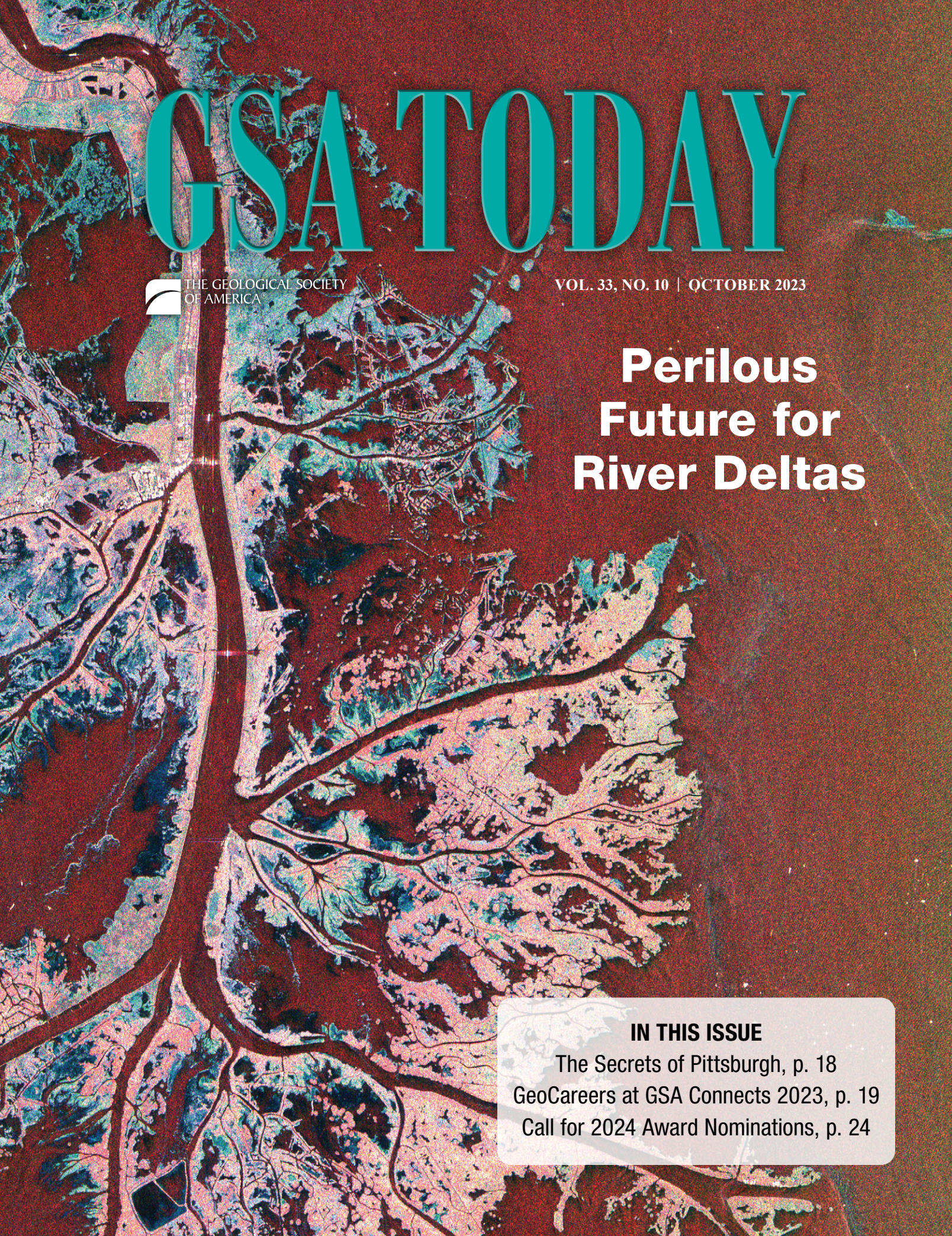

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SCIENCE

Cover: A false color radar image of a "bird's foot" terminus of the Mississippi River Delta (63 x 43 km). Bright spots on the main channel are ships. Over the past 200 years, upstream Mississippi has been heavily modified through damming and diversions, and sediment influx to the delta has been reduced dramatically from 400 to 100-150 million tons annually. Subsidence has more than tripled in areas of oil extraction and over 5000 km^2 of deltaic wetlands have been lost since the 1930s. (Credit: NASA/JPL image archives). For the related article, see pages 4–12.

GSA CONNECTS 2023

GSA NEWS

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Perilous Future for River Deltas

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ABSTRACT

River deltas occupy only ~0.65% of Earth's land surface, but collectively house ~4.5% of the global population and account for more than 6% of the global GDP. Because of ongoing human interventions in the past century (river diversions, groundwater and petroleum extraction, and urbanization), deltas are coming under additional and intense threat from climate change and the impending sea-level rise. Many high-latitude and tropical deltas where population pressure is low and human modification is minimal face less peril for the foreseeable future, but densely populated deltas, especially those in Asia with extreme urbanization and environmental pressures, will be more susceptible to land loss and drowning. Here we consider six key deltas—Mississippi, Yangtze, Niger, Bengal, Nile, and Indus—emphasizing recent findings and consensus as to their health and how human activities have brought these vulnerable ecosystems perilously close to or beyond the point of no return.

INTRODUCTION

Deltas are low-lying extensions, formed off of river mouths by the deposition of river-borne sediment and organic material as the river approaches the coastal zone. Sediment influx promotes the delta's seaward progradation, and subsidence caused by the dewatering and compaction of sediments that are deposited above a flexing lithosphere produces the capacious sedimentary accommodation that allows the delta to thicken. While the seaward limit of a delta is easy to define, its landward extent, and thus its land area, is subject to interpretation; for example, all low-lying land seaward of a break in topographic gradation versus land lying at less than a specified elevation versus land area seaward of the deltaic channel. The area of the Amazon River Delta, for instance, can be considered to be as large as 100,000 km^2 (Ericson et al., 2006) to 300,000 km^2 (da Costa et al., 2019), or as small as 84,000 km^2 (Edmonds et al., 2020), of which only 1970 km^2 lie at elevations lower than 2 m (Syvitski et al., 2009). Reported areas and populations also depend on how the delta is defined—that is, by geographic, economic, or political criteria. For example, Edmonds et al. (2020) define the Pearl River Delta by geomorphic criteria (5600 km^2), whereas the Pearl River Delta Economic Zone (39,000 km^2; Tang et al., 2016) includes islands and mountains locally higher than 900 m. The former, according to Edmonds et al. (2020), has a population of 9.5 million, whereas the latter includes the megapolises of Guangzhou-Shenzhen, with a combined population of more than 24 million.

Due to the fertile nature of their river-derived sediments, abundant freshwater, diverse ecosystems, and inland and seaward access, deltas were centers of early human civilization, particularly in arid climates, e.g., Nile (Egypt), Tigris-Euphrates (Mesopotamia), and Indus (Indus Valley civilization; Macklin and Lewin, 2015). Over the ensuing millennia, the fertile deltas have served as agricultural, fishing, and commercial centers. Although their collective areas account for less than 1% of the global land surface, deltas are among the most densely urbanized and productive landforms on Earth. The major socioeconomic role of deltas is perhaps best illustrated in Table 1, where 12 large deltas collectively occupy 350,000 km^2, less than 0.3% of Earth's land area. Two of the 12 deltas—Amazon and Lena—have sparse populations and little commerce; the other 10 deltas (~0.25% of the global land area) house 245 million people, ~3% of the world's population, and a collective GDP that annually exceeds US$4.8 trillion.

The Edmonds et al. (2020) database includes 1178 deltas larger than 1 km^2 (Fig. 1) with a total area of 848,000 km^2 and 339 million inhabitants. Using a larger database, Syvitski et al. (2022) estimated the global delta area as 855,000 km^2. According to data from Edmonds et al. (2020), deltas >1000 km^2 in area collectively cover 752,000 km^2, deltas between 10 km^2 and 1000 km^2 total 31,000 km^2, and deltas between 1 km^2 and 10 km^2 cover 2,000 km^2; deltas located between 25°N and 5°S occupy ~68% of the global deltaic land area (Fig. 2). As of 2017, Asian deltas housed 262 million people, 77% of the global delta population, with an average population density of 880/km^2. In contrast, the 672 non-Asian deltas listed by Edmonds et al. (2020) have 76 million inhabitants, with an average population density of 222/km^2. Many arctic and tropical deltas are particularly underpopulated. The arctic deltas of the Lena, Pechora, Yana, Indigurka, MacKenzie, and Yukon rivers (collectively 60,000 km^2 of land surface; Walker, 1998) have an average population density of only 0.4/km^2, and the Amazon, Orinoco, and Congo Deltas (130,000 km^2) have an average population density of only 8/km^2. Interestingly, however, one of the most densely populated deltas is the Neva Delta near St. Petersburg in Russia (12,700 inhabitants/km^2).

DELTAS UNDER STRESS

Despite a recent overall gain observed in deltaic land area worldwide (Nienhuis et al., 2020), many of the populated deltas that have significant socioeconomic importance are either eroding or sinking, or both, hence

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TABLE 1. AREAS AND POPULATIONS FOR 12 WORLD DELTAS IN ORDER OF DECREASING AREA

Delta	Country	Area (km^2)	(<2 m elevation) (km^2)	Population (10^6)	Pop. Density per km^2	GDP US$ (10^9)
Amazon	Brazil	84,400	1960	0.75	9	nil
Bengal	Bangladesh	80,200	6170	105	1500	260
Mississippi	USA	51,100	7140	3.1	330	130
Mekong	Vietnam	39,500	20,900	18	455	46
Niger	Nigeria	34,500	350	12.6	860	380
Irrawaddy	Burma	28,700	1100	9.8	170	2
Nile	Egypt	28,300	9440	40	2000	75
Lena	Russia	21,000		0.002	0.1	nil
Yangtze	China	18,300	7080	31	3000	2200
Yellow	China	18,000	3420	5.2	290	150
Pearl	China	5600	3720	12	2100	1200
Chao Phraya	Thailand	4100	1780	8.1	720	370
Totals		414,000	63,000	245,000	600	4800

Note: Most data are from Edmonds et al. (2020) and Syvitski et al. (2009). Right column shows estimated GDP (gross domestic product).

such popular media headlines as "Death of the Indus Delta;" "Mississippi Delta: land loss and erosion;" "Can the Ebro Delta be saved from erosion?;" and "Millions at risk as world's deltas sink!" In nearly all cases, the problem of disappearing deltaic land stems directly or indirectly from a combination of local, regional, and global human actions (Syvitski, 2008).

In many deltas, a primary problem is caused by both upstream river and deltaic modification. Upstream dams can moderate or eliminate seasonal fluxes in water, and dredging of river channels and dikes along the riverbanks can prevent floodwaters from topping onto adjacent land. While such alterations in river and sediment flow protect human habitations, they also prevent new sediment from spreading over floodplains that would offset natural and human-enhanced in situ subsidence. Natural subsidence rates can be rapidly accelerated by groundwater or oil and gas withdrawal from the substrate. Local extensive groundwater pumping that began in the 1970s, together with upstream damming of the Chao Phraya River, for example, resulted in subsidence of as much as 1.6 m in Bangkok by 1988 (Nutalaya et al., 1996; Bidorn et al., 2021).

Climate change will only exacerbate the stresses on river deltas. As Earth's oceans warm and land-based glaciers melt, there is a corresponding volumetric increase in oceanic waters, thus leading to rising sea level that can be measured globally, which when compared to the 1990s, is projected to rise 30 cm by the year 2050 and most likely exceed 1 m by 2100. This melt, combined with reduced sediment influx and accelerated subsidence, means that relative sea-level rise (SLR) in many deltas has exceeded, or will soon exceed, 3–8 mm/yr—a sobering scenario for deltaic land that often lies only 1–2 m above present-day sea level.

DELTAIC AND COASTAL RESPONSE TO ACCELERATING SEA-LEVEL RISE

In its sixth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) revised its estimate of the increase in Earth's mean surface temperature upward to 1 °C since the late nineteenth century. The IPCC projects total warming to reach 1.5 °C between 2030 and 2050 (IPCC, 2022). A major consequence has been the acceleration in the rate of SLR. In 2019, the IPCC revealed that global mean sea level (GMSL) has risen at a rate of 3.4 mm/yr since the 1990s, compared to 1.2–1.7 mm/yr during the first half of the twentieth century (IPCC, 2019). Warming-related acceleration in melting of mountain glaciers and the Greenland and Antarctic ice sheets has contributed ~50% to this increase (Allison et al., 2021); much of the rest is attributed to the steric (thermal) expansion of ocean water, and a smaller amount to permanent transfer of aquifer water to the ocean. Projected GMSL rise may be 1.1 m (IPCC, 2022) or as much as 2.5 m by the year 2100, the higher estimate produced by NOAA models that take into consideration greater instability of western Antarctic ice sheet (Sweet et al., 2022). The 1–2.5 m of SLR will cause the following changes (to a varying degree) on most deltas of the world.

Intensified flooding: Due to their low gradients, deltas are at greater risk when the sea rises rapidly, particularly in the absence of sedimentary replenishment. Deltas (e.g., Bengal, Orinoco, Niger, Indus, Mississippi, and Chao Pharaya) and nearby low-lying areas (e.g., Sumatra, Borneo, the low countries of Europe, southern Baltic, and the U.S. Gulf Coast) that are also undergoing enhanced subsidence will be prone to increasing inundation. It is now well established that warmer seas mean more energy to convert to tropical cyclones, and both the Atlantic and Indian Oceans show an unmistakable trend toward increased frequency of stronger tropical storms that could greatly accelerate coastal destruction (see e.g., Lima et al., 2021; Singh et al., 2000).

Increased erosion: Following SLR, and in part due to decreased sediment supply, many beaches are in retreat caused by erosion. Along the mouth of the Nile Delta, for example, the promontories are eroding rapidly so that the coastline is increasingly wave-dominated (e.g., Darwish et al., 2017).

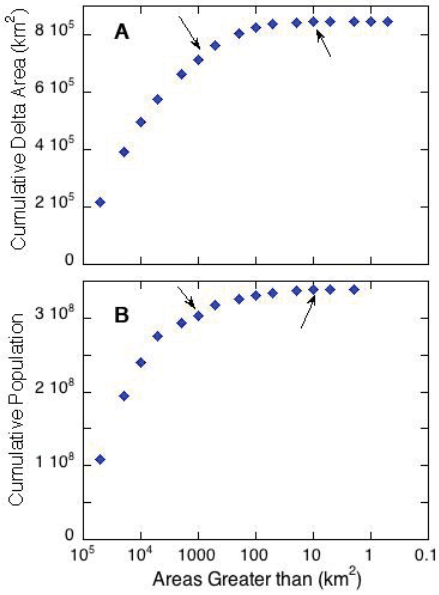

Figure 1. Cumulative areas (A) and populations (B) of global deltas greater than 1 km^2, based on data reported by Edmonds et al. (2020). Arrows delineate deltas >1000 km^2 and 10 km^2.

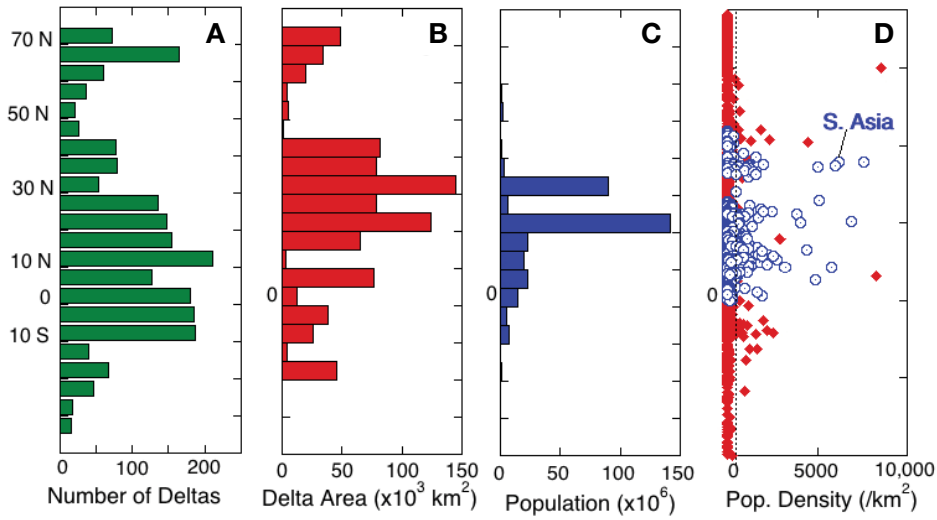

Figure 2. Latitudinal distribution of (A) delta numbers >1 km², (B) combined delta area, (C) population, and (D) population density. Data from Edmonds et al. (2020).

Protective barrier islands, bordering the coasts and formed by repeated wave action, may not be able to keep pace with rapid SLR, and thus may drown when sediment influx cannot keep pace.

Increased salt-water intrusion: Salt-water intrusion into estuaries and coastal aquifers is a serious issue that has intensified where groundwater has been removed for human consumption; SLR will only accelerate salinization. In the Bengal Delta, for example, salt-water intrusion has been observed up to 240 km upstream during dry seasons when the river flow is impeded due to upriver water sequestration (e.g., Akter et al., 2016). In Bangkok, aquifer contamination has been encouraged by excessive and rapid groundwater withdrawal from the Chao Pharaya Delta (Stoecker et al., 2013).

Ecosystem disruption: Delta wetlands (marshes, bogs, mangrove swamps, and estuaries) normally keep pace with gradual SLR, but when vertical accretion is reduced due to a deficit of sediment influx, these ecosystems can rapidly degrade. Another factor is the warming-related augmentation of dissolved CO_2 in the surface waters that leads to an increase in ocean acidification. The IPCC estimates that the ocean has taken up as much as 30% of all anthropogenic CO_2 emission since the 1980s (IPCC, 2021). The increased acidification is injurious to the delicately balanced mixed-water ecosystems of the deltas. The permanent disruption of such habitats has a snowballing effect on the local flora and fauna; fisheries, for example, are a major economic resource that suffers immediately from deltaic damage.

In 1996, we published a volume of collected papers (Milliman and Haq, 1996) that discussed the impacts of river damming, land subsidence, and changes in relative sea level on deltaic and other coastal environments. The ensuing 27 years have witnessed a surfeit of papers and books recording the increasing reality of deltaic change and loss, particularly in light of climate change. Here, we revisit some of the deltas discussed in Milliman and Haq (1996), emphasizing current observations and consensus of the international scientific community. For the sake of brevity, we emphasize results mostly published in the past 20 years; see Syvitski et al. (2022) and Nienhuis et al. (2023) for more detailed reviews.

The Mississippi Delta

The Mississippi River drains more than 40% of the contiguous USA. The delta that has formed at the end of this 5900-km-long river has an area of 51,000 km² (Edmonds et al., 2020), of which 14% (7140 km²) lies at elevations <2 m (Syvitski et al., 2009). Given its importance as a transportation hub (New Orleans, southern Louisiana, and Baton Rouge collectively account for US$11 billion of annual economic activity), the river and its delta have been heavily affected by human modifications for the past 200 years. In order to regulate flow, irrigate fields, and manage river navigation, as well as harness hydroelectric power, more than 40,000 dams of various sizes have been constructed on this watershed, 1220 of which are higher than 15 m (Milliman and Farnsworth, 2011). Following the New Madrid Earthquake in 1811–1812, the river discharged ~400 million tons of sediment annually to the lower Mississippi. After dam construction in South Dakota during the early 1950s, sediment transport decreased dramatically, and after 1965 only ~100–150 million tons of sediment reached the lower Mississippi annually. To prevent flooding of the region's lowlands, more than 1000 km of levees have been built along the banks of the delta, thus preventing lateral escape of water and sediment to the subsiding delta (Blum and Roberts, 2009). Moreover, construction of 30,000 km of canals plus the laying of pipelines along the delta have not only markedly altered the configuration of the delta but also resulted in increased salinization of the lower delta and its groundwaters.

Oil and gas production has greatly affected the delta, increasing from 35 million barrels of oil recovered in 1945 to 445 million in 1970 before dropping to ~30 million barrels in 2019 (Day et al., 2020). The effect upon delta subsidence can be seen in the relative sea-level record at Grande Isle, west of the delta's bird's foot. From 1940 to the late 1960s, the mean subsidence rate was 3.5 mm/yr—~1.4 mm/yr greater than global SLR. Between 1970 and 1995, SLR at Grande Isle accelerated to ~13 mm/yr. Of the 500 mm SLR measured at Grande Isle between 1932 and 2010, ~100 mm was due to natural subsidence and 300 mm was due to petroleum extraction (Day et al., 2020; Blum et al., 2023). The uncompensated subsidence has led to the loss of ~5000 km² of wetlands since 1932, with most of the loss since 1970 (Couvillion et al., 2017; Blum et al., 2023). As hydrocarbon production has declined, so have subsidence rates, although this decline has been partially counterbalanced by a recent acceleration of SLR (~10 mm/yr) in the western Gulf of Mexico (Dangendorf et al., 2023).

The Yangtze Delta

With an area of ~18,000 km², of which 40% lies at elevations <2 m, and a population of 31 million, the Yangtze Delta is one of the most densely populated (1800 inhabitants/km²) and economically productive (US$2.2 trillion/yr) deltas in the world. The delta wetlands, with an average elevation of ~2 m, have been heavily reclaimed since prehistoric times and are now the site for Shanghai (population >31 million), whose annual GDP exceeds US$20 trillion (Table 1).

The Yangtze River, with the largest Asian river drainage basin (18,300 km²), once had

the fifth largest global sediment input, ~500 million tons/yr. Since the 1950s, however, more than 50,000 dams of various sizes have been built along the Yangtze watershed, resulting in a decline to ~300 million tons/yr by the late 1990s. With the construction of the world's largest containment system, the Three Gorges Dam, between 2000 and 2004 (Fig. 3), annual sediment flux to the delta dropped quickly to ~150 million tons by 2005, leading to subaqueous erosion and delta recession (Yang et al., 2011, 2014; Luo et al., 2017). Erosion on the prodelta and mouth bar since 2010 has averaged 200 million m^3/yr, compared to 200 m^3/yr of accretion before 1978 (Li et al., 2020; Luan et al., 2021). As sediment discharge from the Yangtze declines to less than 100 million tons/yr, further recession of the delta front is almost assured (Luo et al., 2017). Despite the marked decrease in sediment flux—and in stark contrast to the Mississippi Delta—coastal wetland areas on the Yangtze Delta have increased considerably, adding 240 km^2 (22%) of coastal wetland between 1997 and 2010, largely due to coastal reclamation and the tidal forcing of subaqueous sediment back onto the delta plain (Yang et al., 2021; Zhang et al., 2022).

The delta has also had a major problem with subsidence in large part due to groundwater pumping. Between 1950 and 1965, subsidence in Shanghai averaged 1100 mm (~73 mm/yr), but locally subsidence was as great as 2600 mm (~173 mm/yr; Xu et al., 2012, 2016). Groundwater withdrawal that was >8 × 10^7 m^3/yr in 2000–2004 was reduced to <1 × 10^7 m^3/yr by 2016 through groundwater recharge (He et al., 2019). These measures have helped to achieve a sharp drop in subsidence; since 2011, in fact, recharge has exceeded withdrawal. Shanghai's rapid population increase, from 5.6 million in 1980s to 34 million in 2022, however, has resulted in an explosion in urban construction, particularly high-rise buildings, which has resulted in 300 mm of additional subsidence since 1980 (Yang et al., 2020), an average of ~7.5 mm/yr. Given the low-lying nature of this subsiding delta (40% <2 m in elevation), rising sea level and increased coastal erosion suggest serious future problems for this economically vibrant delta.

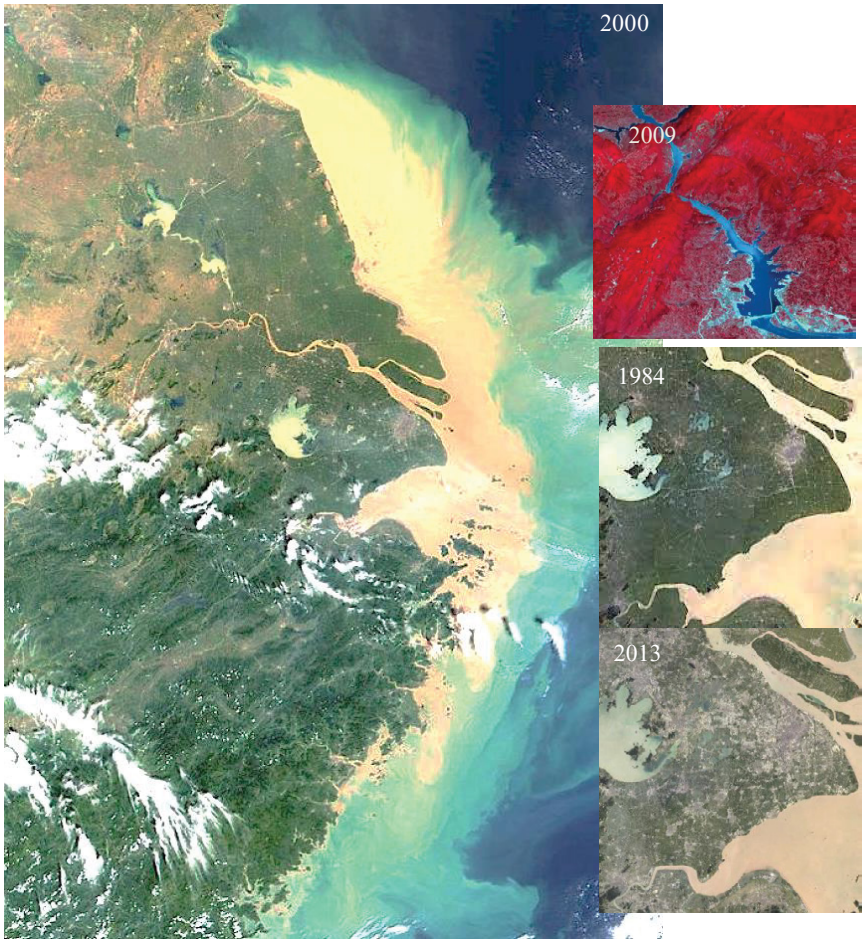

Figure 3. The Yangtze Delta hosts several megacities, including Shanghai (gray area south of the river mouth). Insets: top: A 2009 false-color image of the Three Gorges Dam (the world's largest) on the Yangtze River, which sequesters much of the sediment and water from reaching the delta; middle: A 1984 Landsat image of the Yangtze River mouth and the city of Shanghai; bottom: The same area in a 2013 image showing the growth of greater Shanghai into a megametropolis. Credit: NASA archives.

The Bengal Delta (Ganges, Brahmaputra, and Meghna Rivers)

The Bengal Delta (Fig. 4) is the world's second largest delta (80,200 km^2), ~40% of which lies in India and the rest in Bangladesh, and has one the world's densest populations, with 105 million inhabitants (1500/km^2), including the megapolises of Dhaka (22 million) and Kolkata (15 million). Of the one billion tons of sediment delivered annually to the Bengal Delta (Milliman and Farnsworth, 2011), most are contributed by the Ganges and Brahmaputra River systems, primarily during the summer monsoon. For much of the year, however, the delta is rain-deficient; rainfall during the winter monsoon, between November and March, accounts for only ~5% of the annual total. Additionally, flow has been dramatically reduced by the diversion upstream of Ganges waters into the Hooghly Channel at the Farakka Barrage in India to supply water to Kolkata. Reduced freshwater flux to the delta has resulted in increased saltwater intrusion into both streams and groundwater.

Most freshwater during dry months comes from the pumping of groundwater, retrieved through hundreds of thousands of mostly shallow tube wells (<150 m in depth). Collectively, tube wells provide more than 30 km^3/yr of groundwater to Bangladesh; 90% is used for irrigation, and the remaining 10% furnishes 98% of the pathogen-free drinking water (Shamsudduha et al., 2019). However, when the populace living on the delta changed their freshwater supply from surface water to groundwater, they unwittingly tapped through a naturally occurring layer of arsenic in the delta soil. As much as half the population living on the delta, in both Bangladesh and neighboring West Bengal, is now thought to suffer from the effects of arsenicosis (Kinniburgh and Smedley, 2001; Harvey et al., 2005).

Another predictable result of groundwater withdrawal has been accelerated subsidence. Buried salt kilns and mangrove stumps in

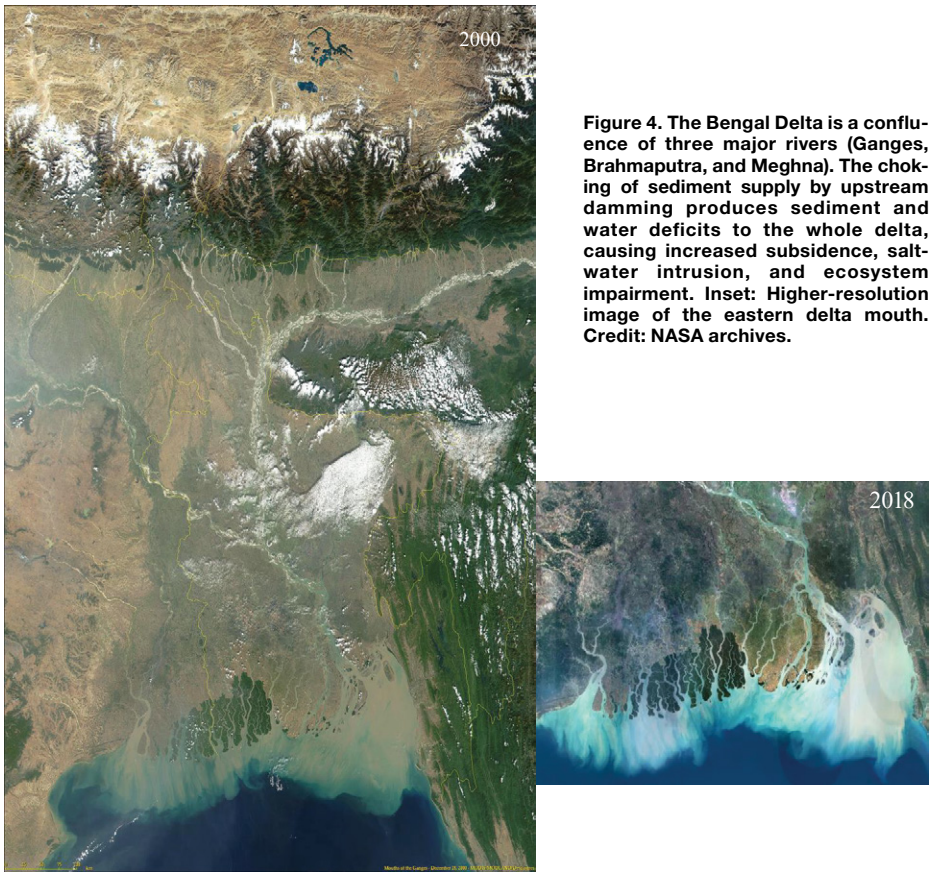

Figure 4. The Bengal Delta is a confluence of three major rivers (Ganges, Brahmaputra, and Meghna). The choking of sediment supply by upstream damming produces sediment and water deficits to the whole delta, causing increased subsidence, saltwater intrusion, and ecosystem impairment. Inset: Higher-resolution image of the eastern delta mouth. Credit: NASA archives.

the southwestern delta, known as the Sundarbans, indicate 4–5 mm/yr of subsidence over the past 300 years (Hanebuth et al., 2013), but subsidence varies significantly on the delta (see Akter et al., 2016). Recent satellite-derived data indicate that average subsidence may be in the range of 2–3 mm/yr (Becker et al., 2020) but still varies greatly. Another study indicates that at least a part of the tidally dominated Sundarbans may be keeping pace with the SLR (Rogers et al., 2013). If the subsidence rates do not worsen, the lower delta may maintain its stability relative to rising sea level.

The coastal delta also suffers from severe cyclonic storms that exacerbate flooding and cause widespread devastation; storm surges can have tidal highs of up to 6 m that can reach over 200 km inland. To manage water supply during dry seasons, levees have been built along the channel, and to protect human habitations from coastal floodings, the World Bank financed the building of a series of 139 polders (a 5700-km network of sea walls) over the past several decades. Over the long term, however, these infrastructures have disrupted the delicate balance between the flow of water and sediment necessary to keep the land above high-flood levels and protect farmlands. Moreover, these embankments also prevent the annual renourishment of the soil and assure additional noncompensated subsidence of the delta. Modelers have reached the conclusion that to maintain long-term health, these polders must allow seasonal flooding rather than continually keeping it out (Cornwall, 2018).

The Niger Delta

The Niger Delta lies at the confluence of three rivers—Niger, Benue, and Imo (Fig. 5)—which collectively drain a catchment area of 2.2 million km^2. Depending on how one delineates its area (29,900 km^2, Kuenzer et al., 2014; 34,500 km^2, Edmonds et al., 2020; 59,000 km^2, Ericson et al., 2006; 70,000 km^2, Ohwo, 2018), the delta is home to between 16 million and 30 million inhabitants. The average elevation is ~3 m above mean sea level, of which 15,300 km^2 lie at or lower than 1 m above sea level (Ohwo, 2018). As such, much of the delta is either permanently or seasonally flooded, thus supporting extensive mangrove swamps. During the wet season, heavy rains can flood towns such as Port Harcourt (which handles nearly 60% of Nigeria's shipping), backing up drainage and sewage systems and causing water contamination, which poses serious health hazards. Damming of the upper Niger and Benue Rivers for hydroelectric power has significantly reduced the sediment influx to the delta. Reduced freshwater flow during dry seasons has led to greater intrusion of saline waters into the delta's groundwater and estuaries. Natural subsidence rates appear to average 2–3 mm/yr (Collins and Evans, 1986).

Hydrocarbon exploration and production has provided the major economic activity in the delta since the 1960s, making up >90% of Nigeria's foreign exchange. Production-related oil spills and the practice of gas flaring (much of it in the economically important mangrove areas) are frequent and have been identified as the most common causes of pollution and environmental degradation of both surface and groundwater (Nwankwoala and Ngah, 2014). Such exploration also has opened up remote areas, bringing attendant detrimental consequences to the rainforests and swamps, which serve as spawning grounds for finfish and shellfish. The major impact of petroleum (and groundwater) withdrawal has been accelerated subsidence. Recent measurements around oil platforms show average subsidence rates of 550 mm/yr (Abija et al., 2020). The rapid urbanization of Lagos (population 25 million) has led to subsidence rates reaching as high as 87 mm/yr in the city's coastal areas (Ikuemonisan and Ozebo, 2020).

A global SLR of 1 m by the end of the twenty-first century would flood much of the Niger Delta and exacerbate the concerns mentioned above. Disappearance of barrier islands due to further acceleration of erosion following ocean transgression would result in the destruction of mangroves and disruption of many of the existing fishing activities, as well as the elimination of future brackish-water aquaculture sites. The economic and societal impacts are difficult to predict, but they could force up to 80% of the delta's population to seek higher ground (IPCC, 2022).

The Nile Delta

Since the mid-1960s, Egypt's Nile Delta (Fig. 6) has served as a prime example of the effect that dams can have on the lower river and its delta. The Aswan Dam, completed in 1964, has prevented most of the Nile's freshwater and nearly all of its sediment from reaching the delta. Theoretically, the Nile no longer has an "active" delta, but

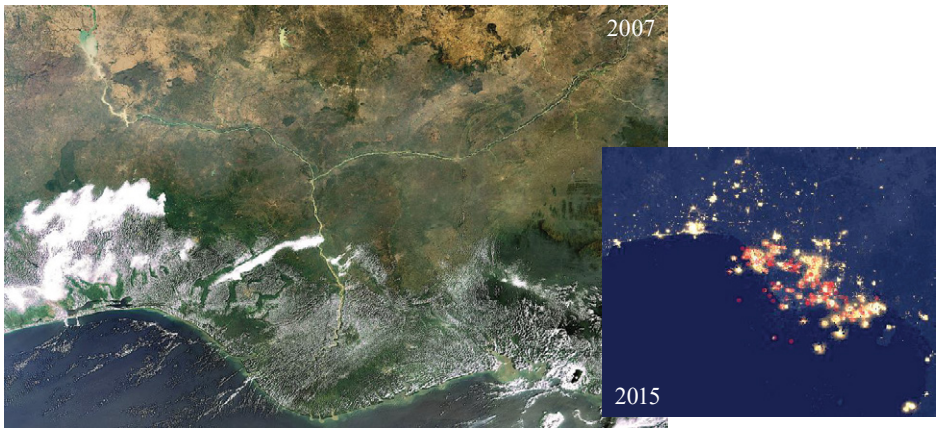

Figure 5. The lower Niger River System, confluence of the Niger River (from the left) and the Benue River (from right) and the Niger Delta with its extensive oil-production infrastructure. This delta provides an extreme example of the intensified subsidence around production platforms due to oil and gas extraction and is among the world's most polluted deltaic systems. Inset: Night view of the delta mouth showing intensive flaring of waste gas emanating from oil wells. Credit: ESA and NASA archives.

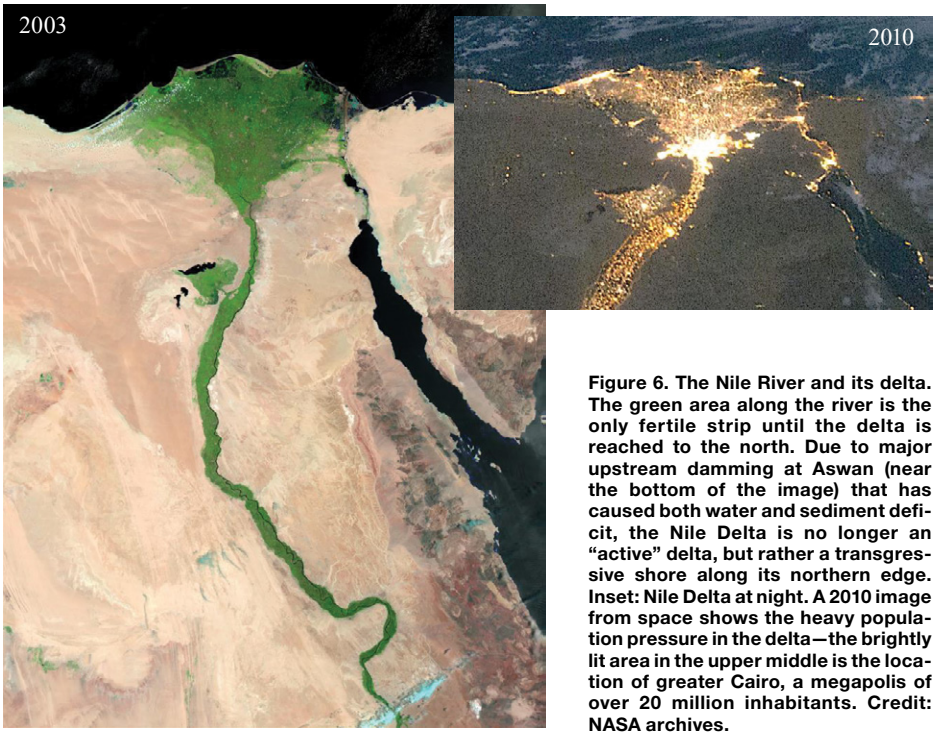

Figure 6. The Nile River and its delta. The green area along the river is the only fertile strip until the delta is reached to the north. Due to major upstream damming at Aswan (near the bottom of the image) that has caused both water and sediment deficit, the Nile Delta is no longer an "active" delta, but rather a transgressive shore along its northern edge. Inset: Nile Delta at night. A 2010 image from space shows the heavy population pressure in the delta—the brightly lit area in the upper middle is the location of greater Cairo, a megapolis of over 20 million inhabitants. Credit: NASA archives.

rather is a wave-dominated coastal plain (Stanley and Warne, 1993). Although the delta covers only 2% of Egypt, it is home to 41% of its population. More than 45 million Egyptians live on or near the lower Nile and its delta, making it more densely populated than the Bengal Delta (1600 vs. 1500 inhabitants/km^2).

Between the years 1500 and 1900, the Rosetta Promontory prograded 15 km. Soon after construction of the Low Aswan Dam between 1899 and 1902, however, the promontory began retreating, ~2 km until 1964 (30 m/yr), and 6 km by 1995, mostly after the construction of the High Aswan Dam, built between 1960 and 1970 (200 m/yr; Sanhory et al., 2022). Delta loading due to urbanization and excessive groundwater withdrawal led to local subsidence rates of between 4 and 20 mm/yr (Becker and Sultan, 2009; Stanley and Clemente, 2017; Saleh and Becker, 2019; Rateb and Abotalib, 2020).

Under normal conditions, Egypt's coastline is protected by sand dunes 1–5 m in height. In the past, four brackish-water lagoons behind the dunes supplied a large percentage of Egypt's fish catch, especially sardines. Since the completion of the High Aswan Dam, however, the lack of water, replenishing sediments, and high subsidence has led to greater shoreline erosion and near-collapse of fisheries in the delta. In places, the shoreline has retreated as much as 10 m/yr. Surprisingly, however, post-High Aswan Dam population explosion and agricultural activity–related contamination by sewage and fertilizer runoff, while causing eutrophication in the delta lagoons, has also led to tripling of fish catch in ocean waters offshore, as compared to pre-Aswan values (Oczkowski et al., 2009). The long-term adverse health effects of the widespread human consumption of fish rich in both biological contaminants and trace metals (Morsy et al., 2020) is as yet unknown, but it should be of grave concern.

The projected 1 m SLR by the end of the twenty-first century increases the chance of promontories being cut back to produce a straighter and smoother wave-dominated coast. Lagoonal areas may shrink due to filling on their seaward sides (Stanley and Clemente, 2017). The loss of wetlands in the delta will also eliminate ecological niches for waterfowl and migrating birds and cause a loss of biodiversity. Widespread salinization (predicted to be up to 100 km inland by 2050) and extensive loss of agricultural land and products are also anticipated. Current trends will inevitably lead to higher pollution levels around the lagoons as the natural wetlands are increasingly converted to anthropogenic use.

The Indus Delta

The Indus Delta (Fig. 7) is 12,700 km^2 in area, of which 4750 km^2 (37%) lies at elevations lower than 2 m (Caldwell et al., 2019; Syvitski et al., 2022). The Indus River has served as a major source of water for much of lower Pakistan, particularly since the construction of a series of upstream barrages and canals in the second half of the twentieth century, which allowed increased irrigation to the arid interior. Present-day discharge past the downriver Kotri barrage for most years is less than 5 km^3/yr, compared to >100 km^3/yr prior to 1960. These barrages have also trapped the river's sediment, down from ~250 million tons/yr prior to 1940 to <5 million tons/yr by 2010 (Milliman and Farnsworth, 2011). This sediment deficit has led to an average delta

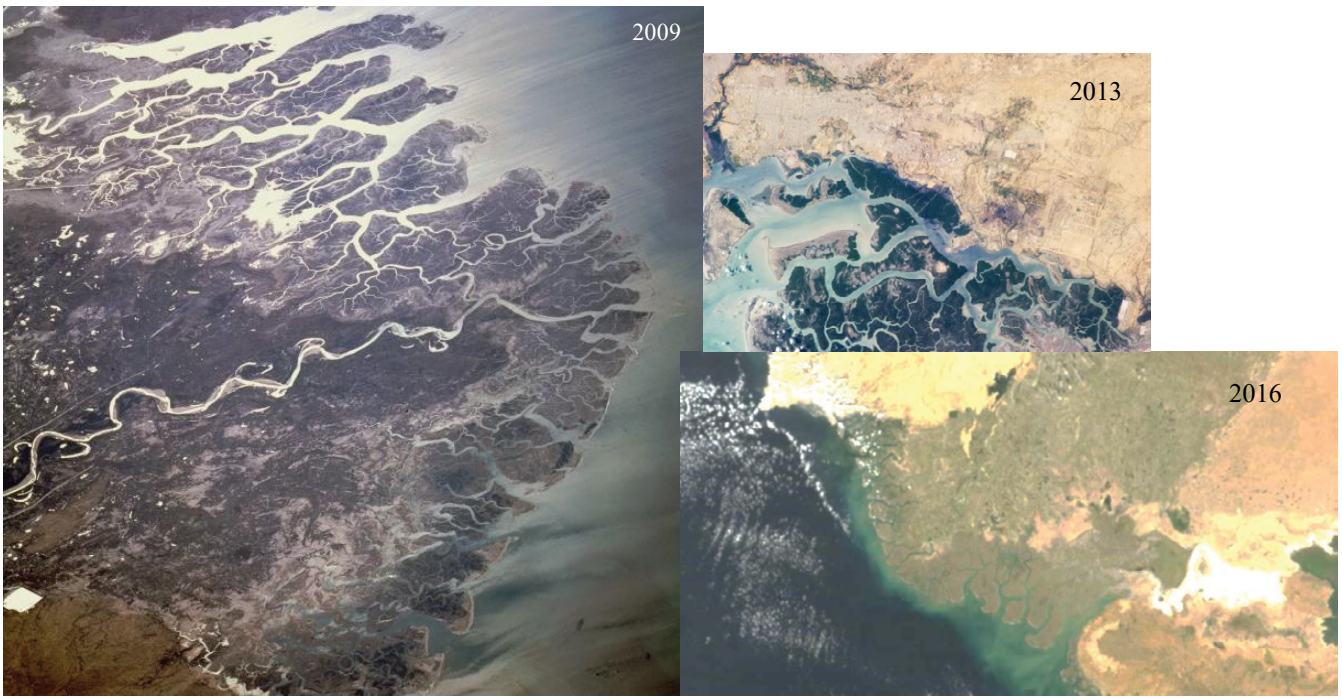

Figure 7. The terminus of the Indus River and its extensive delta system as seen from the west looking eastward. The Indus Delta is a highly dynamic system that is affected by upstream and downstream influences and by seismicity associated with the nearby Makran subduction zone, as well as by tsunamis. The number of distributary channels has reduced from 17 in 1861 to just one today, largely due to upstream diversions and damming. Instead of a fluvially dominated delta, it is now mostly a tidally controlled system, where the mangrove ecosystem has been severely disrupted. Inset: top: 2013 image showing contrast between the still partially active mangrove system (in green) and the now industrialized area of Korangi to its north; bottom: 2016 image of the delta showing widespread desiccation. Credit: NASA archives.

retreat of 16 to >60 m/yr (Hashmi and Ahmad, 2018). Stated differently, between 1944 and 2013, the delta lost 12.7 km^2/yr, fully 14% of its surface area (Syvitski et al., 2013).

Other deleterious effects on the delta include increased subsidence rates, higher surface salinization, and greater salt-water intrusion into both the estuaries and the aquifers; >60% of the groundwater beneath the delta is now either saline or brackish. As such, for all intents and purposes, agriculture has ceased, and fisheries are now the major profession for delta inhabitants. But overfishing and the lack of freshwater nutrients has led to as much as a 70% depletion in fish stock within the delta (Karrar, 2021). This loss of income has led to mass migration; an estimated 1.2 million former residents of the delta have moved, mostly to Karachi, leaving behind <0.3 million inhabitants (Siyal, 2018).

From the 1960s through the end of the twentieth century, the Indus Delta mangroves suffered steady decline, and it was feared that they would be completely decimated (Haq, 1994, 1999). Recent Landsat-image studies show that mangrove recultivation in the delta by the provincial Sindh government has led to gradual recovery and new growth in the southern part of the delta (Masood et al., 2015; Siyal, 2018). Recent major upstream floods on the Indus plain in 2010 and 2013 (and again in 2022) replenished new sediments to the area and are hoped to increase cultivatable land (Rehman and Kazmi, 2018). These recent changes, however, may be only a temporary reprieve, as the estimated eustatic rise of 1 m and increased storm surges predicted by many models will mean further hardship for the declining delta populace. Considering the ongoing climate change and SLR scenarios, it is not difficult to imagine the Indus Delta being—or soon being—a nonfunctioning delta.

CONCLUDING REMARKS

The uniqueness of each delta poses a different set of problems requiring a unique set of strategies to slow or mitigate the looming societal upheavals. For some areas, mitigation may already be impractical or too late; for other areas, the most pragmatic solution now may be adaptation or relocation.

We have cited just a few examples of the major deltas and nearby urban centers where climatic and human-induced change threaten their survival. River dams and dikes prevent the influx and lateral escape of fluvial sediment, which can result in delta erosion and uncompensated subsidence. The most relevant consideration for models of drowning and erosion, however, may be the amount of discharge of freshwater to the deltaic environment. Of the six deltas discussed, two—the Indus and Nile—receive little freshwater from their rivers. In the case of the Indus, this lack of water has led to increased soil salinization and thus failed agriculture. For all intents and purposes, the Indus Delta can be considered moribund, and the area is depopulating. The Nile Delta is somewhat better off, but the future of this vital part of Egypt depends upon optimizing the use of water, reducing land subsidence, and stabilizing erosion. The concerns for the Niger, Yangtze, and Bengal Deltas may be less acute over the short term, but the economic future of these regions will depend on the degree of relative SLR on each of these deltas. On the Mississippi Delta, hydrocarbon production is currently in decline, and once it is established that further exploitation is noneconomical, remediation of the marshlands can begin. Restoration can be undertaken by using dredged sediments to fill subsided marshlands, decontaminating and improving delta hydrology, and replanting marsh vegetation (Day et al., 2020). This delta can most likely be restored to a viable balance

as long as enough freshwater and sediment influx is ensured.

The IPCC has pointed out that adaptation to rising sea level will require a combination of strategies of retreat, accommodation, and coastal protection (IPCC, 2021). Preventing further acceleration of subsidence of the delta, for example, may require the reduction of groundwater withdrawal combined with recharge, such as that being practiced on the Yangtze Delta. While protection may not be feasible for much of Bangladesh's low-lying coastline, its more developed and economically productive areas could be protected from the imminent threat of SLR, at least temporarily, by sea walls, but at great cost. For much of the deltaic population, however, a relocation program may be a more realistic long-term plan. For the Nile Delta, on the other hand, protection may provide a logical solution, given that there is currently no influx of new sediment to the coastal area. Sea walls and other structures could be erected to protect developed areas and urban industrial centers such as Alexandria. Similarly, protecting the entire Nigerian coastline may not be feasible, but shielding the economically vital hydrocarbon infrastructure (depending on the time scale of their utility) and ports may be possible. Relocation of people from the less developed parts of the delta and the coast should be a part of the future plan in this and other deltaic regions in a similar situation.

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Published online 7 September 2023

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With deepest appreciation, the Museum acknowledges Kathryn W. Davis for her generous founding support of the Master of Arts in Teaching (MAT) Program. Leadership support for the MAT program is provided by The Shelby Cullom Davis Charitable Fund.

Generous support has been provided by the Bezos Family Foundation.

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THE GEOLOGICAL SOCIETY OF AMERICA®
CONNECTS 2023
15–18 October
Pittsburgh, Pennsylvania, USA

Welcome

I'm excited to welcome you to GSA Connects 2023, 15–18 Oct., in Pittsburgh, Pennsylvania. Pittsburgh, at the confluence of three major American rivers, is an historic city with a modern vibe, which makes it an excellent venue for our meeting.

This meeting affords many opportunities for scientific engagement and networking with colleagues. Themes for Connects 2023 center around *Diverse Science for a Sustainable Future* and the *Climate and Energy Transition*, with numerous sessions focused on these important topics. As always, there will be groundbreaking symposia and topical sessions across all the geoscience disciplines. The exhibit hall will be a lively space with our vendors and sponsors. We have a wealth of field trips available, including excursions to see caverns and karst, explore Paleozoic stratigraphy in the Appalachian Basin, and even examine the connections between geology and architecture at Frank Lloyd Wright's Fallingwater.

Our Pardee Symposia will cover a wide range of issues, from critical minerals to the future of waste management. There's also as an important session on encouraging positive mental health in the geosciences. This year's Halbouty Distinguished Lecture will be delivered by Susan Brantley, who will discuss fracking and its impacts on our water. On Sunday morning (15 Oct.), consider joining the "Outdoor Afro & GSA Riverwalk!" for a leisurely riverwalk and casual discussion of the geosciences with Outdoor Afro, a national organization dedicated to reconnecting Black people and Black communities to nature.

At the Awards Ceremony, we'll celebrate the outstanding achievements of our GSA members and fellows, from early career professionals to senior scientists. My presidential address will focus on "geoscience at the confluence." The geosciences sit squarely at confluence of time and place, which makes our field rather unique. It'll be a wide-ranging talk that highlights the joy of scientific discovery. If you can, take time out of your meeting to join the GSA community and attend the Awards Ceremony—it'll be time well spent.

Enjoy GSA Connects 2023 and the city of Pittsburgh.

Thanks, and see you soon.

Christopher "Chuck" M. Bailey
GSA President

Thank You Sponsors and Partners!*

Your support of GSA Connects 2023 continues a long-standing tradition of serving science and the profession. The Society appreciates your investment in the growth of current and future leaders in the geoscience community.

**as of 6 September 2023*

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GSA ASSOCIATED SOCIETIES

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Paleontological Research Institution
SEPM Society for Sedimentary Geology
Sigma Gamma Epsilon
The Geological Society of London
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PUBLICATIONS, MAPS, FILMS

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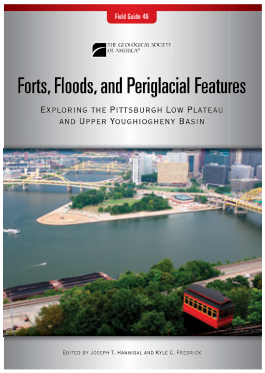
Unearth the Captivating Secrets of Downtown Pittsburgh



Geologic wonders, ancient archaeological finds, and historic treasures await your exploration, and the popular GSA field guide *Forts, Floods, and Periglacial Features: Exploring the Pittsburgh Low Plateau and Upper Youghiogheny Basin,* edited by Joseph T. Hannibal and Kyle C. Fredrick, will lead you on your journey. To help you gear up, we're offering free digital access to this guide through October, so you can make the most of your trip to GSA Connects 2023.

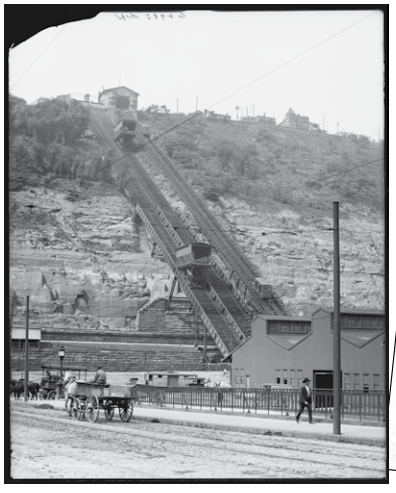
Do you want to delve into the rich history of Pittsburgh while exploring its geologic marvels? The lead guidebook chapter "From Fort Pitt to Coal Hill" offers a captivating walking tour that unveils the fascinating stories behind the local and imported geologic materials used in the eighteenth and nineteenth centuries.

Uncover the story of historic coal use and its impact, as well as the significance of local stone in constructing the city's magnificent buildings. Learn about chert, used in the production of gunflints and millstones, which added to Pittsburgh's industrial legacy. Discover the frontier forts that once stood proudly at this very site. Get ready to be amazed by the natural beauty of Coal Hill (Mount Washington), its notorious landslides, and the world-famous views of the city skyline from atop the Duquesne and Monongahela Inclines.

Additional chapters in this field guide explore periglacial features of the Upper Youghiogheny River basin in Maryland and the Laurel Highlands of Pennsylvania, as well as the hydrologic aspects of the Johnstown, Pennsylvania, flood of 1889.

Immerse yourself in Pittsburgh's captivating past and experience a unique blend of geology, archaeology, and history. Get ready for GSA Connects 2023 and download your free copy from the GSA Bookstore today.

https://store.geosociety.org/Bookstore/ItemDetail?iProductCode=FLD046P



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Above from left: Historic photo of the Monongahela Incline, ~1905 (originally printed by Detroit Publishing Co., now in Library of Congress Prints and Photographs Division. Photograph Collection LC-D4-33967). Ads for French buhr ("burr") millstones, marble mantles and gravestones, and other materials (from I. Harris, 1837, *Harris' Pittsburgh Business Directory for the Year 1837*).

The Geological Society of America®

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GEOCAREERS CORNER

15–17 Oct.
9 a.m.–5 p.m.
Room 403/404/405

- Drop-In Mentoring
- Résumé Review Clinic
- Career Presentations
- Early Career Professional Coffee
- Networking Event
- Women in Geology Program
- Geology Club Meet-up

GEOCAREERS DAY

15 Oct.
9 a.m.– 1 p.m.
Ballroom A
$15 (includes Lunch)

- Career Workshop
- Mentoring Roundtables
- Panel Lunch
- Company Connection Booths

For information on these events and more, please scan the QR code!

THE GEOLOGICAL SOCIETY OF AMERICA®
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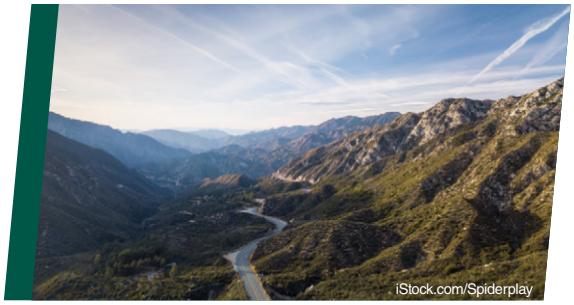
Become a RISE Liaison

RISE stands for Respectful, Inclusive Scientific Events. Through RISE, GSA fosters an environment where all individuals can participate fully in an atmosphere that feels safe, respectful, and professional. RISE also drives awareness of GSA's Events Code of Conduct, which ensures that all concerns are addressed as quickly, fairly, and confidentially as possible.

Join GSA in promoting a respectful, inclusive culture by becoming a RISE Liaison. To start, watch this 15-minute training video (**www.geosociety.org/rise-liaison**). We hope you will consider volunteering for this meaningful role in time for GSA Connects 2023!

Mark your calendar for 22–25 September for an unforgettable experience at GSA Connects 2024 in Anaheim, California, USA! Help shape the future of geoscience exploration and discovery by submitting a proposal for a short course, field trip, and/or technical session.



IGNITE DISCOVERY

Lead a field trip

Propose an exciting field trip to explore spectacular regional localities ranging from a half day to five days in length. Online field trip proposals are also encouraged.

Deadline: 1 Dec. 2023

ELEVATE YOUR INFLUENCE

Chair a technical session

Help create a meeting program that will inspire imaginative insights. Submit your proposal for a Pardee Keynote Symposium or topical session.

Deadline: 1 Feb. 2024

SPARK CURIOSITY

Teach a short course

This is a fantastic opportunity to share your expertise by designing and leading an impactful short course. Courses can range from a half day to two full days and may be conducted in-person or online.

Deadline: 1 Feb. 2024

community.geosociety.org/gsa2024

Now Accepting GSA Award Nominations for 2024!

Honor the brightest minds in the geosciences by nominating a colleague for a medal, award, or recognition.

Individuals selected for GSA awards and medals must adhere to GSA's ethics disclosure requirements and comply with GSA's Code of Ethics & Professional Conduct.

The deadline for receipt of all medal, award, and recognition nominations is 1 Feb. 2024.

www.geosociety.org/awards

GSA MEDAL AWARDS

Penrose Medal

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

Arthur L. Day Medal

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

Young Scientist Award (Donath Medal)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 years or younger throughout the year in which the award is to be presented—*for 2023, only those candidates born* ***on or after 1 Jan. 1988*** *are eligible*) for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in the earth sciences. The award consists of a gold medal (the Donath Medal) and an honorarium.

How to Nominate

To ensure thorough consideration by the respective committees, please follow these nomination instructions carefully; additional information supplied will not enhance the nomination. For each candidate, please submit the following:

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.
2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org. For Penrose, Day, and Donath, the following supporting documents are required:

- Curriculum vitae
- Summary (300 words or less) of the scientific contributions to geology that qualify the candidate for the award
- Selected bibliography of no more than 20 titles (for the Donath Medal, only 10 titles are required)
- Five (5) letters of support from GSA Fellows or members ***in addition*** to the person making the nomination. **For the Day Medal only:** letters from five (5) scientists, with at least three (3) of those being from GSA Fellows or members and up to two (2) from fellows or members of the Mineralogical Society of America, Geochemical Society, or American Geophysical Union.

GSA AWARDS

Florence Bascom Geologic Mapping Award

The Florence Bascom Geologic Mapping Award was approved by GSA Council in October 2013 and the first award was presented in 2015. This award acknowledges contributions in published high-quality geologic mapping that led the recipient to publish significant new scientific discoveries, to bring about greater understanding of fundamental geologic processes and concepts, and to contribute to the application of new knowledge to societal needs and opportunities in such areas as mineral resources, water resources, and the environment.

The recipient will have authored high-quality geologic maps, cross sections, and summary reports that have received scientific acclaim and are available to both peers and the public, through federal or state agencies or major scientific societies. In evaluating the merits of nominees for this award, scientific achievements should be considered rather than contributions in teaching, administration, or service. Nominees may or may not be members of the Society, and they may be from any nation.

The selection criteria employed by the Geologic Mapping Award Committee are as follows: (1) excellence of the nominee's published geologic maps; (2) clear record of greater understanding of fundamental geologic processes and/or concepts, and high-quality publication of same, emerging directly from the meritorious quality of the geologic mapping; and (3) peer acclaim of the practical usefulness of the geologic mapping and the new discoveries that emerged from the mapping.

How to Nominate

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.

2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org:
- Curriculum vitae
- Letter of nomination (300 words or less) addressing the evaluation criteria
- Selected bibliography of geologic maps (15 titles or less)
- Selected bibliography of peer-reviewed publications (20 titles or less)
- PDFs or website links to several key geologic maps authored by the nominee
- Letters of support from three (3) scientists, with at least two (2) from GSA Fellows or members and one (1) from a member of another professional geoscience organization. Diverse supporters (including individuals who are not currently/recently associated with the nominee's institution) are strongly encouraged.

Randolph W. "Bill" and Cecile T. Bromery Award

The Bromery Award shall be awarded to any minority, preferably African Americans, who qualify under at least one of these two categories:

1. Nominee has made significant contributions to research in the geological sciences, as exemplified by one or more of the following:
- Publications that have had a measurable impact on the geosciences
- Outstanding original contributions or achievements that mark a major advance in the geosciences
- Outstanding lifetime career that demonstrates leadership in geoscience research

2. Nominee has been instrumental in opening the geoscience field to other minorities, as exemplified by one or more of the following:
- Demonstrable contributions in teaching or mentoring which have enhanced the professional growth of minority geoscientists
- Outstanding lifetime career service in a role that has highlighted the contributions of minorities in advancing the geosciences
- Authorship of educational materials of high scientific quality that have enjoyed widespread use and acclaim among educators or the general public

The 2022 recipient, Frederic Henley Wilson, accepting his award at GSA Connects 2022 in Denver, Colorado, USA.

How to Nominate

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.
2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org:
- Curriculum vitae
- Letter of nomination (300 words or less)
- Letters of support from three (3) scientists, with at least two (2) from GSA Fellows or members and one (1) from a member of another professional geoscience organization
- Optional selected bibliography of no more than 10 titles

Doris M. Curtis Outstanding Woman in Science Award

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

How to Nominate

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.
2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org:
- Curriculum vitae including dissertation title and abstract
- Letter of nomination that clearly states how the Ph.D. research has impacted the geosciences in a major way. DEI promotion activities, as defined by GSA's Diversity in the Geosciences Position Statement [https://www.geosociety.org/GSA/Science_Policy/Position_Statements/gsa/positions/position15.aspx], are to be included in the submitted letter of nomination.
- Letters of support from three (3) scientists, with at least two (2) from GSA Fellows or members and one (1) from a member of another professional geoscience organization. DEI promotion activities, as defined by GSA's Diversity in the Geosciences Position Statement [https://www.geosociety.org/GSA/Science_Policy/Position_Statements/gsa/positions/position15.aspx], are to be included in the letters of support.
- Additionally, nominators and support letter writers are requested to address the continued impact of the nominee and their Ph.D. research on the scientific community by including the following:
- Relevance of the work to the specialty field and more broadly to the geosciences and society
- Discussion of the impact of the Ph.D. research via altered ways of thinking, new techniques, new citation data of resulting publications, etc.
- Efforts by the nominee to impact the geosciences through activities such as mentoring, teaching, and initiatives promoting diversity in the field
- Selected bibliography of no more than 10 titles

GSA Distinguished Service Award

GSA Council established the GSA Distinguished Service Award in 1988 to recognize individuals for their exceptional service to

the Society. GSA members, Fellows, associates, and employees may be nominated for consideration, and any GSA member or employee may submit a nomination for the award. GSA's Executive Committee will select awardees, and GSA Council must ratify all selections. Awards may be made annually, or less frequently, at the discretion of Council.

How to Nominate

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.
2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org.

- Curriculum vitae
- Letter of nomination (300 words or less)
- Brief biographical sketch that clearly demonstrates the applicability of the selection criteria
- Optional selected bibliography of no more than 10 titles

"I found immense satisfaction in nominating a worthy colleague for a GSA award, as it highlighted the exceptional scientific creativity of an individual whom I deeply respect."
~Kurt Konhauser, nominator for 2022 Day Medal Awardee Timothy W. Lyons

GSA Public Service Award

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

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

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

How to Nominate

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.
2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org:

- Curriculum vitae
- Letter of nomination (300 words or less)
- Brief biographical sketch that clearly demonstrates the applicability of the selection criteria
- Selected bibliography of no more than 10 titles

GSA Michel T. Halbouty Lecturer Award

The Michel T. Halbouty Distinguished Lecturer provides an honorarium for a Halbouty Distinguished Lecturer at the annual GSA Connects meeting. The GSA Foundation fund was established to select a top lecturer on a topic of relevance to natural resources (i.e., water, land, energy, and minerals). The award recognizes scholars with reputable accomplishments across a range of topics regarding natural resources, including: finite limits on worldwide availability; regional overviews (U.S.) of availability, quality, quantity, and use; environmental damage from extraction or exploitation; geologic aspects of environmental remediation; overarching government policies concerning natural resources; regional exploration; and new exploration tools. GSA membership is not required.

How to Nominate

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.
2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org;

- Curriculum vitae
- Letter of nomination (300 words or less)

Honorary Fellow

Established by GSA Council in 1909, Honorary Fellowship may be bestowed on individuals who have made outstanding and internationally recognized contributions to geoscience or, in rare circumstances, provided notable service to the Society. In practice, nearly all candidates are non-North Americans who live and work outside of North America. The most noteworthy exceptions were astronauts. The awardee does not have to be a member of the Society to receive the award. No more than two Honorary Fellows will be awarded annually. Honorary Fellows will be recognized during the GSA Annual Meeting and will receive complimentary lifetime membership to the Society.

How to Nominate

1. **Nomination form:** Please go to https://rock.geosociety.org/forms/Awardform.asp to submit the form online.
2. **Supporting documents,** to be submitted as e-mail attachments to awards@geosociety.org:

- Curriculum vitae
- Nomination letter: 2–3 pages and endorsed by 2 GSA Fellows and 1 GSA Fellow or a person of equivalent international stature
- Selected bibliography of no more than 20 titles

GSA AWARD NOTES

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

All nomination forms and submission instructions can be found online at www.geosociety.org/awards/. For further information, email awards@geosociety.org

OTHER AWARDS

John C. Frye Environmental Geology Award

Deadline: 31 Mar. 2024

In cooperation with the Association of American State Geologists (AASG), GSA grants an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys.

Anyone can nominate a paper as long as it is selected from a GSA or state geological survey publication and published during the preceding three full calendar years. The nomination letter must include a paragraph stating the importance of the paper. Up to three (3) letters from users of the publication can be included to support the nomination.

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

Please send your nominations to awards@geosociety.org. For more information, please visit https://www.geosociety.org/GSA/About/awards/GSA/Awards/Frye.aspx.

AGI Medal in Memory of Ian Campbell

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

AGI Marcus Milling Legendary Geoscientist Medal

The 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 who is nearing completion or has completed full-time regular employment. Prior to 2007 the award was called the AGI Legendary Geoscientist Award. For more information and to submit a nomination, visit www.americangeosciences.org/awards/legendarygeoscientist.

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PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

Southeastern Section

73rd Annual Meeting of the Southeastern Section, USA

Asheville, North Carolina, USA
15–16 Apr. 2024

www.geosociety.org/se-mtg

Photo credit: Ashley Lynn.

LOCATION

The 2024 meeting of the Southeastern Section will be held in Asheville, North Carolina, on 15–16 Apr. Asheville offers easy access to the world-class geology of the Blue Ridge, Piedmont, Valley and Ridge, and Cumberland Plateau, with geologic locales including ancient orogenic belts, exotic mineral districts, active landslides, karst landscapes, and unique fossil sites. The Asheville Renaissance Hotel is downtown in the heart of it all—roughly 20 miles from the Asheville Regional Airport (AVL), and walking distance from popular restaurants, breweries, shops, and other historic and cultural attractions.

CALL FOR PAPERS

Abstracts deadline: 9 Jan. 2024, 11:59 p.m. PST
Submit online at **www.geosociety.org/se-mtg**
Abstract submission fee: GSA members: professionals US$30, students US$18; non-members: professionals US$60, students US$36. If you cannot submit an abstract online, please contact Heather Clark, hclark@geosociety.org.

TECHNICAL PROGRAM

Symposia

S1. **Spanning an Orogen–From the Scandinavian Caledonides of Norway to the Southernmost Appalachians of Alabama: In Honor of the Career of James F. Tull.** Clinton I. Barineau, Columbus State University, barineau_clinton@columbusstate.edu; Christopher Holm-Denoma, U.S. Geological Survey, cholm-denoma@usgs.gov; Mary Beth Lupo, Florida Geological Survey, mary.lupo@floridadep.gov.

This session recognizes James F. "Jim" Tull's >50-year career working at the northern (Norway) and southern (Alabama-Georgia-North Carolina) ends of the Caledonide-Appalachian orogenic belt. We welcome all submissions related to the tectonic evolution of the Appalachian-Caledonian and related orogenic belts.

S2. **Interstate Collaboration in the Southeast US: State Geological Surveys Working Toward Stratigraphic and Lithologic Equivalencies to Address Mapping Discrepancies More Effectively.** Scott Howard, South Carolina Geological Survey, howards@dnr.sc.gov; Kathleen Farrell, North Carolina Geological Survey, kathleen.farrell@deq.nc.gov; Phil Bradley, North Carolina Geological Survey, pbradley@deq.nc.gov.

Cooperative efforts among state geological surveys allow reconciliation of state-line mapping issues, specifically edge-matching and problems of stratigraphic nomenclature. Results promote communication and cooperation. Examples of current projects, past projects, and future projects provide guidance. Areas include the Coastal Plain, Piedmont, Blue Ridge, and anywhere in the southeast, including offshore.

Theme Sessions

T1. **Cores and Rocks from the Southeast Atlantic Continental Margin to Facilitate Interstate Correlation of Along-Strike Units: A Hands-On Poster Session to Support Symposium 2.** Kathleen Farrell, North Carolina Geological Survey, kathleen.farrell@deq.nc.gov; Marcie Occhi, Virginia Department of Energy, marcie.occhi@energy.virginia.gov; Will Doar, South Carolina Geological Survey, doarw@dnr.sc.gov; Mary Lupo, Florida Geological Survey, mary.lupo@floridadep.gov.

This poster session is primarily a hands-on display of geologic core and rock samples that will facilitate interstate correlation on the Southeast Atlantic Coastal Plain and related continental margin provinces (e.g., continental shelf, Triassic Basins, and Piedmont provinces) and support the Southeast Atlantic Coastal Plain cooperative. Some concepts covered by the session include: interstate correlation problems in stratigraphy and bedrock mapping; source rocks for REE minerals; geochronology; and regolith characteristics.

T2. **Geochemical Proxies for Marine and Continental Paleoenvironments.** Shane Schoepfer, Western Carolina University, sschoepfer@wcu.edu; Thomas Tobin, University of Alabama, ttobin@ua.edu; Xikai Wang, University of North Carolina–Chapel Hill, xikai@live.unc.edu; Tian Gan, University of Maryland, gantian@umd.edu.

This session welcomes presentations that employ sedimentological, geochemical, or paleontological proxy methods to reconstruct marine and continental paleoenvironments and provide insight into environmental conditions and change over time. Presentations focusing on paleoecological interactions, at the organism and ecosystem level, are also welcomed.

T3. **Magma, Heat, Fluids, and Critical Resources Across Tectonic Settings, Lithospheric Realms, Volcanic Systems, and Geologic Timescales.** Mattia Pistone, University of Georgia, mattia.pistone@uga.edu; Paulo J. Hidalgo, Georgia State University, phidalgo@gsu.edu; Blake M. Wallrich, Vanderbilt University, blake.m.wallrich.1@vanderbilt.edu; Laura Bilenker, Auburn University, ldb0036@auburn.edu; Ryan Currier, University of West Georgia, rcurrier@westga.edu.

This session invites geoscientists across subdisciplines to share field-based, experimental, analytical, and computational research on magma/fluid transport, geothermal/mineral resources, and translithospheric processes, from mineral to geodynamic scales and volcanic to tectonic timescales. This cross-disciplinary session aims to unite geologists, geochemists, petrologists, economic geologists, geochronologists, volcanologists, tectonophysicists, and beyond.

T4. **The Eastern Piedmont: The Last Frontier of Research in the Southern Appalachian Orogen.** Mark W. Carter, U.S. Geological Survey, mcarter@usgs.gov; David E. Blake, University of North Carolina–Wilmington, blaked@uncw.edu; Robert H. Morrow, IV, South Carolina Geological Survey, morrowr@dnr.sc.gov.

New geologic mapping and geophysical and geochronological datasets are rapidly expanding our knowledge of the eastern Piedmont in the southern Appalachian orogen, where existing geologic data are mostly inadequate, outdated, or sparse. We encourage submissions of new research from the eastern Piedmont that address important scientific and societal questions.

T5. **Carolina Terrane Origins and Evolution.** Andy Bobyarchick, University of North Carolina-Charlotte, andybobyarchick@charlotte.edu; Shane Schoepfer, Western Carolina University, sschoepfer@email.wcu.edu.

The Carolina Terrane is an amalgamation of Neoproterozoic to Cambrian peri-Gondwana arc assemblages accreted to eastern Laurentia in the Ordovician Cherokee orogeny. We invite contributions to this session that explore all attributes of the Carolina Terrane, including stratigraphy, paleontology, magmatism, mineralogy and petrology, deformation, and metamorphism.

T6. **Ductile to Brittle Deformation in the Southern Appalachians: Grenville to Present.** *Endorsed by GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division.* Jackie Langille, University of North Carolina–Asheville, jlangill@unca.edu; Jamie Levine, Appalachian State University, levinejs@appstate.edu.

Deformation along shear zones, faults, and fractures has been documented in the southeastern United States across a uniquely wide range of spatial and temporal scales. This session invites presentations about deformational systems across the southern Appalachians, from ductile to brittle, shallow to deep, Precambrian to Cenozoic.

T7. **Sedimentology, Geochronology and Tectonics in the Southeastern United States and Beyond.** David L. Barbeau, Jr., University of South Carolina, dbarbeau@geol.sc.edu; Alex Pullen, Clemson University, apullen@clemson.edu; Andrew L. Leier, University of South Carolina, aleier@geol.sc.edu.

This session aims to be a forum for the communication of new research on the sedimentary history and tectonic evolution of the southeastern United States, integrating applied geo- and/or thermochronology, as well as for investigations that could be used to elucidate outstanding tectonic questions.

T8. **Geoscience Investigations of the Caribbean: Fundamental Science, Socioeconomic, and Environmental Issues.** Liannie Velazquez Santana, University of Texas at Austin, velazqlc@miamioh.edu; Wilnelly Ventura Valentin, Miami University, venturwa@miamioh.edu; Mark Krekeler, Miami University, krekelmp@miamioh.edu.

This session welcomes talks and posters on petrological, geochemical, geophysical, and environmental research in the Caribbean region, including but not limited to the United States, Greater Antilles, and Mexico. Investigations with a focus on the connection between fundamental science and socioeconomic and environmental issues are highly encouraged.

T9. **In the Field or In the Lab: Revealing Hidden Signals from Minerals via Geochronology and/or Geochemistry.** *Endorsed by GSA Quaternary Geology and Geomorphology Division; GSA Geochronology Division.* Michelle Nelson, Virginia Department of Energy, michelle.nelson@energy.virginia.gov; William Odom, U.S. Geological Survey, wodom@usgs.gov; David Hawkins, Virginia Department of Energy, david.hawkins@energy.virginia.gov.

This session will bring together research involving field- or lab-based geochemical and geochronological signals from mineral grains in unique depositional environments. We invite studies covering the Neogene and Quaternary periods that utilize geochronology and/or geochemistry to better understand surface, burial, and diagenetic processes.

T10. **Water Quality Issues in the Southeastern United States.** *Endorsed by GSA Hydrogeology Division.* Madeline Schreiber, Virginia Polytechnic Institute and State University, mschreib@vt.edu.

This session will focus on water quality research throughout the southeastern United States. In this session, we encourage presentations on field, laboratory, and modeling studies that address aspects of water quality of surface and groundwater resources.

T11. **Wetlands, Springs, and Streams: Hydrologic Studies at the Groundwater-Surface Water Interface.** *Endorsed by GSA Hydrogeology Division.* Jeff Wilcox, University of North Carolina–Asheville, jwilcox@unca.edu.

This session will bring together research conducted throughout the southeast at the groundwater-surface water interface. We invite presentations investigating recharge and discharge processes, quantifying water levels and fluxes, and presenting case studies in varied terrain throughout the region.

T12. **River Systems of the Eastern United States: Dynamics and Evolution from the Pleistocene to the Anthropocene.** *Endorsed by GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division.* Chris Norcross, North Carolina State University, conorcro@ncsu.edu; Karl Wegmann, North Carolina State University, kwwegman@ncsu.edu.

Rivers are constantly changing. This session seeks contributions investigating fluvial variability across multiple temporal and spatial scales where the change may be caused by natural or anthropogenic forcing. Examples might include

floodplain dynamics, stream restoration, biogeomorphology, or future variability in a warming climate. Field, experimental, and modeling studies are encouraged.

T13. **Quaternary Geology and Geomorphology of the Piedmont and Blue Ridge.** *Endorsed by GSA Quaternary Geology and Geomorphology Division.* Brad Johnson, Davidson College, brjohnson@davidson.edu; Martha Cary (Missy) Eppes, University of North Carolina–Charlotte, meppes@charlotte.edu.

This session seeks work that addresses the soils, surface processes, and/or Quaternary landscape evolution of the Piedmont and Blue Ridge–loosely defined–of the eastern United States. We welcome field, modeling, or laboratory approaches.

T14. **Bridging the Gaps Between Landslide Hazard Policy, Research, and Practice.** *Endorsed by GSA Environmental and Engineering Geology Division.* Bobby Sas, North Carolina Geological Survey, robert.sas@deq.nc.gov; Jeremy Jurgevich, North Carolina Geological Survey, jeremy.jurgevich@deq.nc.gov.

We invite researchers, practitioners, and policy stakeholders to present on a wide range of landslide hazard–related topics. This session aims to make connections, bridge gaps, and promote collaborative frameworks for more integrated solutions to understanding landslide hazards and reducing risks.

T15. **Current Technological Trends in Landslide Assessment and Susceptibility Studies: Innovative Digital Techniques, Collection Methods, and Modeling.** *Endorsed by GSA Environmental and Engineering Geology Division.* Anne Carter Witt, Virginia Department of Energy, anne.witt@energy.virginia.gov.

Technological advancements are rapidly transforming how we create and develop landslide assessments, hazard maps, and inventories. This session will showcase the work of researchers, practitioners, and students engaged in innovative landslide studies in the southeastern United States. Topics include change detection, new remote sensing techniques, automated mapping processes, and more.

T16. **Progress Towards Geologic CO_2 Storage in the Eastern United States.** Ryan Pollyea Virginia Polytechnic Institute and State University, rpollyea@vt.edu; David Riestenberg Advanced Resources International, driestenberg@adv-res.com; Lars Koehn, Virginia Polytechnic Institute and State University, larsk@vt.edu; Jeremy Leierzapf, Advanced Resources International, jleierzapf@adv-res.com.

Driven by substantial federal investment in carbon capture and storage (CCS), commercialization efforts are now underway throughout the eastern and southeastern United States, a region previously considered economically and/or geologically unviable. This session invites presentations that discuss science and engineering challenges facing CCS deployment within the eastern United States.

T17. **Paleoclimatology, Paleoecology, and Conservation Paleobiology: Old Tools and New Tricks for Unraveling the Past and Informing the Future.** Garrett Braniecki, University of North Carolina -Chapel Hill, braniegf@email.unc.edu; Molly Bost, National Oceanic and Atmospheric Administration, molly.bost@noaa.gov; Hunter Hughes, University of North Carolina-Chapel Hill, hphughes@email.unc.edu.

Paleoclimatology, paleoecology, and conservation paleobiology use the past to inform the future about environmental and biological changes through time. Recent technological developments are merging with tried-and-tested techniques, creating powerful new insights into once-enigmatic processes. This session aims to showcase new and novel approaches for these interdisciplinary fields.

T18. **Vertebrate Paleontology Research in Southeastern North America.** *Endorsed by Southeastern Association of Vertebrate Paleontology.* Blaine Schubert, East Tennessee State University, schubert@etsu.edu; Josh Samuels, East Tennessee State University, samuelsjx@etsu.edu; Steven Wallace, East Tennessee State University, wallaces@etsu.edu.

This technical session focuses on vertebrate paleontology research in southeastern North America. This includes research on fossil vertebrates from this region and work being done elsewhere by vertebrate paleontologists who reside in the region.

T19. **Southeast Coastal Plain Stratigraphy.** Anthony Boxleiter, Georgia State University, aboxleiter1@student.gsu.edu.

Review, synthesis, and a new look at Coastal Plain stratigraphy.

T20. **Applied Geophysical Survey Methods and Mapping in the Southeast.** Paul S. Martin, Martin Archaeology, psmartin@martinarchaeology.com; Blair Tormey, Western Carolina University, btormey@wcu.edu.

Geology and archaeology intersect through survey and mapping methods. We invite abstracts that will highlight applied methodologies and mapping projects in the southeastern United States, including shallow surface geophysics (e.g., GPR, resistivity, magnetometry), remote sensing (e.g., drones, LiDAR), or comparisons in GPS accuracy and precision (e.g., GNSS, N-Trip, RTK).

T21. **Undergraduate Research Poster Session.** *Endorsed by Council on Undergraduate Research Geosciences Division.* Lee Phillips, University of North Carolina-Greensboro, plphilli@uncg.edu; Jeff Ryan, University of Southern Florida, ryan@mail.usf.edu.

This poster session is designed to showcase undergraduate research efforts. All abstracts should be written by the student or students, and students must present the poster. Topics may include undergraduate research in any discipline of geology or related fields (such as water resources, hydrology, oceanography/marine science, environmental science, GIS science, physical geography, etc.). All submissions should include a faculty mentor as co-author.

T22. **Undergrad Research Oral Session.** Ashley Lynn, North Carolina Geological Survey, ashley.lynn@deq.nc.gov; Cheryl Waters-Tormey, Western Carolina University, cherylwt@wcu.edu.

We seek to highlight and encourage the next generation of geoscience professionals with an oral session featuring contributions conducted and presented by undergraduates. Each speaker will be allotted 10 minutes, to encourage first-time speakers and foster discussion between student peers and faculty mentors.

T23. **Undergraduate and Graduate Posters with Lightning Talk.** *Endorsed by Council on Undergraduate Research Geosciences Division.* Mary I. Abercrombie, Florida Gulf Coast University, mabercrombie@fgcu.edu; Mark Lord, Western Carolina University, mlord@wcu.edu; Marian Buzon, University of West Georgia, mbuzon@westga.edu.

This poster session invites undergraduate and graduate students to present research findings in a 3–5 minute, one-slide talk during a special evening event, followed by a dedicated poster session the next day. This combination will allow students to gain the valuable experience of giving a talk at a scientific meeting in a reduced-pressure setting.

T24. **Geologic Maps, Geophysical Maps, 3-D Geological Models, Digital Mapping Techniques, Map Derivatives, and Digital Map Preparation.** Randy Kath, University of West Georgia, rkath@westga.edu; Karen Tefend, University of West Georgia, ktefend@westga.edu.

This poster session will highlight new geologic maps, mapping programs, and innovations in geologic mapping techniques, including data management, web accessibility, 3D maps and cross sections, and applications in water/land management. We encourage submission of new geologic maps, including derivative maps and map products, from government, academia, and industry.

T25. **Expanding Your Professional Capacity: Navigating Leadership, Communication, Mentoring, Work-life Balance, and Mental Health.** Jennifer Nocerino, The Geological Society of America, jnocerino@geosociety.org; Brandy Myers, The Geological Society of America bmyers@geosociety.org.

Over the past five years, the workforce and our workplaces have seen many changes, including retirements, resignations, hybrid work, and culture shifts. Some of these changes have positive impacts to reduce burnout and increase our capacity for connecting with our colleges. This session aims to grow your leadership capacity by providing tools for navigating change, communication and mentoring strategies, boundaries in the workplace, and compassionate mental health practices. Who we are, as geoscientists, is just as important as the work we do.

FIELD TRIPS

Trip registration opens in January. For additional information, please contact the field trip co-chairs: Mark Carter, U.S. Geological Survey, mcarter@usgs.gov; Arthur Merschat, U.S. Geological Survey, amerschat@usgs.gov.

Paleozoic Tectonics, Pleistocene Landforms, and Holocene Seismicity in the Blue Ridge: Results from Integrated Studies into the 9 Aug., 2020, Mw 5.1 Earthquake Area near Sparta, North Carolina. Arthur Merschat, U.S. Geological Survey, amerschat@usgs.gov; Mark Carter, U.S. Geological Survey, mcarter@usgs.gov; Paula Figueiredo, North Carolina State University, paula_figueiredo@ncsu.edu; Kevin G. Stewart, University of North Carolina-Chapel Hill, kgstewar@email.unc.edu; Ashley Lynn, North Carolina Geological Survey, ashley.lynn@deq.nc.gov; William E. Odom, U.S. Geological Survey, wodom@usgs.gov.

This field trip will examine the co-seismic surface rupture from the 9 Aug. 2020 Mw 5.1 earthquake, near Sparta, North Carolina, and the results of integrated bedrock and surficial geologic mapping, paleoseismic, geomorphologic, and geochronologic studies to understand the tectonic and neotectonic history of the Blue Ridge.

Down the Escarpment and Across the Zone: A Transect from the Eastern Blue Ridge to the Western Piedmont; A Billion Years of Geology and Geohazards. Bart Cattanach, North Carolina Geological Survey, bart.cattanach@deq.nc.gov; David Korte, North Carolina Geological Survey, david.korte@deq.nc.gov.

Visit new and classic stops highlighting western North Carolina geology and geohazards. Descend southward from the eastern Blue Ridge, across the Brevard Zone, into the Piedmont physiographic province. Scenic overview stops illustrate broad structural features and outcrops showcase recent North Carolina Geological Survey mapping.

Big Slow-Movers, Debris Slides and Flows, and Mega-Boulders of the Blue Ridge Escarpment, Western North Carolina. *Endorsed by GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division.* Jesse Hill, Appalachian Landslide Consultants, jesse.hill.geology@gmail.com; Rick Wooten, North Carolina Geological Survey (retired), richard.m.wooten@gmail.com; David Korte, North Carolina Geological Survey, david.korte@ncdenr.gov; Jennifer Bauer, Appalachian Landslide Consultants, jennifer@appalachianlandslide.com; Philip Prince, Appalachian Landslide Consultants, philip@appalachianlandslide.com; Jody Kuhne, Appalachian Landslide Consultants, jody@appalachianlandslide.com; Cheryl Waters-Tormey, Western Carolina University, cherylwt@email.wcu.edu; Lewis Owen, North Carolina State University, laowen2@ncsu.edu; Daria Khashchevskaya, North Carolina State University, dkhashc@ncsu.edu; Karl Wegmann, North Carolina State University, karl_wegmann@ncsu.edu.

This trip highlights the Blue Ridge Escarpment, a sinuous, south-to-north, topographic step traversing the southern Appalachians and separating the high Blue Ridge Mountains from the rolling hills of the Piedmont. This over-steepened zone of poly-deformed, metamorphic terrain exhibits a regional sample of landslides, from large debris flows and slides to rockslides-falls.

Gray Fossil Site and Museum. *Sponsored by National Association of Geoscience Teachers, NAGT Southeastern Section, and NAGT Teacher Education Division.* Blaine Schubert, East Tennessee State University, schubert@etsu.edu; Josh Samuels, East Tennessee State University, samuelsjx@etsu.edu; Steven Wallace, East Tennessee State University, wallaces@etsu.edu;

Mick Whitelaw, East Tennessee State University, whitelaw@etsu.edu; Shawn Haugrud, East Tennessee State University, haugrud@etsu.edu; Season Nye, East Tennessee State University, nyea@etsu.edu.

The Gray Fossil Site is one of only a few pre-Pleistocene Cenozoic fossil sites in eastern North America (outside of Florida), and the only one in the Appalachians. Participants will tour the museum and fossil site, which will include seeing exhibits, ongoing excavations, the prep lab, and collections. Leaders will highlight the diverse fauna and flora preserved at the site, which includes over 100 animal species and 100 plant species. Leaders will also discuss karst landscapes and sinkhole formation, as well as the unique forest ecosystem represented by the fossils preserved at the site.

Ophiolites of Buck Creek/Chunky Gal Mountain Area. Steven Maliner-Colvin, slmalcol@gmail.com.

This one-day trip will visit the Buck Creek mafic-ultramafic complex and Chunky Gal Mountain area in Clay County, southwest of Franklin, North Carolina. The trip will involve a short hike and will focus on the mineralogy, petrology, and field geology of the complex, and the corundum-bearing amphibolites that surround the dunites.

SHORT COURSES

Short course registration opens in January. For additional information, please contact the short course chair: Kenneth Taylor, North Carolina Geological Survey, kenneth.b.taylor@ncdenr.gov.

Classrooms, Careers, & Communities: Maximizing Your TA Experience. Christy Visaggi, Georgia State University, cvisaggi@gsu.edu; Katherine Ryker, University of South Carolina, kryker@seoe.sc.edu.

This short course will introduce students to evidence-based teaching practices for geoscience labs. Participants will identify strategies to enhance instruction, explore extensive resources via Teach the Earth, and connect with other TAs. We will also discuss education-focused career paths, communities in geoscience education, and ways to get recognition for teaching.

Fluorescent Dye Tracing: Putting Principles into Practice. Lee Anne Bledsoe, Western Kentucky University, lee.bledsoe@wku.edu; Chris Groves, Western Kentucky University, chris.groves@wku.edu.

Fluorescent dye tracing is used to study groundwater movement in a variety of applications and settings, including but not limited to karst. This methodology is often the first step in obtaining information to support water resource management, contaminant source tracking, and remediation. This short course will walk participants through the process of planning and conducting a fluorescent dye tracer test.

SPECIAL EVENTS

Geological Society of America Southeast Section Keynote Address: Jennifer Bauer, Appalachian Landslide Consultants, jennifer@appalachianlandslide.com; Monday, 15 Apr. 2024, time and location TBA.

Walking Tour: Thomas Wolfe Memorial and Asheville Art Museum.

Two destinations that can be visited together or separately: (1) Thomas Wolfe House ($5/adult for scheduled half-hour guided tour), not wheelchair accessible; (2) Asheville Art Museum ($13 senior, $15 adult) with optional (pay as you go) lunch at rooftop Perspective Café. Saturday, 13 Apr. 2024, time TBA.

Tour: Folk Arts Center on Blue Ridge Parkway, North Carolina Arboretum, and Grovewood Village.

Three destinations dependent on interest and accessibility needs. Van transportation will be provided. (1) Folk Arts Center on Blue Ridge Parkway (free admission), wheelchair accessible; (2) North Carolina Arboretum with lunch at Bent Creek Bistro (pay as you go), wheelchair accessible; (3) Arts and Crafts-Era Grovewood Village: Biltmore Industries Museum, artisan shops, Antique Car Museum (free, with requested donation at Antique Car Museum), not wheelchair accessible. Sunday, 14 Apr. 2024, time TBA.

REGISTRATION

Early registration deadline: 11 Mar. 2024
Cancellation deadline: 18 Mar. 2024

Registration opens in January. For further information or if you need special accommodations, please contact the general chair, Blair Tormey, btormey@wcu.edu.

ACCOMMODATIONS

Hotel registration deadline: 25 Mar. 2024

A block of rooms has been reserved at the Renaissance Asheville Hotel, 31 Woodfin Street, Asheville, North Carolina, 28801, located downtown. The meeting rate is US$194 per night plus tax. Reservations may be made directly by calling +1-800-468-3571 or via the hotel registration link on the meeting website (www.geosociety.org/se-mtg). Parking is available at the hotel for registered hotel guests at a reduced GSA rate of $10/day.

OPPORTUNITIES FOR STUDENTS AND EARLY CAREER PROFESSIONALS

Career Mentoring Luncheons

Ask your career-related questions and learn about nonacademic pathways in the geosciences while networking with professionals at the Roy J. Shlemon and John Mann Mentor Luncheons. GSA student members are welcome.

Career Workshop Series

This three-part series will feature career development planning, an exploration of geoscience job sectors, and information on best practices for crafting a résumé and cover letter. Non-technical skills and workforce statistics will be reviewed. The series will be led by workshop presenters and geoscientists. No registration is required, and everyone is welcome.

Learn more at **www.geosociety.org/mentors.** Questions? Contact Jennifer Nocerino at jnocerino@geosociety.org.

Student Volunteers

Take advantage of work opportunities to earn free meeting registration. Students interested in helping with the various aspects of

the meeting should contact Frank Forcino, Western Carolina University, flforcino@wcu.edu.

PROFESSIONALS

If you would like to share your interest, enthusiasm, and experience in applied geology, consider being a GSA mentor. Being a mentor is a rewarding experience. To learn more, contact Jennifer Nocerino at jnocerino@geosociety.org.

The meeting also offers an excellent opportunity to earn CEUs toward your continuing education requirements for your employer, K–12 school, or professional registration. The CEU certificate may be downloaded from the meeting website after the meeting.

LOCAL COMMITTEE

General Chair: Blair Tormey, btormey@wcu.edu
Technical Program Co-Chairs: Cheryl Waters-Tormey, cherylwt@wcu.edu; Shane Schoepfer, sschoepfer@wcu.edu
Field Trip Co-Chairs: Mark Carter, mcarter@usgs.gov; Arthur Merschat, amerschat@usgs.gov
Exhibits Co-Chairs: Ashley Lynn, alynn297@gmail.com; Scott Harris, harriss@cofc.edu
Volunteers Coordinator: Frank Forcino, flforcino@wcu.edu
Short Courses & Workshops Chair: Ken Taylor, kenneth.b.taylor@ncdenr.gov
Sponsorship & Events Co-Chairs: Bill Hames, hameswe@auburn.edu; Beth McClellan, emcclellan@radford.edu
Treasurer: Blair Tormey, btormey@wcu.edu
SE Section Treasurer: Katie Luciano, lucianok@dnr.sc.gov

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

Joint Meeting: North-Central and South-Central Sections

58th Annual Meeting of the North-Central Section, GSA
58th Annual Meeting of the South-Central Section, GSA

Springfield, Missouri, USA
21–23 Apr. 2024

www.geosociety.org/nc-mtg

Photo credit: Springfield CVB.

Meet in the Mid-Continent!

We are excited to have the opportunity to host the joint meeting of the North-Central and South-Central Sections. We have built a diverse technical program that spans the geology of the Ozarks (Paleozoic units and abundant karst), to Precambrian basement outcrops both east and west of the Ozarks, to the structural features of the southern margin. This geology includes world-class lead-zinc deposits, paleontological finds, and fascinating environmental challenges. Beyond the rocks, we also invite you to join us as we explore recent changes in our profession and their implications for educational preparation of the next generation of earth scientists. The program has many opportunities for students—our greatest resource for the future—to develop and build their career paths. We look forward to seeing you at the joint meeting!

LOCATION

The meeting will be held in Springfield, Missouri, USA. Situated near the heart of the Ozarks physiographic province, Springfield is a midsize town that provides a great launching point to examine mid-continent geology. The Oasis Hotel and Convention Center offers quality meeting rooms along with many relaxing places to sit and connect with your colleagues to continue discussions of geo-topics. Conveniently located near I-44 and US-65, the hotel is only steps away from parts of historic US Route 66, and it features in-house and nearby restaurants and an indoor pool with relaxing tropical poolside lounge. Take a field trip to see interesting geology from Paleozoic sediments to the basement, view interactions between geology, society and historical development, or just enjoy one of Missouri's 7000+ caves. We invite you to join us at Springfield 2024!

CALL FOR PAPERS

Abstracts deadline: 16 Jan. 2024
Submit online at: **https://www.geosociety.org/nc-mtg**
Abstract submission fee: GSA members: professionals US$30, students US$18; non-members: professionals US$60, students US$36.

If you cannot submit an abstract online, please contact Heather Clark, hclark@geosociety.org.

TECHNICAL PROGRAM

Theme Sessions

T1. **Environmental Geophysics Applications.** *Endorsed by GSA Geophysics and Geodynamics Division.* Jon Fields, U.S. Environmental Protection Agency, fields.jon@epa.gov; Todd Halihan, Oklahoma State University, todd.halihan@okstate.edu; Jordon Massey, Oklahoma State University, jordon.massey@okstate.edu.

The environmental sector is quickly growing in its use of, and expertise in, near-surface geophysics. This session aims to explore the different techniques, environments, and tools used in near-surface geophysical characterization of the subsurface.

T2. **Using Near-Surface Geophysics to Solve Geological Problems.** *Endorsed by GSA Geophysics and Geodynamics Division.* Kevin Mickus, Missouri State University, kevinmickus@missouristate.edu; Doro Kennedy, University of Toledo, doro@utoledo.edu.

Abstracts are requested that use geophysical methods including seismic, gravity, magnetics, electromagnetics, and electrical resistivity to investigate near-surface geological, environmental, and archaeological problems.

T3. **Geophysical, Geochemical, and Geodynamical Investigations of the Mid-Continent.** *Endorsed by GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division.* Kevin Mickus, Missouri State University, kevinmickus@missouristate.edu.

Abstracts are requested from all types of geophysical (seismic, gravity, magnetics, magnetotellurics) investigations, geochemical (major element, trace element, isotopic) studies, and geodynamic modeling to investigate the mid-continent of North America.

T4. **Geological Applications of Potential Field Geophysics.** *Endorsed by GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division.* Luel Emishaw, Oklahoma State University, luel.emishaw@okstate.edu; Andrew Katumwehe, Midwestern State University, andrew.katumwehe@msutexas.edu; Zelalem Demissie, Wichita State University, zelalem.demissie@wichita.edu; Khumo Leseane, University of Cape Town, khumo.leseane@uct.ac.za; Kevin Mickus, Missouri State University,

kevinmickus@missouristate.edu; Mohamed Abdelsalam, Oklahoma State University, mohamed.abdel_salam@okstate.edu.

Gravity and magnetic methods have been extensively used in solving a wide range of large- and small-scale geological problems. We are seeking abstracts that apply gravity and magnetic methods to tectonic, petroleum, mining, environmental, archaeological, and geothermal investigations.

T5. **Patterns, Drivers, and Implications of Natural and Induced Continental Intraplate Earthquakes.** *Endorsed by GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division.* Tandis Bidgoli, California State University–San Bernardino, tandis.bidgoli@csusb.edu; Daniel Sturmer, University of Cincinnati, sturmedm@ucmail.uc.edu.

The occurrence of earthquakes, natural and induced, in continental intraplate settings is at odds with plate tectonics, and their significance for hazard assessments remains controversial. This session seeks contributions focused on patterns, structural and rheological controls, models of continental intraplate earthquakes, and strategies for evaluating, forecasting, and mitigating their hazards.

T6. **Future Directions in Mineralogy and Petrology: A Session for Undergraduate and Graduate Researchers.** *Endorsed by GSA Mineralogy, Geochemistry, Petrology and Volcanology Division*. Gary Michelfelder, Missouri State University, garymichelfelder@missouristate.edu.

This session aims to enhance communication and collaboration among early career researchers, especially undergraduate and graduate students. This session will highlight innovative and interdisciplinary work to provide fresh perspectives, new ideas, and creative answers to mineralogical and petrologic problems. We welcome submissions from all areas of mineralogy and petrology.

T7. **Ultramafic and Mafic Magmatism.** *Endorsed by GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division.* Alison Graettinger, University of Missouri–Kansas City, graettingera@umkc.edu; Matthew Brueseke, Kansas State University, brueseke@ksu.edu.

Ultramafic and mafic magmas enable the study of large-scale tectonic processes or magma production down to local structures, event chronologies, and hazards. This session welcomes petrologic, geochemical, and structural studies that utilize ultramafic/mafic rocks to study the formation, transport, and eruption of magmas and related geologic histories.

T8. **Earth and Planetary Mineralogy and Chemistry.** *Endorsed by GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division.* Neil Van Kanegan, University of Illinois Urbana–Champaign, niv2@illinois.edu.

This session includes abstracts focusing on various aspects of mineralogy, petrology, and geochemistry of Earth and extraterrestrial materials. All methodologies and approaches to questions of the mineralogy and chemistry of these materials are welcome.

T9. **Topics in Volcanology, Geochemistry, and Igneous/Metamorphic Petrology.** *Endorsed by GSA Mineralogy, Geochemistry, Petrology and Volcanology Division.* Gary S. Michelfelder, Missouri State University, garymichelfelder@missouristate.edu; Ethan Wagner, Missouri State University, ew976s@missouristate.edu.

This session is designed to host volcanology-, petrology-, and geochemistry-related contributions that do not easily fit into other sessions at the 2024 joint meeting of the North-Central and South-Central Sections.

T10. **Orogens and Aulacogens: Advances in the Study of Magmatism, Metamorphism, and Deformation.** *Endorsed by GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division.* Liane Stevens, Stephen F. Austin State University, stevenslm@sfasu.edu; Jonathan Price, Midwestern State University, jonathan.price@msutexas.edu; Michael DeAngelis, University of Arkansas at Little Rock, mtdeangelis@ualr.edu.

From the Canadian Shield to the Sierra Madre Oriental, GSA's South-Central and North-Central Sections are home to orogens and aulacogens that shaped Laurentia, with rocks that record over two billion years of magmatism, metamorphism, and deformation. This session welcomes all contributions aimed at improving understanding of these events and processes.

T11. **Evolution of the Mississippian Margin of South-Central Laurentia.** *Endorsed by GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division.* Kevin Ray Evans, Missouri State University, kevinevans@missouristate.edu; Todd L. Robitsch, Missouri State University, tlrkg0pn@gmail.com.

The mid-Devonian through Pennsylvanian Ozarks uplift strongly influenced sedimentation patterns on the southern margin of Laurentia. Intrashelf basins developed in response to faulting and oblique convergence with the Ouachita allochthon. This session highlights continued geologic mapping and stratigraphic studies in the southwestern Ozarks and provides new perspectives on the resulting variety of sedimentary patterns.

T12. **Appalachian & Ouachita-Marathon Orogenesis: Records of Late Paleozoic Supercontinent Assembly Along Southern and Eastern Laurentia.** *Endorsed by GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division.* Brandon Lutz, U.S. Geological Survey (USGS), blutz@usgs.gov; Tyson Smith, USGS, tmsmith@usgs.gov; Mark Hudson, USGS, mhudson@usgs.gov.

We invite submissions that explore late Paleozoic evolution of the Laurentian convergent margin from Appalachia to the Ouachita-Marathon orogenic belts, their adjacent basins, and associated far-field structures. We intend to facilitate collaboration across diverse research approaches aimed at understanding the interplay between tectonics, landscape, and natural resources.

T13. **New Basement Perspectives on the Precambrian Evolution of North America.** *Endorsed by GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division.* Gregory Dumond, University of Arkansas, gdumond@uark.edu; Christopher Daniel, Bucknell University, cdaniel@bucknell.edu; Ruth Aronoff, Furman University, ruth.aronoff@furman.edu.

Recent research on Mesoproterozoic plutonism, deformation, and metamorphism has transformed our understanding of Precambrian North America, i.e., the newly proposed transcontinental Pinware-Baraboo-Picuris orogen. We seek new contributions from exposed and buried basement focused on the evolution of Mesoproterozoic North America, with particular emphasis on continental growth, reactivation, and supercontinent reconstruction.

T14. **New Insights into the Tectonic Evolution and Deformation of the Ozark Plateau of the Mid-Continent Region.** *Endorsed by GSA Structural Geology and Tectonics Division.* Melina Lazar, Oklahoma State University, melina.lazar@okstate.edu; Daniel Lao Davila, Oklahoma State University, daniel.lao_davila@okstate.edu.

This session will highlight the latest studies on the tectonic evolution and deformation of the Ozark Plateau and how the kinematics of the Ozarks can provide information about the tectonics of the mid-continent region. We are interested in contributions that apply structural geology, geophysics, thermochronology, remote sensing, and geodesy.

T15. **Carbonate-Hosted Base Metal Deposits of the U.S. Mid-Continent: Genesis, Exploitation, and Remediation.** *Endorsed by Society of Economic Geologists.* Aaron W. Johnson, The American Institute of Professional Geologists, awj@aipg.org.

The carbonate rocks of the mid-continent of the United States host multiple world-class base metal deposits. This session focuses on every aspect of these deposits. Abstracts focusing on the genesis, mining methodologies, remediation techniques, and social, economic, or environmental impacts of these deposits are welcome.

T16. **Advances in Understanding Critical Mineral Deposits.** *Endorsed by Society of Economic Geologists.* Martin Appold, University of Missouri–Columbia, appoldm@missouri.edu; Hector Lamadrid, University of Missouri–Columbia, lamadridh@missouri.edu.

Reducing U.S. supply chain vulnerabilities for critical minerals is a major priority for the federal government and domestic industries. Contributions are invited that investigate the origin, geologic characteristics, economics, and regulatory aspects of critical mineral deposits in the United States.

T17. **Critical Mineral Studies in the Mid-Continent United States.** *Endorsed by Society of Economic Geologists.* Cheryl Seeger, Missouri Geological Survey, cheryl.seeger@dnr.mo.gov; Kyle Ganz, Missouri Geological Survey, kyle.ganz@dnr.mo.gov; Nick Umholtz, Missouri Geological Survey, nick.umholtz@dnr.mo.gov.

Recent interest in critical mineral resources and their geologic frameworks have led to new geologic mapping, acquisition of geochemical and geophysical data, and graduate studies on multiple related deposit types. Abstract submissions for recent related studies and federally funded projects, including Earth MRI-funded, are welcome.

T18. **Undergraduate Research Poster Session.** *Endorsed by Council on Undergraduate Research Geosciences Division.* Robert Shuster, University of Nebraska–Omaha, rshuster@unomaha.edu; Jeffrey Strasser, Augustana College, jeffreystrasser@augustana.edu.

This poster session will highlight research conducted by undergraduate students. All abstracts must be written by the student or students and may have nonstudent co-authors (although students must present the poster). Topics may include undergraduate research in any discipline of geology or related fields (such as water resources, hydrology, environmental science, or physical geography).

T19. **Undergraduate and Graduate Geoscience Student Showcase.** *Endorsed by Council on Undergraduate Research Geosciences Division.* Claire McLeod, Miami University, mcleodcl@miamioh.edu; Ken Brown, DePauw University, kennethbrown@depauw.edu; Ginny Peterson, Grand Valley State University, petersvi@gvsu.edu; Robert Shuster, University of Nebraska–Omaha, rshuster@unomaha.edu.

This session will highlight research from students in a hybrid oral-poster format. Although presenters will submit only one abstract for this session, they will prepare two presentations—a three-minute lightning talk for the morning session and a poster for the afternoon session. This will offer student presenters multiple opportunities to practice a variety of science communication techniques.

T20. **Limestone Karsts of Asia and Other Regions: Imperiled Regions of Endemic Biodiversity.** *Endorsed by GSA Karst Division.* Peter A. Cohen, Iris Metals, petercohen@hotmail.com.

The overexploitation of the world's natural resources for commercial benefit calls for the prioritization of biologically important ecosystems for conservation. Limestone karsts are "refugia" of biodiversity and often contain high levels of floral and faunal endemism. Humans have exploited karsts for a variety of products, yet unsustainable practices have caused population declines and extinctions among site-endemic taxa.

T21. **Urbanization in a Karst Terrane.** *Endorsed by GSA Karst Division.* Wendell Barner, Barner Consulting, LLC, wendell.barner@gmail.com; Douglas Gouzie, Missouri State University, douglasgouzie@missouristate.edu.

Growing urban areas within sensitive karst terranes impose potential problems associated with stormwater management, structural integrity of buildings, engineering, and environmental challenges. This session will focus on innovative and technological approaches to solving these complex problems within urbanized karst terranes.

T22. **Agricultural Impacts on Hydrology and Water Quality in the Midwest.** *Endorsed by GSA Environmental and Engineering Geology Division.* Eric W. Peterson, Illinois State University, ewpeter@ilstu.edu.

This session invites papers examining water-quality/quantity topics associated with agricultural practices in Midwest watersheds. Studies examining nutrient issues, sediment transport, deicers, irrigation, bacteria/microbes, and temperature are welcome. New and emerging remediation strategies including wetlands, stream restoration, bioreactors, saturated riparian buffer zones, or other novel approaches are sought.

T23. **Analysis of Long-Term Water-Level Changes in the Oklahoma Panhandle and Other Regions of the High Plains Aquifer.** *Endorsed by GSA Environmental and Engineering Geology Division.* Zachary Tomlinson, Oklahoma Water Resources Board, zachary.tomlinson@owrb.ok.gov; Derrick Wagner, Oklahoma Water Resources Board, derrick.wagner@owrb.ok.gov; Jessica Correll, Oklahoma Water Resources Board, jessica.correll@owrb.ok.gov; Chris Neel, Oklahoma Water Resources Board, chris.neel@owrb.ok.gov.

The High Plains aquifer underlies a major agricultural region in the central United States and has been extensively used for irrigation since the 1930s. Water-level declines of over 100 ft have been recorded in several areas; tracking and reducing these declines has become a priority in multiple states.

T24. **Recent Trends in Environmental Geology.** *Endorsed by GSA Environmental and Engineering Geology Division.* Melida Gutierrez, Missouri State University, mgutierrez@missouristate.edu.

General topics in environmental geology: water contamination, geologic hazards, soil and sediment contamination, contamination prevention, and resilience.

T25. **General Topics in Geochemistry.** *Endorsed by GSA Environmental and Engineering Geology Division.* Tara Kneeshaw, Grand Valley State University, kneeshta@gvsu.edu; Melida Gutierrez, Missouri State University, mgutierrez@missouristate.edu.

We invite contributions from studies that highlight a large range of applications and represent a broad spectrum of geochemical research. Topics of interest include, but are not limited to, analytical chemistry, geochemical modeling, environmental geochemistry, igneous geochemistry, geochemistry of mineral deposits, isotope geochemistry, and advances in teaching geochemistry.

T26. **Case Histories of Practicing Environmental and Engineering Geologist Investigations.** *Endorsed by GSA Environmental and Engineering Geology Division.* Bobbi Koepke, Environmental Works Inc., bkoepke@environmentalworks.com.

Presentations are requested that highlight how practicing environmental and engineering geologists conduct field studies. The studies include, but are not limited to, waste cleanup in the soils and groundwater using drilling, geochemistry and geophysics, karst studies, aerial survey, locating buried pipes/conduits/containers, and soil/rock strength testing.

T27. **Professional Applied Geology: Case Studies and Practice.** *Endorsed by GSA Environmental and Engineering Geology Division.* Gregory L. Hempen, EcoBlast, LC, greg@ecoblst.com.

Case studies and innovations in the practice of applied geology are welcome. The session's goal is to provide students with examples of applied geologic practice for their employment consideration; professionals with innovations from other areas that may be used in their practice; and all with networking possibilities.

T28. **Pleistocene-Age Continental Deposits Beyond the Glacial Border.** Charles Rovey, Missouri State University, charlesrovey@missouristate.edu.

This session addresses Pleistocene-age sedimentary systems and deposits outside of glaciated regions, especially those that may be related to glaciation and Pleistocene climate cycles.

T29. **Recent Advances in Remote Sensing and GIScience and Their Applications in Geosciences.** Mohamed Aly, University of Arkansas, aly@uark.edu.

Recent advances in remote sensing and GIScience have resulted in a remarkable number of earth science applications. In this session, we solicit contributions dealing with all kinds of geospatial methods and applications related to geosciences. Submissions related to big data analytics and cloud-based processing techniques are also welcome.

T30. **Emerging Voices in Paleontology.** *Endorsed by Paleontological Society.* Sarah Jacquet, University of Missouri, jacquets@missouri.edu; Jim Schiffbauer, University of Missouri, schiffbauerj@missouri.edu; John Huntley, University of Missouri, huntleyj@missouri.edu; Tara Selly, University of Missouri, sellyt@missouri.edu.

This session encourages undergraduates, graduates, and early career researchers to present their original research across any subdiscipline, taxonomic group, or geologic era within the field of paleontology. It also serves as a platform for emerging paleontologists to present ideas, engage in meaningful discussion, and network with their peers.

T31. **Echinoderm Paleobiology: Evolution, Ecology, and Earth History.** *Endorsed by Paleontological Society.* David F. Wright, Sam Noble Museum of Natural History, University of Oklahoma, wrightdf@ou.edu; Selina R. Cole, Sam Noble Museum of Natural History, University of Oklahoma, colesr@ou.edu; Elizabeth Petsios, Baylor University, elizabeth_petsios@baylor.edu; Anne Raymond, Texas A&M University, raymond@geo.tamu.edu.

Echinoderms are a diverse, ecologically significant phylum of marine animals with a rich geologic history spanning more than a half-billion years. This session will address broad, cutting-edge topics in echinoderm paleobiology. We welcome presentations on diverse subjects, including

evolution, paleoecology, taphonomy, functional morphology, and geochemical applications to understanding Earth history.

T32. **Building the Pipeline: 4th Grade through Two-Year Colleges**. Melanie Carden-Jessen, Missouri State University, mcardinjessen@missouristate.edu.

The National Science Standards now place introductory earth sciences in 4th grade learning goals. Talks are sought for any aspect of colleges and schools discussing team approaches to attract, retain, and encourage students in the geosciences through junior and senior high and on to two- and four-year programs.

T33. **The Role of Computers in Geoscience Research.** Heidi Krauss, Michigan State University, heidi.n.krauss@gmail.com; John Salako, Michigan State University, salakojo@msu.edu; Allison Pease, Michigan State University, peaseall@msu.edu.

Machine learning and supercomputers have revolutionized our approach to scientific research in the past decade. These tools push our knowledge of how Earth, nature, and the solar system work. We welcome abstracts highlighting research conducted using machine learning and/or supercomputers.

T34. **Long-Term Impact on Student Learning from Classroom Disruptions Associated with Global Pandemics, School Shootings, or Academic Strikes in the Field of Geosciences.** Allison Pease, Michigan State University, peaseall@msu.edu; Andrea Saavedra, Michigan State University, saaved16@msu.edu; Heidi Krauss, Michigan State University, kraussh2@msu.edu.

Over the past four years, students have experienced a unique learning landscape. Pandemics, shootings, and strikes have rippled across academic campuses. This session aims to discuss the long-term impact of these major disruptions on student learning and the techniques teachers have taken to support and accommodate students.

T35. **Expanding Your Professional Capacity: Navigating Leadership, Communication, Mentoring, Work-Life Balance, and Mental Health.** Jennifer Nocerino, The Geological Society of America, jnocerino@geosociety.org; Brandy Myers, The Geological Society of America bmyers@geosociety.org.

Over the past five years, the workforce and our workplaces have seen many changes, including retirements, resignations, hybrid work, and culture shifts. Some of these changes have positive impacts to reduce burnout and increase our capacity for connecting with our colleges. This session aims to grow your leadership capacity by providing tools for navigating change, communication and mentoring strategies, boundaries in the workplace, and compassionate mental health practices. Who we are, as geoscientists, is just as important as the work we do.

FIELD TRIPS

Trip registration opens in January. For additional information, please contact the field trip co-chairs: Charles Rovey, charlesrovey@missouristate.edu, and Matthew McKay, matthewmckay@missouristate.edu.

Ordovician and Mississippian Stratigraphy in Southwestern Missouri. Charles Rovey, Missouri State University, charlesrovey@missouristate.edu; Damon Bassett, Missouri State University, dbassett@missouristate.edu.

This one-day trip provides an overview of Paleozoic carbonate stratigraphy in southwest Missouri. Stops display evidence for: (1) seismic activity during deposition of Ordovician peritidal strata; (2) proximal-to-distal facies changes within the Mississippian carbonate platform; and (3) a brief influx of deltaic siliciclastics during the Middle Mississippian.

Urbanization in a Karst Terrane. Wendell Barner, Barner Consulting, LLC, Wendell.barner@gmail.com; Doug Gouzie, Missouri State University, douglasgouzie@missouristate.edu.

This one-day field trip will visit several sinkhole sites within the Springfield area and discuss historical development issues that led to the city-wide and eventually to a county-wide regulatory approach to construction near sinkholes. We will also visit sinkholes that have occurred since regulations were implemented and review current approaches to dealing with sinkholes in urban areas.

Phenix Rising: Restoration and Revitalization of a Major Dimension-Stone Manufacturer in Southwest Missouri. Kevin Ray Evans, Missouri State University, kevinevans@missouristate.edu; Joseph T. Hannibal, Cleveland Museum of Natural History.

The historic Phenix quarry, located between Ash Grove and Walnut Grove, Missouri, has provided building stone from the upper part of the Mississippian Burlington-Keokuk Limestone since 1888 and finished dimension stone since the early 1900s. The Phenix Marble Company produced Napoleon Gray® and Ozarks Fleuri® varieties, cut perpendicular and parallel with bedding, respectively. Production was curtailed during the Great Depression and World War II, but the need for repairs and renovations of existing applications and installation of new applications has brought renewed interest, reviving production of Phenix marble. Since the mid-2010s, the reorganized Phenix Marble Company has installed state-of-the-art cutting, polishing, and finishing equipment to fulfill increased demand for finished dimension stone. This half-day field trip will visit exposures of the Burlington-Keokuk Limestone near Willard, Missouri, and facilities of the Phenix Marble Company.

Spectacular Trace-Fossil Assemblages within the Northview Formation, SW Missouri. Charles Rovey, Missouri State University, charlesrovey@missouristate.edu; Damon Bassett, Missouri State University, dbassett@missouristate.edu.

The trace-fossil density in the Northview Formation of SW Missouri is so high that local residents have called it "worm rock." This half-day trip will view associations of common ichnogenera, their vertical successions, and associated sedimentary structures to help decipher the Northview's depositional environment(s).

The Burlington Formation, Route 66, and Cold Storage Warehousing. Douglas Gouzie, Missouri State University, douglasgouzie@missouristate.edu; James McDaniel, Missouri State University, jim898s@missouristate.edu.

This half-day trip will examine the Burlington Formation, primarily viewing the unit in a quarry pit used to provide aggregates for the original Route 66 highway construction. From the open pit, we will continue into an underground quarry turned cold storage warehouse space and explore the relationships between geology, public works projects, and profitable business operations.

Petrology and Structure of the Mesoproterozoic Igneous Rocks of the St. Francois Mountains, Southeast Missouri. Gary Michelfelder, Missouri State University, garymichelfelder@missouristate.edu; Hanlin Zhang, Missouri State University, hz423s@missouristate.edu.

This two-day field trip will explore the mid-continent granites and rhyolites of the St. Francois Mountains. Field stops will visit classic locations on the volcanic stratigraphy of rhyolites and associated ring granitoid plutons of the Mesoproterozoic calderas. We will also visit lesser-known locations related to younger plutons.

Geology of the Ouachita Mountains and Linkages to North American Late Paleozoic Orogenesis. Matthew McKay, Missouri State, matthewmckay@missouristate.edu; William Jackson, University of Memphis, wtjckson@memphis.edu.

The Ouachita Mountains of Arkansas form the western arm of a major orogen in late Paleozoic Laurentia. This two-day, one-night field trip departing from Springfield, Missouri, will showcase pre- to syn-orogenic strata and well-exposed Ouachita structures.

Ozarks Uplift and Influence of Structure on Deposition of the Backstepping Incipient Mississippian Margin of South-Central Laurentia. Kevin Ray Evans, Missouri State University, kevinevans@missouristate.edu; Todd L. Robitsch.

The mid-Devonian through Pennsylvanian Ozarks uplift strongly influenced sedimentation patterns on the southern margin of Laurentia. Intrashelf basins developed in response to faulting and oblique convergence with the Ouachita allochthon. This one-day field trip highlights continued recent geologic mapping in McDonald County, Missouri, and provides new perspectives of the resulting variety of styles of allochthonous sedimentation.

The Geology and Genesis of the World-Class Pb-Zn-Cu Ores of the Viburnum (MO) Trend. Aaron W. Johnson, The American Institute of Professional Geologists, awj@aipg.org.

This two-day trip will focus on geology of the host rocks and the processes by which these world-class deposits were emplaced. This field trip will include a tour of one of the active underground mines in the Viburnum Trend with other potential stops at surface outcrops if time and weather permit.

SHORT COURSES

Short course registration opens in January. For additional information, please contact the short course co-chairs: Melanie Carden-Jessen, Missouri State University, mcardinjessen@missouristate.edu, and Melida Gutierrez, Missouri State University, mgutierrez@missouristate.edu.

Introduction to Visualizing and Interpreting 3D Geologic Data Using X-ray Tomographic Microscopy. Tara Selly, University of Missouri, sellyt@missouri.edu; Sarah Jacquet, University of Missouri, jacquets@missouri.edu; James Schiffbauer, University of Missouri, schiffbauerj@missouri.edu.

Join our workshop to explore the wide-ranging applications of 3D X-ray tomography in the earth sciences. Gain insights into acquisition techniques, data processing, and analytical methods. The MizzoμX lab will provide free data collection prior to the meeting, enabling participants to focus on data visualization, assessment, and curation during the course.

Applications of the Geochemical Code Visual Minteq to Medical Geology. Melida Gutierrez, Missouri State University, mgutierrez@missouristate.edu.

The application of Visual Minteq to the geochemical processes that affect the toxicity of water solutes will be presented: precipitation, dissolution, adsorption, and complexation of contaminants. This is an introductory half-day course for non-modelers who are using this software for the first time. The software can be downloaded free of charge from the Internet.

Using Project WET to Teach Earth and Environmental Science. Indigo Tran, Missouri State University/Missouri Project WET, indigotran@missouristate.edu; Melanie Carden-Jessen, Missouri State University, mcardenjessen@missouristate.edu.

For 30 years, Project WET has been used by teachers, resource professionals, and university professors to help youth learn how to think. This six-hour workshop will introduce participants to Project WET activities, emphasizing earth science concepts. Participants will be provided an activity guide, web portal membership, and NGSS correlations. Participants should be ready to be actively engaged in Project WET activities that teach both earth and environmental science concepts. Materials are appropriate for K–16 ages and are correlated to NGSS standards. Dressing for both indoor and outdoor activities is suggested. All materials will be provided for the session as part of the course fee.

Getting Started with Drones and Structure from Motion Photogrammetry in Your Research and Teaching. Toby Dogwiler, Missouri State University, tdogwiler@missouristate.edu.

Students or faculty interested in acquiring aerial imagery will learn how to easily and inexpensively integrate small unmanned aerial systems (i.e., sUAS or drones) into their research and teaching. Topics covered will include: FAA certification, risk management and safety, selection of sUAS and related equipment, field-based methodologies, and post-processing workflows. Many of these steps will include hands-on demonstrations and participants will leave the workshop with templates, written workflows, and safety checklists for both the field and post-processing methodologies. This short course will introduce participants to the opportunities for using sUAS in their research or teaching. No prior experience with drones is expected or necessary.

REGISTRATION

Early registration deadline: 18 Mar. 2024
Cancellation deadline: 25 Mar. 2024

Registration opens in January. For further information, or if you need special accommodations, please contact one of the general

co-chairs: Douglas Gouzie, Missouri State University, douglasgouzie@missouristate.edu, or Mohamed Aly, University of Arkansas, aly@uark.edu.

ACCOMMODATIONS

Hotel registration deadline: 31 Mar. 2024, 5 p.m. Central Time

A block of rooms has been reserved at the Oasis Hotel (Ascend Collection, Choice Hotels), 2546 N. Glenstone Ave, Springfield, Missouri, 65803, USA, located near I-44 and US-65. The meeting rate is US$114 per night plus tax (1–4 persons). The hotel offers many amenities (restaurants, bar, pool, Wi-Fi) and a complimentary shuttle to and from Springfield-Branson National Airport. Reservations can be made by calling +1-417-866-5253 or +1-888-532-4338. Please be sure to identify yourself as part of our meeting and ask for the "North-Central & South-Central Sections" group rate. Parking is available at the hotel and convention center (behind the hotel).

OPPORTUNITIES FOR STUDENTS AND EARLY CAREER PROFESSIONALS

Career Mentoring Luncheons

Ask your career-related questions and learn about nonacademic pathways in the geosciences while networking with professionals at the Roy J. Shlemon and John Mann Mentor Luncheons. GSA student members are welcome.

Career Workshop Series

This three-part series will feature career development planning, an exploration of geoscience job sectors, and information on best practices for crafting a résumé and cover letter. Non-technical skills and workforce statistics will be reviewed. The series will be led by workshop presenters and geoscientists. No registration is required and everyone is welcome.

Learn more at **www.geosociety.org/mentors.** Questions? Contact Jennifer Nocerino at jnocerino@geosociety.org.

Student Volunteers

Take advantage of work opportunities to earn free meeting registration. Students interested in helping with the various aspects of the meeting should contact Damon Bassett, Missouri State University, dbassett@missouristate.edu.

PROFESSIONALS

If you would like to share your interest, enthusiasm, and experience in applied geology, consider being a GSA mentor. Being a mentor is a rewarding experience. To learn more about serving as a mentor, contact Jennifer Nocerino at jnocerino@geosociety.org.

The joint meeting also offers an excellent opportunity to earn CEUs toward your continuing education requirements for your employer, K–12 school, or professional registration. The CEU certificate may be downloaded from the meeting website after the meeting.

LOCAL COMMITTEE

General Co-Chairs: Douglas Gouzie, Missouri State University, douglasgouzie@missouristate.edu; Mohamed Aly, University of Arkansas, aly@uark.edu
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Short Course Co-Chairs: Melanie Carden-Jessen, Missouri State University, mcardinjessen@missouristate.edu; Melida Gutierrez, Missouri State University, mgutierrez@missouristate.edu
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Student Volunteer Chair: Damon Bassett, Missouri State University, dbassett@missouristate.edu
Welcome Party Chair: Nancy Williams, whimsicalwms@gmail.com
Section Secretary (Budget Approval):
North-Central Section: Tandis Bidgoli, California State University–San Bernardino, tandis.bidgoli@csusb.edu
South-Central Section: Michael DeAngelis, University of Arkansas at Little Rock, mtdeangelis@ualr.edu

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Northeastern Section Meeting

Manchester, New Hampshire
17–19 March

www.geosociety.org/ne-mtg

Left: Beach near Portsmouth, New Hampshire.

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Joint Cordilleran/ Rocky Mountain Section Meeting

Spokane, Washington
15–17 May

www.geosociety.org/cd-mtg

Below: Spokane Falls. Photo credit: Chad Pritchard.

Southeastern Section Meeting

Asheville, North Carolina
15–16 April

www.geosociety.org/se-mtg

Above: Blue Ridge mountains. Photo credit: Ashley Lynn.

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Joint North-Central/ South-Central Section Meeting

Springfield, Missouri
21–23 April

www.geosociety.org/nc-mtg

Right: Smallin Civil War Cave. Photo credit: Springfield CVB.

Look below the surface to

WHY THE FUTURE OF THE GEOSCIENCES NEEDS YOU...

Did you know that

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1

THAT MEANS...

Less than 1/3 of GSA members alone gave over **$1.6 MILLION to support critical programs** and advance the geosciences and the Society.

2

3

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OR

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4

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Bookmark the Geoscience Job Board at **www.geosociety.org/jobs** for up-to-the-minute job postings. Job Board ads may also appear in a corresponding monthly print issue of *GSA Today*. Send inquiries to advertising@geosociety.org, or call +1-800-427-1988 ext. 1053 or +1-303-357-1053.

POSITIONS OPEN

Tenure-Track Assistant Professor, Geochemistry Related to the Environmental and Health Sciences, University of Illinois Chicago

The Department of Earth and Environmental Sciences in the College of Liberal Arts and Sciences at the University of Illinois Chicago (UIC) invites applications for a tenure-track assistant professor who pursues fundamental research in geochemistry as related to the environmental and health sciences. The applicant's research must address environmental Earth systems and be relevant to human health at multiple scales. While all areas of geochemistry will be considered, we are especially interested in candidates with expertise in trace, redox-sensitive, toxic, and/or critical mineral elements. The successful candidate is expected to establish an innovative and productive program of scientific research, using more than one approach (e.g., experimental, modeling, observational), that complements department strengths in geochemistry, hydrology, geobiology, and climate science. Candidates with interests in community engagement are encouraged to apply. The candidate will be expected to teach undergraduate courses in core topics in the earth sciences and graduate courses in their area of specialty, advise graduate students (M.S. and Ph.D.), and mentor undergraduate students in research projects. Applicants must have a Ph.D. in earth sciences or a related field and a record of research accomplishments; postdoctoral experience is preferred.

The Department (https://eaes.uic.edu/) has extensive laboratory and computing facilities, hosts a diverse and growing undergraduate and graduate student body, and has expanding collaborations with other campus units, including chemistry, health sciences, biological sciences and engineering, Argonne National Laboratory, and community organizations. UIC is one of the most ethnically and culturally diverse universities in the country and the Department is committed to closing the diversity gap in the earth sciences by fully supporting underrepresented students, faculty, and staff. UIC is a public R1 institution and the largest institution of higher education in the Chicago area, with over 34,000 undergraduate, graduate, and professional students. To apply, please complete the online application providing contact information and three professional references at https://uic.csod.com/ux/ats/careersite/1/home/requisition/6714?c=uic and upload a cover letter, curriculum vitae, and separate statements of research plans, teaching plans, and perspectives on and commitment to diversity, equity, and inclusion in the geosciences. For full consideration, please apply by 30 Oct. 2023. Final authorization of the position is subject to availability of funding.

The University of Illinois Chicago is an affirmative action, equal opportunity employer, dedicated to the goal of building a culturally diverse and pluralistic faculty and staff committed to teaching and working in a multicultural environment. We are committed to equal employment opportunity regardless of race, color, national origin, sex, religion, age, sexual orientation, gender identity, veteran, or disability status. The University of Illinois may conduct background checks on all job candidates upon acceptance of a contingent offer. Background checks will be performed in compliance with the Fair Credit Reporting Act. The University of Illinois System requires candidates selected for hire to disclose any documented finding of sexual misconduct or sexual harassment and to authorize inquiries to current and former employers regarding findings of sexual misconduct or sexual harassment. For more information, visit https://www.hr.uillinois.edu/cms/One.aspx?portalId=4292&pageId=1411899.

Faculty Position and Louise H. Kellogg Endowed Chair in Geophysics, University of California, Davis

The Department of Earth and Planetary Sciences at the University of California, Davis, seeks an outstanding faculty member for the Louise H. Kellogg Endowed Chair in Geophysics. This chair will be appointed at the associate or full professor level and is open to applicants from all areas of Earth and planetary geophysics. The Louise H. Kellogg Endowed Chair in Geophysics honors the memory of an inspiring scientist, mentor, and leader, dedicated to increasing equity, inclusion, and diversity throughout the scientific community. The appointee is expected to develop and maintain a vigorous externally funded research program, to engage students through teaching and mentoring at the undergraduate and graduate levels, and to provide visionary leadership that enriches and expands scientific excellence in the geophysics community and beyond. The successful candidate will be appointed as an academic year (nine-month) tenured faculty at the appropriate level and must have a Ph.D. or equivalent in Earth and planetary sciences or a related field, and a least five years of relevant professional experience following award of the Ph.D.

The endowed chair position is a five-year appointment, with option for reappointment. The Chair recipient will be selected in accordance with university procedures for endowed chair/professorship appointments (APM 191, UCD 191). All endowed chair appointments are reviewed at least every five years. In addition to exemplifying excellence with the honorary title, the Louise H. Kellogg Endowed Chair holder will receive supplemental financial support for teaching, research, outreach, and other related purposes, with the amount subject to the financial market performance of the endowment. The teaching load will average three quarter-long courses per year. The salary range for this position is $120,000–$290,000. "Off-scale salaries" and other components of pay, i.e., a salary that is higher than the published system-wide salary at the designated rank and step, are offered when necessary to meet competitive conditions, qualifications, and experience.

Initial deadline for applications is 28 Feb. 2024. Apply by this date to ensure full consideration by the committee.

Application packages must be submitted online through UC Recruit via the job listing (https://recruit.ucdavis.edu/JPF05891) and must include the following documents:

- Cover Letter
- Curriculum vitae with full list of publications and other research products, service roles held at the department, university or professional level, and research funding for up to 10 years (project title, funding agency, duration of award).
- Selected Publications List with up to 10 publications including 2–3 sentences describing the significance of the work and 1–2 sentences describing the candidate's contributions to the publication (example provided here: https://ucdavis.box.com/s/gpb1migvhqtr9w46rbjb78194b4m9zj2).
- Contact information of 3–4 individuals who can be asked to provide a letter of reference.
- Authorization to Release Information form for an academic misconduct reference check (available on the Recruit website; see explanation below)
- Statement of Research
- Statement of Teaching and Mentoring
- Statement of Contributions to Diversity, Equity, and Inclusion (guidance provided here: https://academicaffairs.ucdavis.edu/guidelines-writing-diversity-statement)

Each of the statements should highlight prior accomplishments, current interests, future directions, and leadership roles, and each should not exceed two pages in length. Inquiries concerning the submission of application materials should be directed to the Search Committee Chair at eps-search@ucdavis.edu.

Reference Checks for Finalists. The University of California is committed to creating and maintaining a community dedicated to the advancement, application, and transmission of knowledge and creative endeavors through academic excellence, where all individuals who participate in university programs and activities can work and learn together in a safe and secure environment, free of violence,

harassment, discrimination, exploitation, or intimidation. With this commitment, UC Davis conducts a reference check on all first-choice candidates for Academic Senate Assistant Professor, Steps 4, 5, or 6 through Professor, Lecturer with Potential for Security of Employment, Steps 4, 5, or 6 through Senior Lecturer with Security of Employment, and Acting Professor of Law through Professor of Law positions. The reference check involves contacting the administration of the applicant's previous institution(s) to ask whether there have been substantiated findings of misconduct that would violate the University's Faculty Code of Conduct. To implement this process, UC Davis requires all applicants for any open search for these faculty positions to complete, sign, and upload the form entitled "Authorization to Release Information" into RECRUIT as part of their application. If an applicant does not include the signed authorization with the application materials, the application will be considered incomplete, and as with any incomplete application, will not receive further consideration. Although all applicants for faculty recruitments must complete the entire application, only finalists considered for these faculty positions will be subject to reference checks.

Faculty Position, Critical Zone Geosciences, Utah State University, Logan

The Department of Geosciences and the Ecology Center at Utah State University (USU), Logan, invite applications for an academic-year (nine-month), tenure-track assistant professor position in interdisciplinary critical zone geosciences, anticipated to begin August 2024. We seek candidates who conduct innovative, interdisciplinary, and quantitative investigations across a range of critical zone (CZ) processes linked to societal importance. Successful candidates will demonstrate outstanding potential for excellence in research through development of a vibrant, externally funded research program and will contribute to our graduate and undergraduate curriculum. We are especially interested in candidates committed to advancing access and opportunity in the geosciences. Learn more about the Department of Geosciences [https://www.usu.edu/geo/] and Ecology Center [https://www.usu.edu/ecology/] online.

Visit https://careers-usu.icims.com/jobs/6893/assistant-professor/job for more details and to apply. Required materials include cover letter; CV; statement of research interests, vision, and societal impacts; statement of teaching and mentoring philosophy and contributions toward equitable learning; names and contacts for three references; and one representative publication. Please contact Tammy Rittenour, Search Committee Chair, tammy.rittenour@usu.edu, with inquiries. USU is an AA/EO employer. Review of applications begins on 15 Oct. 2023.

Tenure-Track Assistant Professor, Changing Cryosphere, Washington University in St. Louis

The Department of Earth, Environmental, and Planetary Sciences and the Program in Environmental Studies at Washington University in St. Louis invite applications for an assistant professor position in the field of the changing cryosphere (e.g. glaciers, polar ice sheets, permafrost, sea ice). The candidate is expected to conduct research on the physical processes controlling the evolution of the cryosphere, and its complex interactions with the solid earth, hydrosphere, and/or atmosphere. Candidates may make use of a variety of techniques including field data collection (geodesy, geophysical data) and remotely sensed data (lidar, radar, satellite remote sensing), as well as theory, modeling, and experiments.

The successful candidate is expected to develop a vigorous, externally funded research program, maintain a strong publication record, advise undergraduate and graduate students, teach a range of undergraduate and graduate courses, and be active in departmental governance and university service. We seek candidates who complement our existing research and teaching expertise in climate, Earth surface processes, geophysics, and planetary science while also fostering collaboration with environmental scientists and scholars across the Washington University community. This position is a joint appointment between the Department of Earth, Environmental and Planetary Sciences (75%) and the Environmental Studies program (25%).

Candidates must have a Ph.D. with a focus in earth science, glaciology, environmental science, or a related field, at the time of appointment. Complete applications comprise a cover letter, curriculum vitae, and research and teaching statements. The research and teaching statements should each include both plans and philosophies. Plans should address proposed future courses and research projects, including potential sources of research funding. Philosophies should address topics such as how applicants would broaden scientific participation, cultivate curiosity and creativity, develop civic and community engagement, encourage critical thinking, independence, and self-confidence, foster the development of people of all backgrounds, promote intellectual freedom and inquiry, and ensure that all individuals are treated with fairness and equality. Applicants should include the names and contact information of at least four references, submitted via Interfolio at http://apply.interfolio.com/130098. Applications must be received by 1 Nov. 2023 to ensure full consideration.

Washington University in St. Louis is committed to the principles and practices of equal employment opportunity and especially encourages applications by those underrepresented in their academic fields. It is the University's policy to recruit, hire, train, and promote persons in all job titles without regard to race, color, age, religion, sex, sexual orientation, gender identity or expression, national origin, protected veteran status, disability, or genetic information. Diversity and Inclusion are core values at Washington University, and the strong candidate will demonstrate the ability to create inclusive classrooms and environments in which a diverse array of students can learn and thrive. Each year Washington University publishes a Safety and Security brochure that details what to do and whom to contact in an emergency. This report also publishes the federally required annual security and fire safety reports, containing campus crime and fire statistics as well as key university policies and procedures. You may access the Safety and Security brochure at https://police.wustl.edu/clery-reports-logs/.

Assistant Professor, Geosciences, Trinity University

The Department of Geosciences at Trinity University invites applications for a tenure-track assistant professor of geosciences. A Ph.D. in geosciences is required and experience teaching at the college level is preferred. The successful candidate must have a commitment to undergraduate teaching and will be expected to develop an active research program that involves undergraduates. The successful candidate will teach across the geosciences curriculum, including introductory and core geosciences courses, as well as upper-level courses related to environmental geosciences. Preference will be given to candidates who can also contribute to department and university core curricula (e.g., the First-Year Experience) and have experience with interdisciplinary instruction and/or global education. We seek research specialties that complement current expertise in the department; examples include, but are not limited to, oceanographic and coastal processes, terrestrial geomorphic processes, critical zone research, environmental geophysics, and climate and/or environmental change research. The use of GIS in research and teaching will be considered an asset.

Trinity University is a secular, independent, private institution. Both the Department of Geosciences and the University value and safeguard academic freedom for faculty in their teaching and scholarship. Trinity is committed to engaging in practices that ensure a welcoming, inclusive campus and community of learning for all students, faculty, and staff.

Trinity is a primarily undergraduate institution that offers high-quality science, liberal arts, and pre-professional programs to approximately 2500 undergraduate students from the U.S. and many foreign countries. The attractive campus overlooks downtown San Antonio, a city rich in heritage and ethnic diversity. The Department, housed in the Center for Sciences and Innovation, has granted degrees in the geosciences for over 50 years and is a member of the Keck Geology Consortium.

Interested? Trinity faculty will be attending GSA Connects 2023. If you'd like to meet with

them in Pittsburgh, please email geossearch@trinity.edu.

How to apply: candidates must apply through Trinity University's Employment Opportunities Portal (https://trinity.wd1.myworkdayjobs.com/en-US/Trinity_University/). Under "Start your application" select "Apply Manually" and only complete required fields. Candidates should submit the following items in PDF format in the Application Documents field (limited to five total files):

- a single file containing a cover letter (1–2 pages, single-spaced), a curriculum vitae, and the names and contact information for three professional references;
- a file with a statement of undergraduate teaching experience and philosophy;
- a file with documentation of teaching effectiveness;
- a file with description of research plans; and
- a file with a 250–500-word diversity statement responding to the prompt, "Trinity University is committed to the value of intentional inclusion. Please provide a brief statement describing your past efforts as well as your future plans to advance diversity, equity and inclusion in your teaching and research."

Please ensure that all required documents are uploaded prior to submitting your application. If you need to revise your application or need help submitting an application, please contact Human Resources at +1-210-999-7507 or email HumanResources@trinity.edu. Review of completed applications will begin on 24 Oct. 2023, and the position will remain open until filled. Questions about the search can be directed to Dr. Benjamin Surpless, Search Committee Chair, Department of Geosciences [geossearch@trinity.edu].

Trinity University is an Equal Opportunity Employer. As such, it provides equal opportunity for employment and advancement of all employees without regard to race, color, religion, sex, age, national origin, disability, military/veteran status, sexual orientation, gender identity, gender expression, or any status protected by federal, state or local laws.

Canada Research Chair Tier 1, Isotope Geochemistry and Geochronology, University of British Columbia

The Department of Earth, Ocean, and Atmospheric Sciences (EOAS) in the Faculty of Science at the University of British Columbia (UBC) seeks a global research leader in isotope geochemistry and geochronology for a Tier 1 Canada Research Chair (CRC).

Reporting to the Head of EOAS, the successful candidate will hold a Ph.D. in geosciences or a related discipline. They will be an established researcher and have received wide recognition for their sustained accomplishments in high-temperature geo/thermochronology or isotope geochemistry. The successful candidate will have extensive analytical experience, a publication record demonstrating impactful scientific contributions, demonstrated excellence in teaching and supervision at the undergraduate and graduate levels, and a strong track record of attracting research funding. In addition to research and teaching, the successful candidate will contribute to ongoing academic leadership of geochemical and geochronologic research for the Pacific Centre for Isotopic and Geochemical Research (PCIGR). They will have a strong commitment to equity, diversity, and inclusion, to create a welcoming community for all, particularly those who are historically, persistently, or systematically marginalized. The successful candidate will be eligible to be hired as a tenured Professor or Associate Professor in the Department of EOAS at the University of British Columbia, Vancouver. Salary will be commensurate with experience and scholarly record. The anticipated start date is 1 Sept. 2024, or as soon as possible thereafter.

More details and how to apply can be found here: https://www.eoas.ubc.ca/about/job-opportunities

Open Rank TTT Faculty Position, Energy Transition, Earth, Environmental & Planetary Sciences, Rice University

The Department of Earth, Environmental and Planetary Sciences at Rice University, in Houston, Texas, is seeking applications to fill an open-rank tenure or tenure-track faculty position with active research broadly relevant to the energy transition. Potential areas of interest include, but are not limited to, geothermal energy, geologic carbon capture and sequestration, subsurface energy storage, critical mineral resources, subsurface fluid flow, and environmental impacts. Applicants using geochemistry, geophysics, geomechanics, basin and reservoir analysis, and numerical and/or machine learning techniques are all welcome.

The successful candidate is expected to establish a vigorous, externally funded research program, teach core courses, develop undergraduate and graduate courses within their area of expertise, and be involved in service to the department, university, and the broader scientific community. Contributions to the growing professional master's programs in energy geoscience and the energy transition are welcome. The successful candidate will be appointed at a rank commensurate with accomplishments and expertise.

Requirements: All candidates must have earned a Ph.D. degree in earth, environmental, or planetary science or a related field by the time of the appointment. Applicants must submit the following: (1) cover letter; (2) curriculum vitae; (3) statement of research; (4) statement on teaching; (5) statement on diversity, mentoring, and outreach (see guidelines here: https://eeps.rice.edu/diversity-mentoring-and-outreach-statement-guidelines); and (6) the names, affiliations, and email addresses of at least three professional references. Details about the department and its facilities can be found at http://eeps.rice.edu. All required application materials submitted by 1 Nov. 2023 are ensured full consideration. For questions, please contact eeps-search@rice.edu.

Applications for this position must be submitted electronically at apply.interfolio.com/130377.

Assistant Professor, Planetary Science, Earth, Environmental & Planetary Sciences, Rice University

The Department of Earth, Environmental and Planetary Sciences at Rice University is seeking applications for a tenure-track assistant professor position in planetary science with expertise that complements current departmental research. Particular interests include, but are not limited to, studies of meteorites, returned samples, and other planetary and analog materials applied to fundamental questions on the formation and evolution of planetary systems and planetary habitability. Applicants who use one or more analytical and/or experimental tools on planetary samples are especially encouraged to apply.

Successful candidates are expected to establish a vigorous, externally funded research program, teach core courses, develop undergraduate and graduate courses within their area of expertise, and be involved in service to the department, university, and the broader scientific community.

Requirements: All candidates must have earned a Ph.D. degree in earth, environmental, or planetary science or a related field by the time of the appointment. Applicants will be required to submit the following: (1) cover letter; (2) curriculum vitae; (3) statement of research; (4) statement on teaching; (5) statement on diversity, mentoring, and outreach (see guidelines here: https://eeps.rice.edu/diversity-mentoring-and-outreach-statement-guidelines); and (6) the names, affiliations, and email addresses of at least three professional references. Details about the department and its facilities can be found at http://eeps.rice.edu. All required application materials submitted by 1 Nov. 2023 are ensured full consideration. For questions, please contact eeps-search@rice.edu.

Applications must be submitted electronically at http://apply.interfolio.com/130235.

Lecturer, Earth and Environmental Sciences, Rice University

The Department of Earth, Environmental and Planetary Sciences at Rice University in Houston, Texas, invites Ph.D. applicants for a lecturer position in earth and environmental sciences, commencing 1 Jan. 2024 (or earlier). We seek candidates who can teach courses

in oceanography, atmospheric science, and climate science at the introductory and intermediate level. Knowledge of and interest in the cryosphere, sea level change, and coastal processes are desirable. Familiarity with and/or interest in earth science education research, pedagogy, and experiential learning would be beneficial. Strong written and verbal communication skills are required.

The successful applicant primarily will teach at the undergraduate level, but also will be expected to assist with other academic duties, such as undergraduate advising, mentoring student internships, research, or field experiences.

This is a non-tenure-track position for an initial 18-month term (1 Jan. 2024–30 June 2025), with the possibility of extension. This is a full-time, nine-month academic calendar position, with opportunities to teach summer courses for additional compensation. Successful candidates will also have opportunities to develop innovative teaching methods and pursue independent research or collaborations with existing research programs (see http://eeps.rice.edu).

Evaluation of applications will begin 1 Aug. 2023 and continue until the position is filled. Applicants should submit the following: (1) curriculum vitae (including a list of publications); (2) statement of teaching interests; and (3) statement on diversity and outreach. Eligible candidates must have a Ph.D. in geosciences or related fields by 1 Jan. 2024. Information regarding letters of recommendation will be requested from a subset of candidates following initial review. For questions, please contact eeps-search@rice.edu.

Applications must be submitted electronically at apply.interfolio.com/130064.

Mendenhall Postdoctoral Research Fellowships, U.S. Geological Survey, Various Locations

The U.S. Geological Survey (USGS) is recruiting Mendenhall Research Fellows. The Mendenhall Research Fellowship Program allows postdoctoral fellows to conduct concentrated research in association with USGS scientists. Current opportunities include topics ranging from advanced computing, programming, and modeling, to ecology, water resources, energy and minerals, and natural hazards.

Check out the available research opportunities [https://www.usgs.gov/centers/mendenhall-research-fellowship-program/research-opportunities?utm_source=gsa&utm_medium=external&utm_campaign=ss-mendenhall-aug-2023] for more information.

Postdoctoral fellows are hired as full-time USGS employees at the GS-12 (step 1) level, including full salary and benefits. Mendenhall Fellow appointments are time limited, not to exceed two years. Under certain circumstances, the appointment may be extended up to two additional years.

Applicants should contact the research advisor(s) for the research opportunity of interest to coordinate the development of a research proposal.

Applications will be accepted from 5 Sept. 2023 to 1 Nov. 2023.

Specific application requirements can be found on the Mendenhall Program website [https://www.usgs.gov/centers/mendenhall-research-fellowship-program].

For more information, contact the Mendenhall mailbox at mendenhall@usgs.gov.

The U.S. Geological Survey is an Equal Opportunity Employer.

Assistant Professor, Solid Earth Geosciences, Baylor University

Baylor University's Department of Geosciences invites applications for a tenure-track faculty position at the assistant professor level in the area of solid earth geosciences, effective Fall 2024. We seek applicants who demonstrate a commitment and potential to develop an outstanding, externally funded research program.

The most competitive candidates will establish a clear connection between their research program and current big-picture questions in the fields of solid earth geosciences. The specific area of expertise is open and includes field- and lab-based methods in areas including, but not limited to, geodynamics, active tectonics, geophysics, volcanology, basin analysis, geochronology, structure, petrology, mechanics, faulting, hazards, seismology, geodesy, and high-temperature geochemistry.

Top applicants will also enthusiastically commit to the teaching and mentoring of undergraduate and graduate students and postdoctoral researchers. Teaching opportunities may include a broad scope of undergraduate and graduate classes such as structural geology, mineralogy, petrology, volcanology, geochemistry, geophysics, and field camp. It is expected that teaching responsibilities will include existing undergraduate and graduate courses in the Department of Geosciences and new course offerings in the candidate's area of expertise.

To apply please submit a cover letter, curriculum vitae, statements describing your research agenda and funding goals and your teaching philosophy, experience, and interests, a copy of a transcript from the highest degree grant institution, and contact information for three references via Interfolio using this link: https://apply.interfolio.com/127680.

Complete applications must be submitted by 20 Oct. 2023. For further information or questions, contact the Search Committee Chair, Dr. Dan Peppe, at daniel_peppe@baylor.edu.

Statement of Ownership, Management, and Circulation

(Required by Title 39 U.S.C. 4369)

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d.	Nonrequested distribution (*by mail and outside the mail*)	0	0
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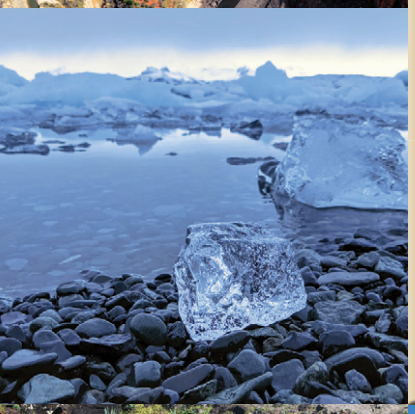

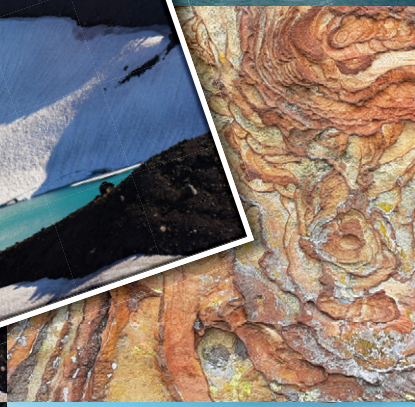

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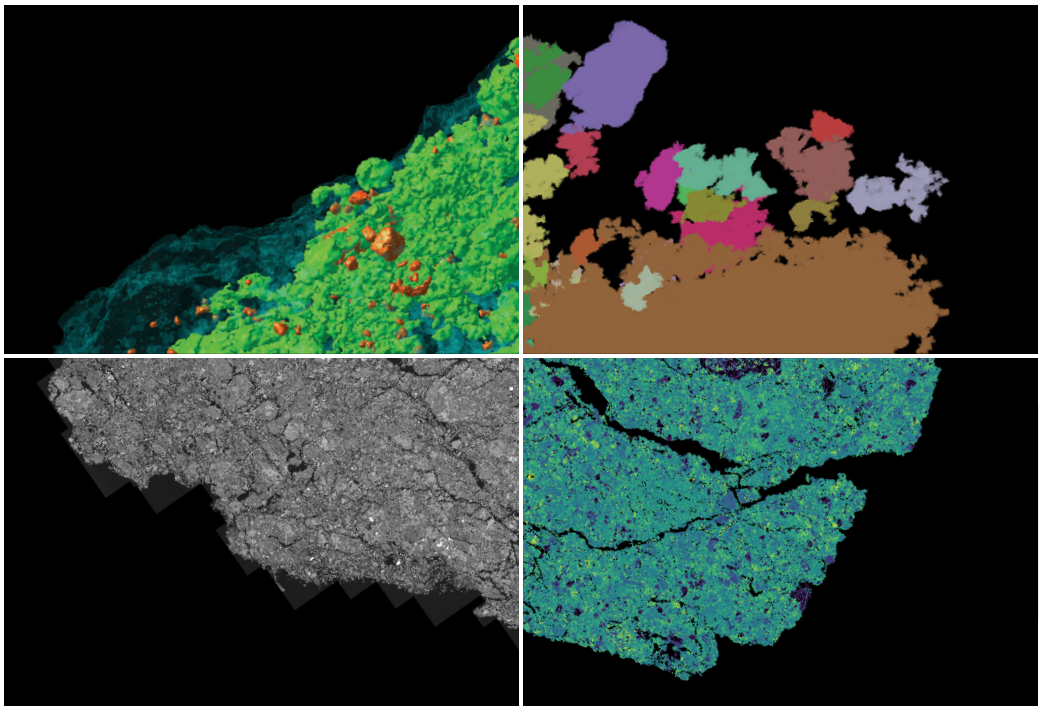

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