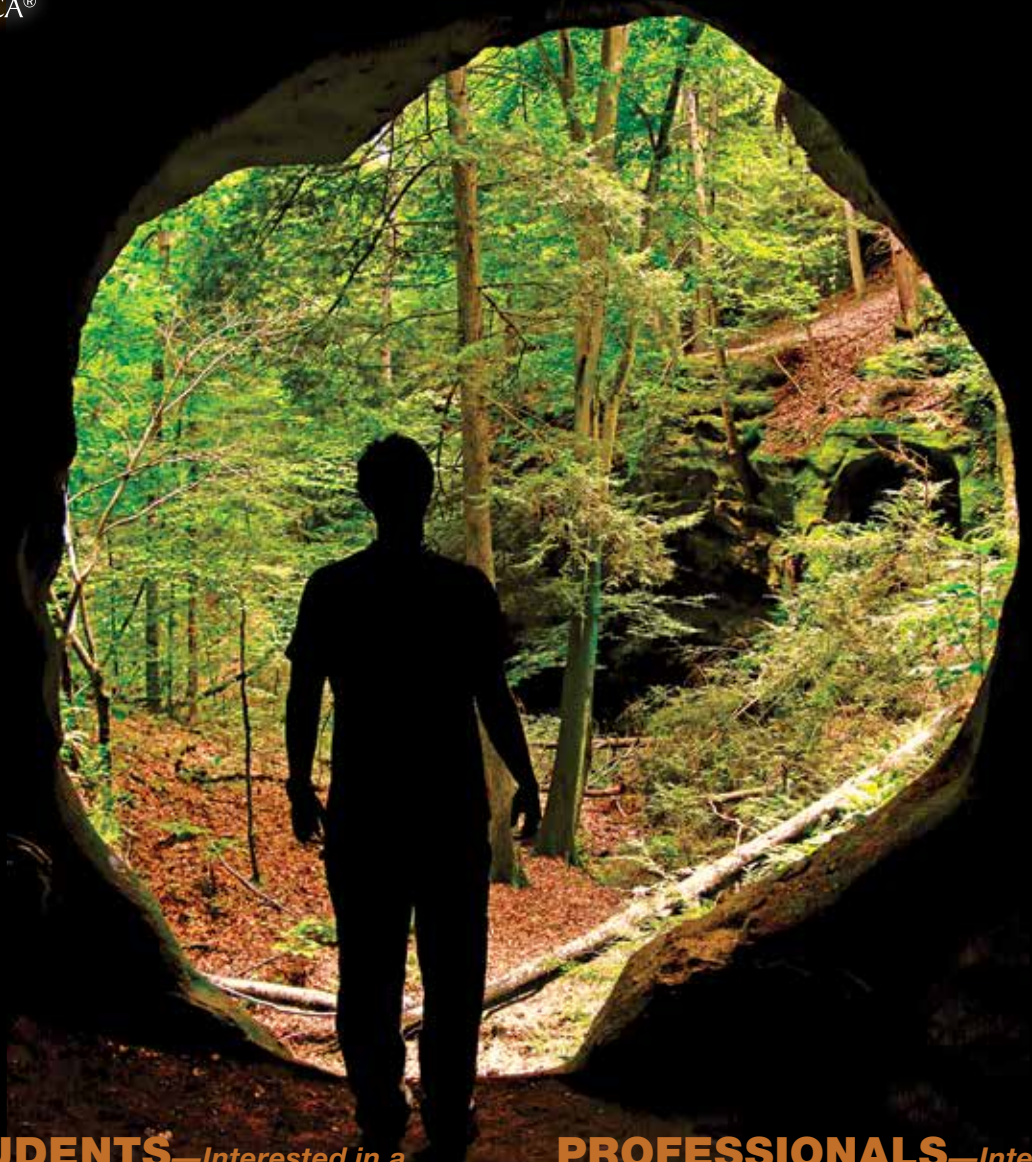


STUDENTS—*Interested in a career in the applied geosciences?*

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 2017 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. If you are interested in becoming a mentor at one of the GSA Section Meetings, contact Jennifer Nocerino, jnocerino@geosociety.org. Early career professionals are encouraged to volunteer.

www.geosociety.org/mentors/

Geoscience Jobs & Opportunities

Ads (or cancellations) must reach the GSA advertising office no later than the first of the month, one month prior to the issue in which they are to be published. Contact advertising@geosociety.org, +1.800.472.1988 ext. 1053, or +1.303.357.1053. All correspondence must include complete contact information, including e-mail and mailing addresses.

Positions Open

TWO TENURE-STREAM FACULTY POSITIONS: GLOBAL CHANGE PROCESSES/GEOPHYSICS MICHIGAN STATE UNIVERSITY

The Dept. of Earth and Environmental Sciences at Michigan State University (MSU) is searching for two tenure-stream Assistant Professors starting Fall 2017. Exceptional candidates at Associate or Full Professor level will also be considered. Both positions include an enhanced level of flexible research funding from endowment resources.

Global Change Processes: We seek a global change geoscientist focused on near-surface environments. Areas of emphasis could include sediment transport, the cryosphere, environmental geophysics, stable isotope geochemistry, geochronology, geobiology, and ocean/atmospheric circulation.

Geophysics: We seek a geophysicist who will complement our current strengths in lower mantle dynamics, mineral physics, surface tectonics, and geochemistry. We especially encourage applicants with expertise in seismology.

Review of applications will begin on January 9, 2017, and continue until the positions are filled. Further details and instructions for applying can be found on jobs.msu.edu, posting 2591.

Please direct questions to Michael Gottfried at gottfrie@msu.edu, copied to eeshire@msu.edu. MSU is an EOE/Affirmative Action employer, which includes protected veterans and persons with disabilities. We endeavor to facilitate employment assistance to spouses or partners of candidates for faculty and academic staff positions.

HARRY HESS FELLOWS PROGRAM DEPARTMENT OF GEOSCIENCES PRINCETON UNIVERSITY

The Dept. of Geosciences at Princeton University announces competition for the 2016–2017 Harry Hess Fellows Program. This honorific postdoctoral fellowship program provides opportunities for outstanding geoscientists to work in the field of their choice. Research may be carried out independently or in collaboration with members of the Geosciences Department. One or more Hess Fellows may be appointed. Applicants must have obtained a Ph.D. at the time of the start of the fellowship, but not more than five years before. Current areas of research include:

- Biogeochemical Cycles
- Paleoclimatology
- Environmental Chemistry
- Paleontology
- Geochemistry
- Petrology
- Geodynamics
- Seismology
- Geomicrobiology
- Tectonics
- Mineral Physics
- Atmospheric Science
- Oceanography
- Planetary Science
- Geochronology
- Earth History

Applications are due on January 1, 2017, but evaluation of applications and interviews of candidates will begin immediately. Applicants should include a cover letter, a curriculum vitae including a publication list, a 1–2 page statement of research interests and goals, and name, address and email address of three referees familiar with their work by applying on the Princeton University jobsite at https://jobs.princeton.edu. Hess Fellowships provide a competitive annual salary, depending upon experience, along with a significant allowance for travel to meetings and for research support. Initial awards are for one year, with the possibility of renewal for additional years depending upon satisfactory performance and available funding. A preferred starting date is on or before September 1st, 2017. Applicants for the Hess Fellowship may also be considered for other available postdoctoral positions in the Geosciences Department.

Princeton University is an equal opportunity/affirmative action employer and all qualified applicants will receive consideration for employment without regard to age, race, color, religion, sex, sexual orientation, gender identity or expression, national origin, disability status, protected veteran status, or any other characteristic protected by law. This position is subject to the University's background check policy.

Information about the research activities of the Dept. of Geosciences may be viewed at http://geoweb.princeton.edu.

TENURE-TRACK ASSISTANT PROFESSOR, GEODESY, CALIFORNIA STATE UNIVERSITY NORTHRIDGE

The Dept. of Geological Sciences at California State University, Northridge invites applications for a full-time tenure-track faculty position at the level of Assistant Professor in geodesy to study surface and/or subsurface Earth processes. We offer B.S., and M.S., degrees in Geology and in Geophysics. We seek an innovative geodesist with technical expertise in GPS, InSAR, LiDAR, radar altimetry, gravimetry or other geodetic methods. Candidates with research that complements our current research program are encouraged including but not limited to surface processes, sedimentology, geomorphology, climate, coseismic and interseismic fault physics, marine geology and geophysics, planetary geophysics, and crust and mantle scale tectonics. The successful candidate is expected to develop a vigorous research program, which includes obtaining extramural funding, publishing peer-reviewed papers, and involving B.S. and M.S. students. The successful candidate is also expected to demonstrate teaching excellence and provide effective instruction to students of diverse backgrounds in a multicultural setting. Potential classes to be taught by the new hire include an undergraduate core course in Earth Systems or Plate Tectonics and Structure, general education courses, and elective offerings at the upper-division and/or graduate level in the candidate's research specialty. The successful candidate must have a Ph.D. at the time of appointment. Experience in post-doctoral research and/or University-level lecture instruction is desirable. Applicants should submit a statement of research interests, a statement of teaching philosophy and experience, a cover letter, CV, and the names and full contact information for three references,. Electronic submissions are strongly encouraged and should be sent to geodesy@csun.edu. Materials can also be sent to: Geodesy Search Committee, Dept. of Geological Sciences, California State University Northridge, 18111 Nordhoff Street, Northridge, CA 91330-8266. Review of applications will begin January 5, 2016. Priority will be given to applications received by this date, but the position remains open until filled. For additional information, see http://www.csun.edu/geology.

The University is an EO/AA employer.

TENURE-TRACK ASSISTANT PROFESSOR POSITIONS IN ENVIRONMENTAL/ENGINEERING GEOLOGY, KANSAS STATE UNIVERSITY

The Dept. of Geology at Kansas State University is searching for a faculty member at the assistant professor level with expertise in Environmental/Engineering Geology, starting in August 2017. The successful candidate's research will emphasize water resources. Anticipated areas of specialization could include at least one of the following: geological/environmental engineering with focus on water resources, geohazard risk assessment and prediction, numerical modeling of flow in porous media and fracture networks, soil and vadose zone hydrology, remote sensing applied to hydrogeology/engineering geology, and hydro-mechanical coupling.

A detailed advertisement for the position is located: http://careers.k-state.edu/cw/en-us/job/497608/assistant-professorgeology. Screening of applications begins January 02, 2017, and continues until the position is filled. Full consideration will be given to applications received by January 02, 2017. Kansas State University is an EOE of individuals with disabilities and protected veterans. Kansas State University actively seeks diversity among its employees. Background check required.

GEOLOGICAL CONSULTANT (SENIOR GEOCHEMIST) ARAMCO SERVICES

Our Houston Research Center focuses on research and innovation in geology, geophysics, reservoir engineering, production technology, drilling, and sensors development to advance the discovery and recovery of oil and gas. Located in Houston's Energy Corridor, the center neighbors the nation's leading petroleum engineering universities, labs, manufacturers, and service companies.

The Aramco Research Center in Houston seeks a Senior Quantitative Geochemist to develop a research program in applied organic and inorganic

geochemistry research with a strong emphasis on computational modeling linked to laboratory analyses and experimentation. The candidate will bring broad industry knowledge of organic and inorganic geochemistry applications ranging from nano- to basin scale, providing technical leadership for integrated research including diagenesis, hydrocarbon systems evaluation and source-rock analysis. The candidate will be expected to work with laboratory with support staff in the use of analytical equipment for organic geochemistry research and to collaborate with other researchers in the Aramco Global Research Centers. Geochemistry modeling research will benefit from a keen awareness of advanced analytical and experimental methods and connections to novel technology developments. The position offers an outstanding opportunity to establish and grow a geochemistry research program in a well-integrated, multi-disciplinary research environment.

Applicants should apply online at http://aramcoservices.applytojob.com/apply/TDigvy/Geological-Consultant-Senior-Geochemist-302858?source=Geological+Society+of+America

INSTRUCTOR OF GEOLOGY
UNIVERSITY OF MISSISSIPPI

Job Description: The Dept. of Geology and Geological Engineering at the University of Mississippi invites applications for an Instructor of Geology. This is a non-tenure nine-month academic position subject to continuous renewal.

Responsibilities: The successful candidate is expected to teach a variety of non-major geology courses and geology courses required for students in the geology and geological engineering undergraduate degree programs, as needed to meet departmental responsibilities; this includes overseeing or assisting with laboratory coordination. The candidate is also expected to contribute to departmental service, including advising undergraduate students for the B.S. in Geology program and student retention efforts.

Qualifications/Skills: Competitive candidates will have a Master of Science degree in Geology or Geological Engineering, minimum of 2 years of demonstrated teaching experience, strong interpersonal and communication skills, and a commitment to undergraduate education with demonstrated excellence in teaching, student mentoring, and advising.

Contacts and application: Review of applications will begin immediately and continue until the position is filled or until an adequate applicant pool is established. Apply online only at http://jobs.olemiss.edu. Applications cannot be accepted in any other format. Required application materials are (1) resume or CV, (2) cover letter, (3) statement of teaching philosophy, (4) summary of teaching evaluations, and (5) list of references. If you need assistance with the online application process, please contact The University of Mississippi Employment Office at 662-915-5690. For additional information, contact Dr. B.F. Platt at bfplatt@olemiss.edu. The University of Mississippi is an EOE/AA/Minorities/Females/Vet/Disability/Sexual Orientation/Gender Identity/Title VI/Title VII/Title IX/504/ADA/ADEA employer.

ENVIRONMENTAL GEOSCIENCE
ASSISTANT PROFESSOR
UNIVERSITY OF NORTHERN COLORADO

The College of Natural and Health Sciences at the University of Northern Colorado invites applications for the position of Assistant Professor of Earth and Atmospheric Sciences, Environmental Geoscience. This 9-month tenure-track position requires a terminal degree or ABD in geosciences or closely related field. ABDs will be considered with the expectation the terminal degree is received within one (1) year of the starting date. The successful candidate will demonstrate the potential for excellent instruction of environmental geoscience courses that could include any of the following: hydrology, soils, petroleum and sustainable energy resources, near-surface geophysics, geosphere/atmosphere transfer processes, geomorphology, and environmental geochemistry. Candidates applying for this position are expected to demonstrate potential for continued scholarly activity, ability to secure outside funding, and engagement in the environmental sciences profession. Preference will be given to applicants who demonstrate the ability to collaborate with colleagues in industry, regulatory agencies, government, education or consulting to create research and internship opportunities for our students. The full vacancy announcement and application instructions are available at http://www.unco.edu/natural-health-sciences/about-us/employment-opportunities.aspx.

Screening of applications begins January 17, 2017, and continues until the position is filled. Contact chair of the search committee for questions: Steven.Anderson@unco.edu.

The University is an AAEO employer.

ASSISTANT PROFESSOR IN
ORGANIC GEOCHEMISTRY
CONOCOPHILLIPS SCHOOL OF
GEOLOGY AND GEOPHYSICS
THE UNIVERSITY OF OKLAHOMA

The University of Oklahoma invites applications for a tenure-track position in organic geochemistry at the level of Assistant Professor. The ConocoPhillips School of Geology and Geophysics has a distinguished history in organic geochemistry. We seek an individual who will complement our existing strengths in the geochemical study of organic matter, and who will help us move forward into new and exciting areas of research. The successful candidate must show potential to be an effective teacher who will contribute to our core undergraduate curriculum as well as offer advanced classes in the discipline. The successful applicant will hold a Ph.D. at the time of application, develop an externally funded research program, and sponsor and train graduate students at the Masters and Doctoral levels.

The ConocoPhillips School of Geology and Geophysics is housed in the Sarkeys Energy Center. Our research facilities, which are detailed at http://www.ou.edu/content/mcee/geology/Research.html, include extensive laboratory capabilities in mass spectrometry of carbon compounds and bulk and compound-specific stable isotopic analysis. As the chemistry of carbon figures prominently in research campus-wide, this position in organic geochemistry fills a prominent role with many avenues for collaboration with faculty within and outside of the School.

Review of applications will begin January 1, 2017. The search will continue until the position is filled. The anticipated start date for the position is Fall semester 2017. Applicants can apply online at http://apply.interfolio.com/38699. Applicants will be required to submit a vita/resume, statement of plans for sponsored research, teaching interests, and a list of five references who can be contacted, including telephone numbers, e-mail addresses, and mailing addresses. Questions or information requests should be addressed to the Chair of the Organic Geochemistry Search Committee, at 405-325-3253 or ougeochemistrysearchchair@ou.edu.

The University of Oklahoma (OU) is a Carnegie-R1 comprehensive public research university known for excellence in teaching, research, and community engagement. In 2014, OU became the first public institution ever to rank #1 nationally in the recruitment of National Merit Scholars, with 311 scholars. The 277-acre Research Campus in Norman was named the No.1 research campus in the nation by the Association of Research Parks in 2013. Norman is a culturally rich and vibrant town located just outside Oklahoma City. With outstanding schools, amenities, and a low cost of living, Norman is a perennial contender on the "Best Places to Live" rankings. Visit http://soonerway.ou.edu for more information.

The University of Oklahoma is an Affirmative Action, Equal Opportunity Employer. Individuals from underrepresented groups are encouraged to apply.

TENURE-TRACK FACULTY POSITION
UNIVERSITY OF ROCHESTER

The Dept. of Earth and Environmental Sciences at the University of Rochester invites applications for a tenure-track position in the broad field of geophysics and geodynamics. We anticipate hiring at the Assistant Professor level but exceptional candidates at the Associate and Full Professor level will be given full consideration. We are interested in dynamic educators and researchers who use experimental, computational and/or field approaches in their research and can establish externally funded, internationally recognized research programs that involve graduate students. The field of specialization is open, but preference will be given to individuals who can offer a research and teaching program that complements and expands upon our existing strengths in solid Earth processes and climate science. See http://www.ees.rochester.edu for more information about the department's strengths in geochemistry, geophysics, tectonics, and climate science. We also encourage interdisciplinary applicants who can bridge the gap between traditional Earth Science and planetary science, as well as applicants who can utilize other outstanding research facilities at the University, including the Laboratory for Laser Energetics, http://www.lle.rochester.edu, and the Goergen Center for Data Sciences, https://www.rochester.edu/data-science/.

The University of Rochester is a highly ranked research university, and the Rochester area's cultural, educational, and recreational assets frequently place

it among the best places to live, work, and raise a family in the United States. Applicants should submit materials via: https://www.rochester.edu/faculty-recruiting Materials include a curriculum vitae, select reprints, statements of research and teaching goals, and the names and contact information of four references. The review of applications will begin December 31, 2016, and will continue until the position is filled. The preferred start date for the position is July 1 2018. The University of Rochester, an equal opportunity employer, has a strong commitment to diversity and actively encourages applications from candidates from groups underrepresented in higher education.

EOE / Minorities / Females / Protected Veterans / Disabled.

ENDOWED DISTINGUISHED PROFESSORSHIP IN GEOSCIENCES
DEPT. OF GEOLOGICAL SCIENCES
THE UNIVERSITY OF TEXAS AT SAN ANTONIO

The University of Texas at San Antonio invites applications for a tenured position at the Professor or Associate Professor level, subject to qualifications, in Hydrology, including appointment to the Dr. Weldon W. Hammond, Jr., Endowed Distinguished Professorship in Geosciences, to begin Fall 2017. Full information is available at www.utsa.edu/geosci/positions.html. UTSA is an AA/EEO employer.

INSTRUMENTATION SPECIALIST
UNIVERSITY OF WISCONSIN OSHKOSH

The Dept. of Geology seeks a technician for a 12-month, academic staff position starting September 1, 2017. BS/BA in geology required, MS preferred. She or he will maintain samples, supplies, and equipment, help teach summer field camp, and help train and supervise students: (1) in use of instruments and laboratories, and (2) as outreach presenters. Experience with geology laboratories and instruments, field mapping, specimen/sample curation, and geology software preferred. Refer to https://www.uwosh.edu/hr/employment/instrumentation-specialist-051a.1617 for more information.

FOGARTY ENDOWED CHAIR IN ECONOMIC GEOLOGY (ASSOCIATE OR FULL PROFESSOR)
DEPT. OF GEOLOGY AND GEOLOGICAL ENGINEERING, COLLEGE OF EARTH RESOURCE SCIENCES AND ENGINEERING
COLORADO SCHOOL OF MINES

The Dept. of Geology and Geological Engineering at Colorado School of Mines invites applications for the Charles Fogarty Endowed Chair in Economic Geology. The position is anticipated to be filled at the rank of Associate or Full Professor. The successful candidate must bring the skills needed to develop a world-class research program and will be expected to have strong network connections with both the national and international minerals industry. Will be expected to develop a vigorous externally funded research program in the field of economic geology, maintain a strong record of scholarly publishing, teach at the undergraduate and graduate levels, and direct graduate research and supervise thesis projects. Will participate in field education at the graduate level and represent the department and campus through service and professional engagement in the global economic geology community.

Applicants will have earned a doctoral degree in economic geology or a related discipline, and demonstrate or possess the skill set necessary for tenure at a research-active university. Must have demonstrated leadership in scholarship, service, and teaching at the undergraduate and graduate levels or must have a leadership role in the exploration and mining industry.

For the complete job announcement and directions on how to apply online, visit http://jobs.mines.edu/cw/en-us/job/492525/charles-fogarty-endowed-chair-in-economic-geology.

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

TENURE TRACK ASSISTANT PROFESSOR POSITION IN GEOMORPHOLOGY AND/OR COASTAL PHYSICAL OCEANOGRAPHY
DEPT. OF EARTH, OCEAN AND ATMOSPHERIC SCIENCE
THE FLORIDA STATE UNIVERSITY

The Dept. of Earth, Ocean and Atmospheric Science (EOAS) at the Florida State University (FSU) announces a search for a tenure track Assistant Professor in coastal/land-sea processes, specifically Geomorphology and/or Coastal Physical Oceanography. Candidates must hold a Ph.D. or its equivalent in an Earth Science or closely related field. The successful applicant will be expected to develop an internationally visible research program, mentor students and postdocs and teach at the graduate and undergraduate levels. Interested parties should submit a cover letter, curriculum vita, statement of teaching and research and contact information for three references using FSU's electronic submission system at http://jobs.fsu.edu, job title# 40820.

EOAS has over 40 faculty members, approximately 160 graduate students, a diverse undergraduate population and grants graduate degrees in Meteorology, Oceanography, Geology and Aquatic Environmental Sciences. FSU resources include the Center for Ocean-Atmosphere Prediction Studies, the Geophysical Fluid Dynamics Institute and the National High Magnetic Field Laboratory. A recent research initiative at FSU emphasized Coastal and Marine Science by adding eight faculty members within the departments of EOAS, Biological Science and Geography. This position continues to build on this initiative. Tallahassee is the capital city of Florida, home to three institutions of higher learning and was recently named an All-American City by the National Civic League.

Applications will be considered until the position is filled; those received by December 1, 2016 are assured of full consideration. Women and members of minority groups are especially encouraged to apply. Please direct questions to Profs. William K Dewar (wdewar@fsu.edu) and Vincent Salters (vsalters@fsu.edu).

An Equal Opportunity/Access/Affirmative Action Employer. Florida State University subscribes to Equal Opportunity and complies with the Americans with Disabilities Act. All eligible candidates are invited to apply for position vacancies as appropriate. Florida State University is a public records agency pursuant to Chapter 119, Florida Statues.

WIESS VISITING PROFESSOR
DEPARTMENT OF EARTH SCIENCE
RICE UNIVERSITY

We are soliciting applications for the Wiess Visiting Professor in the Dept. of Earth Science at Rice University. Our department has lively research programs in:

1. Carbonate and Clastic Sedimentology and Coastal Processes
2. Paleoclimatology
3. Atmospheric Chemistry
4. Biogeochemistry
5. Geobiology
6. Low and High Temperature Geochemistry
7. Petrology
8. Rock Physics and Geomechanics
9. Environmental, Exploration, Solid Earth and Theoretical Seismology
10. Crustal and Mantle Structure and Geodynamics,
11. Planetary Science

We invite applications from established scientists whose research falls in any of these areas, and request that you identify one or more of our faculty whose research interests overlap yours. The department is characterized by collegiality and interdisciplinary research. Our faculty have ties to the Rice departments of Biosciences, Chemistry, Computational and Applied Mathematics, Mechanical Engineering, and Physics and Astronomy. We also have strong ties to the local petroleum industry, the NASA Johnson Space Center, and the Lunar Planetary Institute.

The Wiess Visiting Professorship provides travel expenses to and from Rice, and living expenses while in residence, details are negotiable. Visiting Professors are typically in residence from a few months to a full academic year. Ideally Wiess Visiting Professors interact at a high level with members of our department, often through topical seminars. We particularly encourage women and minority geoscientists to apply.

See: http://earthscience.rice.edu for more details about our department, and http://earthscience.rice.edu/directory/wiess-visiting-professor/ for a list of previous Wiess Visiting Professors.

Please provide a curriculum vita, research statement, and indication of availability. Applications and inquiries can be sent to: Chair, Wiess Visiting Professor Committee, Dept. of Earth Environmental and Planetary Science, Rice University, MS-126, 100 Main Street, Houston, TX 77005, or esci-search@rice.edu. Please put Wiess Visiting Professor on the subject line.

Rice University, located in Houston, Texas, is a private, coeducational, nonsectarian university that aspires to path-breaking research, unsurpassed teaching, and contributions to the betterment of our world. Rice fulfills this mission by cultivating a diverse community of learning and discovery that

produces leaders across the spectrum of human endeavor. From its beginning in 1912, Rice has been dedicated to excellence in all regards.

Rice University is an Equal Opportunity Employer with commitment to diversity at all levels, and considers qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national or ethnic origin, genetic information, disability or protected veteran status.

ASSISTANT PROFESSOR
STABLE ISOTOPE GEOCHEMISTRY
WESTERN WASHINGTON UNIVERSITY

About the Position: Applications are invited for a tenure track Assistant Professor position in Stable Isotope Geochemistry in the Geology Dept. at WWU in Bellingham, Washington, with an expected start date of September 2017. We encourage applications from candidates from underrepresented backgrounds who are interested in this faculty position.

Position Responsibilities: The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in stable isotope geochemistry applied to any of a diverse range of geoscience problems. Areas of interest include, but are not limited to paleoclimatology/paleolimnology/paleoceanography/paleoecology, fluid flow and fluid-rock interactions, applications of stable isotopes to (bio) geochemical processes and (bio)mineralization. The applicant will be expected to successfully contribute to the department's course and curricular offerings, establish a successful research program that includes BS and MS students and securing external funding for support of major research instrumentation, work with department faculty and staff to develop connections to WWU departments and programs in marine and environmental sciences and allied fields. The faculty member will be expected to participate in service activities, including departmental committees and student advising.

Required Qualifications: Earned doctorate by hire date in the geosciences with an emphasis and experience in stable isotope geochemistry; Record of or potential for high quality undergraduate teaching; Commitment to establishing a vigorous research program involving graduate and/or undergraduate students; Ability to establish an externally-supported research program; Demonstrated commitment to working effectively with a diverse student body

Preferred Qualifications: Post-doctoral research experience in the geosciences; Experience teaching in a BS and/or graduate program; Ability and interest to work with other interdisciplinary programs in materials science, marine and environmental science; Experience or demonstrated ability managing geochemistry research lab.

Application Instructions: Applications must include (1) a detailed cover letter that addresses the required and preferred qualifications and describes the applicant's background and interest in joining the department, (2) a statement outlining the candidate's plans and approaches for teaching and course development at WWU, including a statement on how the applicant's background and experiences (academic and non-academic) have prepared them to effectively teach increasingly diverse students and work effectively with diverse colleagues, (3) a detailed research statement including plans for laboratory development and undergraduate/graduate student involvement in future research projects, (4) a full curriculum vitae including the names, addresses, e-mail addresses, and telephone numbers of three professional references, and (5) undergraduate and graduate transcripts. Submit all application material to the WWU Electronic Application System for Employment (https://jobs.wwu.edu/JobPosting.aspx?JPID=7158). Inquiries may be addressed to Prof. Brady Foreman at (360) 650-2546 or Brady.Foreman@wwu.edu. WWU is an AA/EO employer. For disability accommodation, call (360) 650-3774. Review of applications begins December 19, 2016; position open until filled.

ASSOCIATE OR FULL PROFESSOR IN ENVIRONMENTAL GEOSCIENCES, DEPT. OF EARTH & ENVIRONMENTAL SCIENCES
RENSSELAER POLYTECHNIC INSTITUTE

Troy, New York 12180-3590

The Dept. of Earth & Environmental Sciences at Rensselaer Polytechnic Institute in Troy, New York, invites applications for the position of Associate or Full Professor in Environmental Geosciences, with emphasis on individuals with research interests in the areas of environmental geochemistry, hydrogeology, environmental remote or local sensing, global climate science/modeling (paleo or future), environmental data analysis, or environmental field-imaging visualization.

The successful candidate will have duties that include teaching graduate and undergraduate courses in the Dept. of Earth & Environmental Sciences, fulfilling the duties of the Director of the Environmental Sciences undergraduate program, developing and maintaining robust programs of research and scholarship, and providing service to the department, the School of Science, and to Rensselaer.

Rensselaer has recently initiated several bold, new initiatives; the successful candidate should interface with one or more of these areas. Examples of these include the Rensselaer Institute for Data Exploration and Applications (IDEA; http://idea.rpi.edu), the Darrin Fresh Water Institute (DFWI), a comprehensive freshwater ecological field station and Institute-wide research effort that hosts The Jefferson Project at Lake George (http://jeffersonproject.rpi.edu). In addition, the Institute is conceptualizing a new, broader initiative that will bring together research and education activities in water, environment, ecology, and sustainability.

The successful candidate will have a Ph.D. or foreign degree equivalent in geoscience or related discipline, along with the ability to demonstrate, through accomplishments achieved over a post-graduate academic career of seven or more years, an international reputation and record of excellence in scholarship, along with a sustained level of high quality educational activities including teaching and advising, and a significant level of professional service.

To apply, applicants must submit as single pdf document a curriculum vitae, a statement of research accomplishments and goals, a description of teaching interests, and a list of four professional references to: E&ES Faculty Search, Dept. of Earth and Environmental Sciences, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180-3590; Email: spearf@rpi.edu (electronic submissions are preferred). Up to four select publications may be sent as separate files. Consideration of candidates will begin upon receipt of application. Applications are encouraged by midnight, December 24, 2016, and recruiting will continue until the position is filled. Preliminary interviews will be conducted at GSA and AGU in Fall 2016.

We welcome candidates who will bring diverse intellectual, geographical, gender, and ethnic perspectives to Rensselaer's work and campus communities. Rensselaer Polytechnic Institute is an Affirmative Action/Equal Opportunity, Race/Gender/Veterans/Disability Employer.

Opportunities for Students

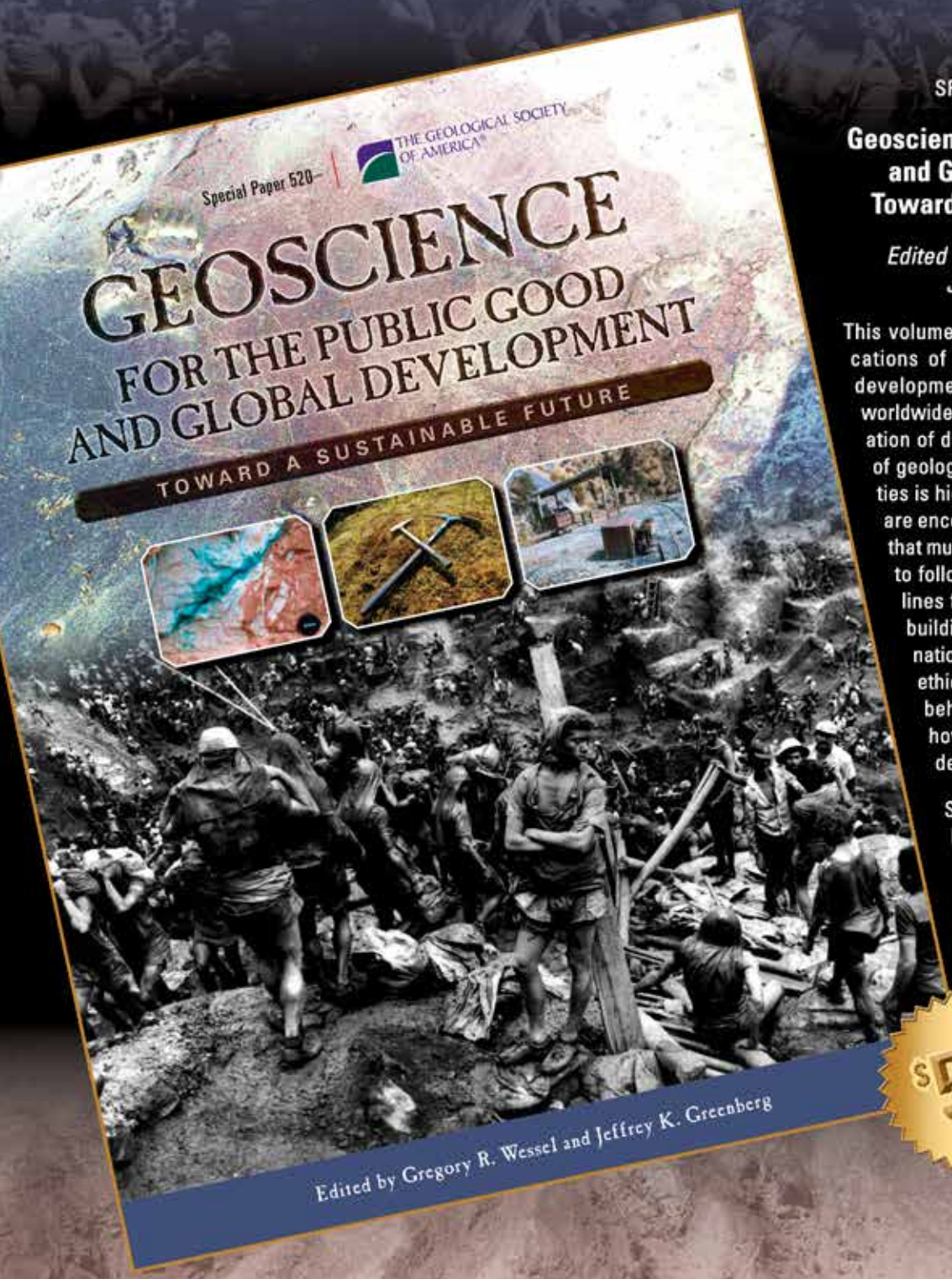
Lindahl Ph.D. Scholarships, The University of Alabama. The University of Alabama, Dept. of Geological Sciences seeks Ph.D. students with specializations that complement faculty research interests. Exceptional students will receive Research or Teaching Assistantships and a Lindahl Scholarship totaling $22,000 for a nine-month appointment, and the cost of non-resident tuition is covered. Funding is renewable for 4 years if expectations are met. Other fellowships are available from the Graduate School. Further details are at http://www.geo.ua.edu/. Applicants should contact Dr. Robinson (dmr@ua.edu) to express interest. Review of applications for Fall 2017 admission will begin January 15, 2017.

Graduate Student Opportunities, University of Akron. The Dept. of Geosciences, Univ. of Akron, Ohio has MS assistantships available starting in fall 2017 for students who have the drive and curiosity to succeed in graduate school. Examples of the on-going research include studies in geobiology, structural and environmental geology, studies of the climate record contained in lake sediments and caves, and studies in karst terrains. Interested students may contact Dr. John Peck atjpeck@uakron.edu for more information and apply online at http://www.uakron.edu/gradsch/apply-online/

Jonathan O. Davis Scholarship, University of Nevada, Reno. The Jonathan O. Davis Scholarship supports graduate students working on the Quaternary geology of the Great Basin. The national scholarship is $7,500 and the University of Nevada, Reno stipend is $7,500. The national scholarship is open to graduate students enrolled in an M.S. or Ph.D. program at any university in the United States. The Nevada stipend is open to graduate students enrolled in an M.S. or Ph.D. program at the University of Nevada, Reno. Applications must be post-marked or submitted electronically by February 17, 2017. Details on application and submission requirements can be found at http://www.dri.edu/GradPrograms/Opportunities/JonathanDavis. Proposals will not be returned.

Graduate Student Opportunities: The Dept. of Earth and Planetary Sciences at Northwestern University invites applications for fall 2017 from prospective doctoral candidates interested in the fields of climate change, geobiology, paleolimnology, radiogenic and stable isotope geochemistry, stratigraphy and paleoecology, geophysics, seismology, seismic imaging and mineral physics. Our program guarantees five years of competitive financial support. The deadline for applications is December 20, 2016, but consideration after the deadline will continue for candidates with excellent credentials. Applicants should visit www.earth.northwestern.edu for submission instructions. AA/EOE. Northwestern University is an Equal Opportunity, Affirmative Action Employer of all protected classes including veterans and individuals with disabilities. Women and minorities are encouraged to apply.

Graduate Student Opportunities at Case Western Reserve University. Students with backgrounds in geology, physics, chemistry, biology, engineering and related fields are encouraged to apply for our Ph.D. and MS programs in Earth, Environmental, and Planetary Sciences. Areas of active research in the department include planetary geology and geodynamics, planetary materials, high-pressure mineral physics and geochemistry, core and mantle processes, sedimentary geology, and sediment transport. For more information, see http://eeps.case.edu or write to eeps-gradinfo@case.edu. Financial assistance is available. Application deadline: 1/15/2017.



SPECIAL PAPER 520:

Geoscience for the Public Good and Global Development: Toward a Sustainable Future

Edited by Gregory R. Wessel and Jeffrey K. Greenberg

This volume offers an overview of the applications of the geosciences to sustainable development and geophilanthropic efforts worldwide, and offers advice to guide the creation of development projects. The primacy of geologic input to all development activities is highlighted along with problems that are encountered and environmental issues that must be addressed. General principles to follow are discussed, including guidelines for creating sustainable solutions, building foundations for effective international development, the importance of ethical and social values, the motivation behind sustainable development, and how geoscientists can best become development practitioners.

SPE520, 478 p., ISBN 9780813725208
list price $79.00
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THE GEOLOGICAL SOCIETY OF AMERICA®

John W. (Jack) Hess, *GSA Foundation President*

The Impact of Mentoring

As a professional geologist, whether in academia, government, or industry, your experience is invaluable to a student contemplating his or her future. The GSA Foundation supports a number of mentor opportunities that GSA offers, ranging from Career Pathway programs at the Annual Meeting to Section Meeting programming.

One popular mentor opportunity is available through GSA's On To the Future grassroots initiative to help build a diverse geoscience community. Volunteer mentors are paired with students from underrepresented groups in the geosciences who receive travel grants and registrations to attend their first GSA Annual Meeting. These mentors guide their students throughout the meeting while sharing professional and personal experiences of geoscience careers. This often includes helping choose sessions and making introductions to others at the conference.

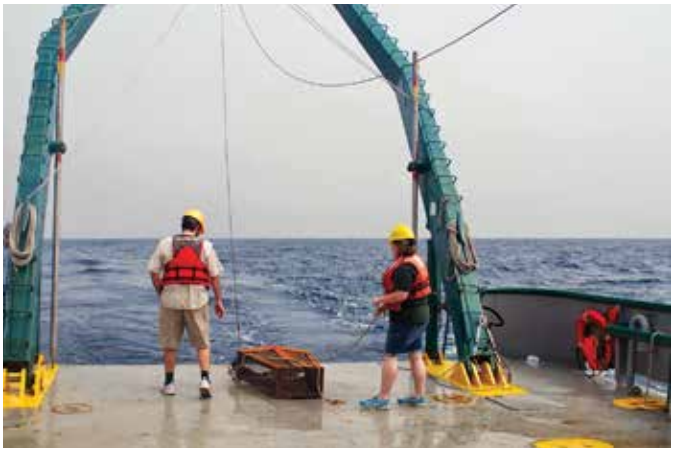
Judy Parrish, a current GSA Foundation Trustee and Past President of GSA, was paired with student Kaydee West for the 2014 program. "When I first met Kaydee, I could tell she was terribly nervous but also absolutely determined to make the best of the experience. She impressed me right away with her grit, articulateness, and positive attitude, and I just knew she would be a success. We met several times during that meeting, and I was so pleased to be able to introduce her to so many people. Over the years, I have enjoyed keeping up with her progress and experiences, such as a research cruise she went on. I was delighted she sent me pictures of the cruise. We've met at both GSA annual meetings since the first. I've introduced her to subsequent OTF mentees, and she has been welcoming and generous with her time. At the most recent meeting, I heard her give a talk, and she was poised and organized, really hit it out of the park. A very prominent person in her field of expertise shouted out "Great idea!" at the end of her talk. I am so pleased she is entering a Ph.D. program, and feel honored to be her OTF mentor."

Kaydee conveys an equally positive experience from her perspective as mentee: "I was a part of the OTF cohort in Vancouver in 2014. I had just started working on a master's degree at the University of South Florida, and flying across the continent to my first GSA meeting was intimidating to say the least. I'm not sure I can adequately express how being paired with a mentor at GSA helped both at that first meeting and in the years since. Judy immediately took me under her wing, and she's been a source of encouragement to me since I've known her. During my first GSA, she met with me every day and introduced me to so many people I lost count. She came to my first poster and oral presentations at GSA and provided constructive feedback after both. I am grateful that I was fortunate enough to be paired with Judy my first year as an OTF student, and I am looking forward to mentoring OTF scholars in the future."

The year after her OTF participation, Kaydee received an outstanding mention on her GSA student grant proposal. That year she also received the Association for Women Geoscientists Winifred Goldring Award. Kaydee completed her master's degree in August 2016 and is currently working as an instructor at Hillsborough Community College. She has accepted a fellowship from the University of Alabama to start working on a Ph.D. in the spring of 2017.

Please consider contributing to success stories like this one through support of On To the Future—and see video of Judy with another OTF mentee at the 2015 Baltimore meeting at http://www.gsafweb.org/fund/on-to-the-future-fund/.

Kaydee West receiving a research grant outstanding mention from past GSA President Jon Price (2015).



Kaydee West at work on a research cruise.

GROUNDWORK
Furthering the Influence of Earth Science

Physical Experiments of Tectonic Deformation and Processes: Building a Strong Community

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ABSTRACT

The recent revolution in the analysis of physical experiments of tectonic processes has provided new quantitative tools to analyze their outcomes. Physical experiments using scaled analog models are unique in providing information on complex three-dimensional deformation where processes can be directly observed. These observations critically complement insights gained from field and analytical/numerical investigations. Recent innovations in rheologic testing, digital image processing, and data collection are revolutionizing how we use experiments to provide insight into crustal deformation. At the same time, we are seeing the benefits of physical experiments in classroom teaching by engaging students in hypothesis testing and hands-on laboratory experience. Strengthening of the community of physical experimentalists and instructors using analog materials to simulate tectonic processes will enhance our understanding of these processes, lend more power both to interpretations of field observations and to validation of numerical models, and deepen student understanding of tectonic mechanisms. A step toward a stronger community has been made with a recent workshop on physical modeling of tectonic processes, and this report is one outcome of that workshop.

THE REVOLUTION IN PHYSICAL EXPERIMENTS

Two hundred years ago, Hall (1815) published the first research paper to use physical experiments using analog materials to investigate mountain belt formation. Since these very first experiments, physical models in earth science have not only been useful tools for visualizing deformation but also have great power to investigate physical processes that govern deformation. For example, the innovative experiments of Tapponnier et al. (1982) and Davis et al. (1983), each with over 2,000 citations, have transformed our thinking about tectonic processes. Carefully scaled analog models provide a means to directly observe deformational processes that within Earth's crust are too slow and too large to directly document (Hubbert, 1937). Furthermore, within such experiments we have control over boundary conditions and material properties so that we can directly assess their effect on deformation. While fieldwork and analytical and numerical models are essential tools for investigating crustal processes, they often do not inform all aspects of the deformational story. Using physical experiments in conjunction with field observations and analytical/numerical investigations provides a strong three-legged stool upon which we can build a robust understanding of crustal deformation processes (Fig. 1).

Advances in experimental procedures have been developed at physical modeling laboratories within both academia and the petroleum industry. The past 10 years have seen a revolution within physical modeling of crustal deformation spurred by the utilization of new innovative analog materials (e.g., Di Giuseppe et al., 2015), systematic rheologic testing (e.g., Klinkmüller et al., 2016), incorporation of laser and image processing techniques for data analysis (e.g., Haq, 2012), measuring in situ stress (e.g., Herbert et al., 2015), and reconstruction of the evolution of complex 3D structures (e.g., Colletta et al., 1991). These advances all strengthen the quantitative rigor of physical modeling of tectonic processes. The vanguard of this recent revolution has been in Europe, which has many active laboratories staffed with technicians implementing and advancing these new technologies. While presently a typical experimental laboratory in the United States is run by a single principal investigator with his or her students, European labs are run with a team of lead scientists with tens of students. Consequently, the core of the experimental community is in Europe, where experimentalists host regular workshops and conference sessions focused on physical modeling. Strengthening the U.S.

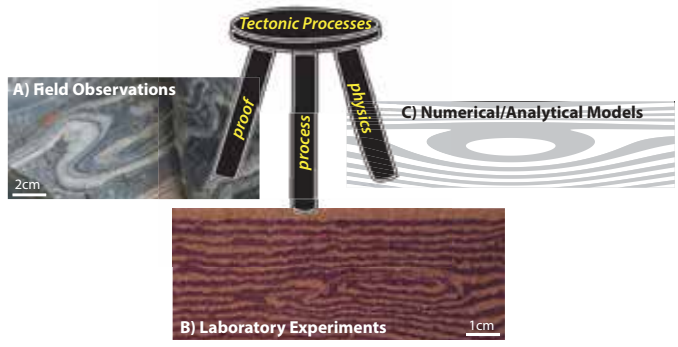

Figure 1. Deep understanding of crustal deformation relies on three approaches: field measurements of deformation, physics-based predictions of deformation, and direct documentation of deformational processes within laboratory experiments. To illustrate the power of the tectonics three-legged stool, we show results from a fully integrated study on the development of sheath folds in simple shear. (A) Sheath fold from Cap de Creus, Spain. (B) Photo from a physical experiment investigating the impact of layer viscosity contrast on the fold formation (Reber et al., 2013). (C) Cross section from an analytical model investigating the effect of total shear strain (Reber et al., 2012).

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experimental community requires coordinated and structured growth in the numbers of researchers involved in physical experiments as well as instructors engaging students with classroom experiments.

PHYSICAL EXPERIMENTS PROVIDE CRITICAL INSIGHTS

A strong U.S. physical modeling community will have manifold benefits for research and teaching in tectonics. Below are a few examples of the insights provided by experimental data that cannot be gained by other approaches.

Provide Data for Calibration of Numerical Models

Numerical simulations of crustal deformation are plagued with uncertainties about crustal structure, strength, and evolution. Within physical experiments, the boundary conditions are known, the material rheology is constrained, and the evolution of deformation can be directly observed. Experimental results are the perfect data sets for validating our numerical models before we apply them to crustal systems.

Provide Insight into Specific Processes

Within the laboratory, we can isolate single mechanisms contributing to tectonic deformation. Scaled physical experiments with controlled boundary conditions and constrained material rheology allow us to pinpoint the impact of targeted processes. Insights from this approach can assist the interpretation of field data where multiple processes and mechanisms may have acted to produce complex deformation patterns.

Outreach and Teaching

Understanding geologic time is one of the hardest concepts for students new to geology. Physical experiments can assist these students because they demonstrate slow geologic processes happening over millions of years within minutes on the tabletop. This helps students to integrate both space and time as they directly observe the three-dimensional deformation and temporal evolution of structures. The hands-on approach complements other styles of teaching within the classroom and reaches student with diverse learning strengths. Additionally, physical experiments provide an accessible means for hypothesis testing in the classroom because the boundary conditions and material properties can be manipulated (Feldman et al., 2010). Furthermore, the visual and hands-on nature of physical experiments engages and inspires students and the public alike.

Physical experiments provide the only mechanism for direct observation of the processes of tectonic deformation. Consequently, they hold the key to understanding information obtained in the field that documents the results of deformation and analytical/numerical models that capture the physics of deformation. To best understand tectonic deformation, we need to use a variety of approaches, including physical experimentation.

FUTURE DIRECTIONS

In an effort to strengthen and expand the U.S. community of physical experimentalists in tectonics, the U.S. National Science Foundation sponsored a workshop in 2015 on "Analog Modeling of Tectonic Processes" at the University of Massachusetts–Amherst with 46 participants. This workshop was a great success and helped connect researchers and teachers using physical modeling. One of the outcomes of the workshop was learning that it is essential to continue growing the U.S. community of experimentalists, to increase networking among the researchers so that we can advance our techniques, enable sharing of techniques and teaching approaches involving physical models, and to facilitate collaboration between experimentalists and others investigating tectonic processes. A valuable aspect of the 2015 workshop was the presentation of innovative curricula, which inspired participants to implement new activities within their courses. Having experiment-focused workshops on a regular basis as well as continued support for research and teaching involving physical modeling will grow this community and strengthen our understanding of deformational processes. A successor workshop planned for 2017 will continue this effort.

Within the next ten years we hope to continue strengthening the collaboration between field geologists, numerical modelers, and experimentalists to build a stronger three-legged stool upon which we can advance our tectonic understanding.

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NEW CODE OF CONDUCT FOR GSA EVENTS

GSA Council passed a new Code of Conduct for GSA Events at its 24 Sept. 2016 meeting. GSA is in the process of developing procedures and response mechanisms for implementation prior to the spring 2017 Section Meetings.

View the policy at

http://www.geosociety.org/gsa/events/conduct. aspx

Check *GSA Today* and "GSA Connection" over the next two months for more information.

2017 Graduate Student Research Grants

GSA graduate student members may receive up to two GSA graduate student research grants during their academic career, regardless of the program in which they are currently enrolled. The maximum award per grant is US$2,500. Graduate students may also qualify for specialized awards and thereby receive more than US$2,500 in funding.

Apply online only at **www.geosociety.org/gradgrants.** No paper applications or letters will be accepted. Submissions must be completed by Wed., 1 Feb. 2017, at 5 p.m. MST.

Can't find what you're looking for on the website? Call +1-303-357-1025, or e-mail awards@geosociety.org.

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GEOLOGY

for All GSA Members

While GSA has delayed its plan to make the journals open access, all GSA memberships will include free online subscriptions to *Geology* beginning in January 2017. Print subscriptions will continue to be available for a fee.

In the meantime, GSA will continue its hybrid open access approach, which includes gold (author pays) immediate open access or 12-month green (repository) open access. For more information on publishing options and costs, visit http://www.geosociety.org/pubs/contrib.htm.

To browse a list of open access articles and book chapters, visit www.gsapubs.org/cgi/collection/gsa-oa. In addition, *GSA Today*, book front matter, and all *Geology* Research Focus, comment, and reply articles will continue to be freely accessible.

If you are interested in supporting GSA's transition to open access, please contact the GSA Foundation (gsafweb.org) to learn more about the new Author's Fund.

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Call For Field Trip, Short Course, and Technical Session Proposals

GSA 2017

22–25 October
Seattle, Washington, USA

GSA 2017 Seattle Meeting

Thank you to all the 2016 GSA Denver Annual Meeting attendees. We hope you enjoyed the geology, networking, and libations. It's time to plan for our 2017 Annual Meeting in Seattle, Washington, USA. GSA is excited to head back to the Pacific Northwest. Our 2009 meeting in Portland, Oregon, USA, attracted nearly 6,500 attendees from over 50 countries, so our 2017 meeting should be international, well attended, and full of excitement!

A highlight will be the Seattle-area geology: Glaciation, deposition, tectonics, crustal deformation, unconformities, erosion, bedrock structures, and drumlins. We challenge you to propose a field trip, short course, and/or technical session that will teach your colleagues and promote discussion about the incredible regional geology.

Photo by Alabastro Photography.

Photo by Alabastro Photography.

EXCHANGE THE GEOLOGY BY ORGANIZING AND CHAIRING A TECHNICAL SESSION.

Technical Session deadline: 1 Feb. 2017

Proposals are being taken for both Pardee Keynote and Topical Sessions. The proposal form is online at **https://gsa.confex.com/gsa/2017AM/cfs.cgi.**

SHARE THE GEOLOGY AS AN INSTRUCTOR THROUGH A SHORT COURSE.

Short Course proposal deadline: 1 Feb. 2017

Courses run the Friday and Saturday before the Annual Meeting and are typically a half day to two full days. The proposal form is online at **https://gsa.confex.com/gsa/2017AM/shortcourses/cfs.cgi.**

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SCIENCE EDITOR OPENINGS FOR 2018

GSA is soliciting applications and nominations for science co-editors for *Geology*, *GSA Bulletin*, *Geosphere*, and *GSA Today* with four-year terms beginning 1 January 2018. Duties include: ensuring stringent peer review and expeditious processing of manuscripts; making final acceptance or rejection decisions after considering reviewer recommendations; and maintaining excellent content through active solicitation of diverse and definitive manuscripts.

POSITIONS AVAILABLE

GSA Today ▸ 1 position

GSA TODAY The editor of *GSA Today*, one of the most widely read earth science publications in the world, must have a wide range of interests and expertise along with the ability to identify research topics of both high quality and broad appeal. Prior editing experience and a publication record in a wide range of journals is key.

GSA Bulletin ▸ 1 position

GSA BULLETIN Research interests that would complement those of the continuing editors include, but are not limited to: stratigraphy; geomorphology; geochemistry; tectonics; structural geology; deformation; and paleoclimatology.

Geosphere ▸ 1 position

GEOSPHERE Research interests that would complement those of the continuing editors include, but are not limited to: geochronology; geochemistry; volcanology; petrology; sedimentary geology; remote sensing/GIS; tectonics, structural geology; geosciences education; and dynamic content.

Geology ▸ 1 position

GEOLOGY Research interests that would complement those of the continuing editors include, but are not limited to: hard-rock geology; tectonics; geodynamics; geochemistry; tectonophysics; volcanology; marine geology; structural geology; geophysics; and planetary geology.

Note that candidates should not feel they must have expertise in *every* area listed; however, editors will sometimes need to handle papers outside of their main disciplines.

A SUCCESSFUL EDITOR WILL HAVE

- a broad interest and experience in geosciences, including familiarity with new trends;
- international recognition and familiarity with many geoscientists and their work;
- a progressive attitude and a willingness to take risks and encourage innovation;
- experience with online manuscript systems and the ability to make timely decisions; and
- a sense of perspective and humor.

INTERESTED?

- Please submit a curriculum vitae and a letter describing why you are suited for the position to Jeanette Hammann, jhammann@geosociety.org.
- To nominate another, submit a nomination letter and the person's written permission and CV.

Editors work out of their current locations at work or at home. The positions are considered voluntary, but GSA provides an annual stipend and funds for office expenses. **DEADLINE** First consideration will be given to nominations or applications received by **15 February 2017**.

FUTURE OPENINGS (terms begin January 2019): One position each for *GSA Bulletin*, *Geosphere*, *Lithosphere*, *GSA Books*, *GSA Today*, and *Environmental and Engineering Geoscience*.