NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

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MEETING ANNOUNCEMENT

DATE: Wednesday, March 27, 2024

LOCATION: Orinda Masonic Hall

TIME: Social time: 6:30 to 7:15 pm; Program: 7:15 to 8:30 pm

SPEAKER: ***Jessica R. Murray, USGS Earthquake Science Center, Moffett Field***

TOPIC: ***"Inclusion of real-time Global Navigation Satellite System-based earthquake source characterization in the ShakeAlert earthquake early warning system to improve estimates of anticipated ground shaking and the alerts derived from them"***

Abstract:

The ShakeAlert® earthquake early warning system, which operates in California, Oregon, and Washington, aims to alert users of impending strong ground shaking due to an earthquake before the shaking reaches them. This system does not predict earthquakes. Rather, ShakeAlert can provide users with seconds of warning once an earthquake is underway, allowing them to take protective actions such as Drop Cover and Hold On as well as enabling automatic actions such as slowing trains or opening firehouse doors.

ShakeAlert incorporates two algorithms based on seismic data to characterize the location and magnitude of an earthquake in real-time. Anticipated ground shaking at user locations is then calculated using this information and empirical models. Locations that are anticipated to experience shaking exceeding a pre-defined threshold level will be issued an alert (for example, via the Wireless Emergency Alert system or cell phone apps).

Accurate magnitude estimates are critical to useful ground motion estimates. It is known that magnitudes determined from the first few seconds of the P-wave recorded on seismometers, one of the methods used by ShakeAlert, tend to saturate above ~M7.0. This is especially detrimental in the event of large subduction slab interface earthquakes such as the 2011 M9.0 Tohoku, Japan event and anticipated future earthquakes on the Cascadia megathrust. The Global Navigation Satellite System (GNSS) provides data that can directly measure the full range of ground displacement during an earthquake, thus giving a more complete picture of the earthquake's size. Similar to seismic methods, empirical relationships have been developed that use peak ground displacement measured in real-time using GNSS data to obtain robust magnitude estimates for very large earthquakes. This approach has been incorporated into the ShakeAlert system for testing and is expected to begin running

 (continued on last page)

NCGS 2023 – 2024 Calendar

April 24, 2024 7:15 pm (6:30 social hour)

Nicholas Swanson-Hysell, UC Berkeley

Chronostratigraphy of Miocene strata in the Berkeley Hills and the arrival of the San Andreas transform boundary

May 29, 2024 7:15 pm (6:30 social hour)

(Dinner meeting; check for update on times)

Libby Ives, Jet Propulsion Laboratory (NASA/Caltech)

Sedimentary geology of the Jezero crater western fan as seen by NASA's Mars Perseverance rover

June 26, 2024 7:15 pm (6:30 social hour)

Don Medwedeff, Consultant

Structure, Timing, and Western Extent of the Stockton Arch: Constraints on Neogene strike slip fault offset in the Diablo Range

New Youtube Channel:

By vote of the Board in May 2023, we returned to in-person meetings only, as of the September 2023 meeting. We will still record the meetings to Zoom for archiving on our new YouTube channel, @NCGS1000 (which you can access now by typing in the entire name @NCGS1000 into the search bar for Google or YouTube). This is where recently recorded talks can be accessed a few days after each meeting, or past talks recorded since September 2022 can be reviewed at any time. Only talks for which authors have given permission for this archiving will be accessible.

Invitation For New Officer Appointment

Due to the recent resignation of our Secretary, Steve Self, for personal reasons, we are looking to appoint a new secretary to fill the rest of Steve's elected term (through August 31, 2024) and potentially to stand for re-election next June. Please contact President Jim O'Brient or Past President Noelle Schoellkopf if you are interested or have a candidate to suggest. The duties are few, but vitally important to the society:

(1) The **Recording Secretary** shall attend and take notes at all Executive Committee board meetings (typically three times per year) and shall notify the members of proposed amendments to the Constitution and Bylaws.

(2) When any other membership-wide communication is required, assist other officers in sending out email and occasional postal communications. Note: Since NCGS has moved to a new web-based system for emails, sign-ups, and payments (RegFox), this will chiefly be a consulting role to help others such as the President, Newsletter Editor, Treasurer, Membership Chair, Program Chair, or Field Trip Chair, all of whom will be trained on sending out such messages directly.

(3) Maintain Google drive folders and access for our archive of past information.

(4) Maintain hard cc files (as backup) only for critical Society records.

(5) Serve as alternate check signer when neither Treasurer nor President is available.

Website News

From Andrew Alden, NCGS Website Manager/Social Media

Way over on the right side of our home page is a link called "Links." The Links page is kind of a backwater and has been for a while, but I'm ready to start revamping it. It ought to give NCGS members ready access to all kinds of places on the Web, whether they're for news, information, amusement, community, or feeding your inner life. Are you in a related society that isn't listed? Do you have good Facebook groups to recommend? Are there places you check every day? One that I plan to add, for instance, is the USGS current earthquakes map at earthquake.usgs.gov/earthquakes/map. I'm seeking feedback and advice from all and any members. Let's make this page represent and serve us.

Now that the website renovation is done, I'm starting to think about writing up some of our old field trips in my spare time. For instance, there's our memorable jaunt to Lake Tahoe in June 2011. Between the field-trip guide, my memories and my photos, like the one below, I could have it done in . . . a while, let's say.

Lake Tahoe NCGS field trip, June 2011. Courtesy of Andrew Alden.

NCGS Photo of the Month

This month we have a couple gems from member Larry Wendell. Both photos are of a boulder on the beach about a quarter mile south of the beach access at Andrew Molera State Park near Big Sur. These are folded and faulted Franciscan cherts with their typical interbeds of shaly matter. They are best visited at low tide.

The one below is a close-up of a part of the same boulder.

The Northern California Geological Society's

RICHARD CHAMBERS MEMORIAL SCHOLARSHIPS

2023-2024 AWARDS

The NCGS is pleased to announce that it is awarding $2,000 scholarships to two graduate students pursuing research in northern California. The availability of the Richard Chambers Memorial Scholarship is announced to all Colleges and Universities having graduate programs in northern California. These scholarships are funded from the Richard Chambers Memorial Scholarship fund and donations made by NCGS members and others for scholarships. These two students were chosen from a collection of well-prepared applications made to the NCGS during the fall of 2023. Serving on the NCGS Scholarship Committee were Phillip Garbutt (chair), Andrew Alden, Don Medwedeff, Noelle Schoellkopf and Will Schweller.

The recipients are:

Eden Pikowski, CSU Chico, for a master's research proposal titled ***"Paleoecology of the hydrocarbon seeps of Blue Ridge, Colusa, County, CA".*** Project advisor is Dr. Robert Shapiro.

Evelyn H. Usher, for a master's degree research proposal titled: ***"Transition from Walker Lane deformation to Cascade Range faulting and volcanism within Lassen National Park".*** Project advisor is Dr. Michael Oskin.

UC Berkeley Earth & Planetary Science Weekly Seminar Series

In-person EPS Seminar talks have resumed for the semester and are scheduled through the academic year. On Thursday, March 21, 2024 at 3:45 pm, Francis Macdonald, UCSB will speak on ***The Great Unconformity and flooding of North America*** at 141 McCone Hall. To join the department's email list, send an email to eps_frontoffice@berkeley.edu. For updated listings of upcoming seminars, go to https://eps.berkeley.edu/seminars-courses/eps-seminars.

For the Rockhounds

For links to upcoming rock and mineral shows, go to www.cfmsinc.org/shows.

USGS Evening Public Lecture Series

The USGS evening public lecture series events are free and are intended for a general public audience that may not be familiar with the science being discussed. Pre-Covid, talks were held at USGS; the talks are now online. **Talks had been scheduled through June, but USGS is currently taking a pause on their Virtual Public Lecture Series.** To be added to the email notification list for future USGS Public Lecture Series events, please email: wmcesic@usgs.gov.

2023-2024 NCGS Registration and Dues

A 21st Century Innovation Takes Hold

Following a successful pilot for August's field trip, NCGS is converting from last century's check-based

system for membership renewal, field trip registration, and dinner meeting registration, to an electronic system. The system is hosted by RegFox, which is a fee-per-use system, with no software or internet costs to the NCGS. The fees per registration, which are 2.99% + $0.99 per registration (or $1.71, $2.49, or $3.24 for 1, 2, and 3-year registrations, respectively), will be covered by the NCGS.

To cover these new fees and increased costs for hall-rental, mailings, web-hosting, and insurance, the board approved an increase in dues beginning September 1st to $25 annually for membership and $25/annually for surcharge for paper mailing.

All registrations will be accessed via this link: https://NCGS.regfox.com/ncgs-landing. This brings up an electronic version of the legacy NCGS Membership page (see attached figure). This page will always be active and a link to it will be included in the Newsletter and sent annually to members whose renewal date has arrived. Funds received are directly deposited in the NCGS account and membership details are immediately available to the Membership Secretary for recording.

Registration for Field Trips or the Annual Dinner Meeting will be accessed from the tabs above the Membership Renewal form. These tabs will be grayed out when inactive and highlighted when active. The electronic system is particularly effective for these time-sensitive reservations, as trip availability and dinner commitments are instantaneously updated for both organizers and attendees.

Final Note: If you are among those unable to use the electronic registration, you can contact me (Don M.) via mail at 146 Roan Drive, Danville, CA 94526.

Regards,
Don Medwedeff
NCGS Treasurer

WE'RE ON FACEBOOK!

CHECK OUT THE MOST RECENT POST: @NCGEOLSOC

ALSO, VISIT TWITTER @NORCALGEOSOC

NCGS Board Meetings

Board meetings (online for now) are open to all NCGS members. If you'd like to attend, please contact Jim O'Brient at j.obrient @ comcast.net. Board meetings generally are on Saturday mornings in Jan., Apr./May, and Aug./Sep. Upcoming meeting: **Saturday, May 18, 2024 at 9 a.m., by Zoom**.

A Great Website to Visit

Last year Dr. Ray Sullivan completed an excellent website – see http://raysullivangeologist.com/. As many of you know, Ray was a longtime professor of geology at San Francisco State University as well as serving in multiple positions with other societies and organizations, and with NCGS as president, program chair, field trip leader and counselor, and co-editor of the Mount Diablo volume recently published with the Geological Society of America. The website has a biography, list of journal and book publications, and a list of projects on which he worked, with some great photos and stories.

[Editor's Note: Below is part of a recent entry from the Save Mount Diablo organization's blog, with short text descriptions of the classic rock types along the mountain's trails and their geologic significance, and specifically where to see them; there are also excellent short videos of Ken Lavin explaining some of the picturesque rocks at points of interest along the Mary Bowerman and other trails.]

Fascinating Geology, Rocks on Mount Diablo, and Where to Find Them

https://savemountdiablo.org/blog/fascinating-geology-rocks-on-mount-diablo-and-where-to-find-them/

February 12, 2024 By Mel Bearns

The Mount Diablo Summit Museum and Devils' Pulpit from the Devil's Elbow Trail. Photo by Scott Hein

Our beloved mountain has a complex geological history and reveals the processes that shaped the Coast Ranges over millions of years.

During the last three decades, our understanding about the geological history of Mount Diablo has evolved a great deal, illuminating the hidden processes that shaped our mountain and surrounding ranges.

One facet that is particularly fascinating is that although the rocks that form the mountain are incredibly old, the mountain is quite young by comparison. Join me [Mr. Bearns] on a trip through time to find out why our mountain is so amazing.

Discovery of faults on Pacific Ocean floor adds new insights to theory of plate tectonics

Findings show Pacific Plate is being torn apart at undersea plateaus spanning the ocean by the weight of the oceanic plate subducting at the Western Pacific Ring of Fire

EurekAlert!, February 24, 2024
Source: University of Toronto

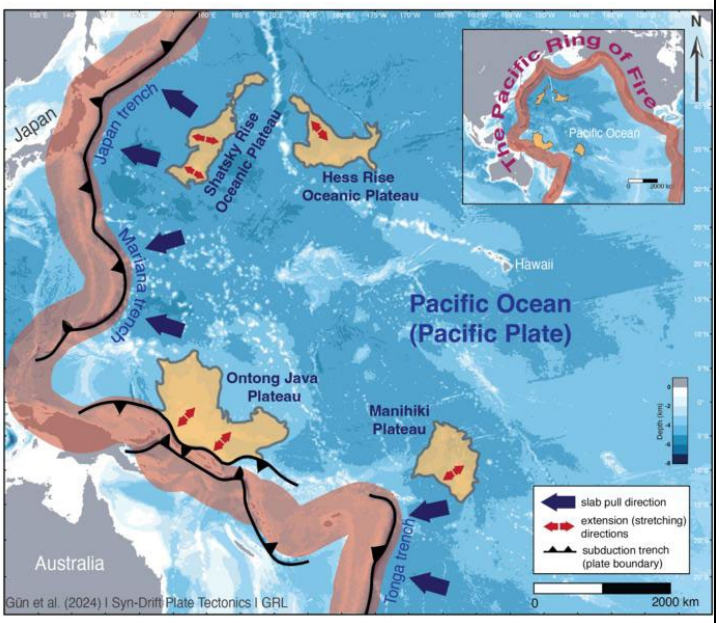


Image: The map highlights in yellow the zones of the Pacific Plate that are being pulled apart by the sinking tectonic plate along the Pacific Ring of Fire.
Credit: Erkan Gün & Russell Pysklywec/University of Toronto

TORONTO, ON – New research led by a team of University of Toronto (U of T) geoscientists is refining the century-old model of plate tectonics that holds the plates covering the ocean floors are rigid as they move across Earth's mantle.

Instead, the researchers found the Pacific Plate is scored by large undersea faults pulling it apart. The newly discovered faults, some thousands of metres deep and hundreds of kilometres long, are the result of enormous forces within the plate tugging it westward.

The researchers describe their findings in a paper published in the journal *Geophysical Research Letters*. The authors include Erkan Gün, a postdoctoral fellow, and Professor Russell Pysklywec in the Department of Earth Sciences in the Faculty of Arts & Science at U of T, Phil Heron, an assistant professor in the Department of Physical & Environmental Sciences at University of Toronto Scarborough, as well as researchers from the Eurasia Institute of Earth Sciences, Istanbul Technical University.

"We knew that geological deformations like faults happen on the continental plate interiors far from plate boundaries," says Gün. "But we didn't know the same thing was happening to ocean plates."

Says Pysklywec, "What we're doing is refining plate tectonics — the theory that describes how our planet works — and showing those plates really aren't as pristine as we previously thought."

For millions of years, the Pacific Plate — which constitutes most of the floor of the ocean — has drifted westward to plunge down into Earth's mantle along undersea trenches or subduction zones that run from Japan to New Zealand and Australia. As the western edge of the plate is pulled down into the mantle, it drags the rest of the plate with it like a tablecloth being pulled from a table.

The newly discovered plate damage at the faults occurs within extensive, sub-oceanic plateaus formed millions of years ago when molten rock from the Earth's mantle extruded onto the ocean floor; the faults tend to run parallel to the closest trench

"It was thought that because the sub-oceanic plateaus are thicker, they should be stronger," says Gün. "But our models and seismic data show it's actually the opposite: the plateaus are weaker."

If the Pacific Plate is like a tablecloth being pulled across a tabletop, the plateaus are patches of weaker cloth more prone to tearing.

The researchers studied four plateaus in the western Pacific Ocean — the Ontong Java, Shatsky, Hess and Manihiki — in a vast area roughly bounded by Hawaii, Japan, New Zealand and Australia. They made their discovery using supercomputer models and existing data, some collected in studies done in the 1970s and 1980s.

"There is evidence that volcanism occurred at these sites in the past as a result of this type of plate damage — perhaps episodically or continuously — but it isn't clear if that's happening now," says Gün. "Still, we can't be certain because the plateaus are thousands of meters below the ocean surface and sending research vessels to collect data is a major effort. So, in fact, we're hopeful our paper brings some attention to the plateaus and more data will be collected."

The theory of plate tectonics has been refined over many decades by numerous earth scientists — including U of T's John Tuzo Wilson who made significant contributions to it during his career.

"But the theory is not carved in stone and we're still finding new things," says Pysklywec. "Now we know this fault damage is tearing apart the center of an ocean plate —and this could be linked to seismic activity and volcanism.

"A new finding like this overturns what we've understood and taught about the active Earth", he says. "And it shows

that there are still radical mysteries about even the grand operation of our evolving planet."

Journal Reference: *Geophysical Research Letters*. DOI: 10.1029/2023GL105452

Atmospheric carbon dioxide drawdown from rock weathering processes has its limits

EurekAlert! March 7, 2024
Source: American Association for the Advancement of Science (AAAS)

Atmospheric carbon dioxide (CO_2) drawdown from the chemical weathering of rocks peaks across a narrow range of moderate erosion rates, according to a new study. The findings provide new insights into the constraints of weathering-mediated CO_2 drawdown and help to resolve conflicting data on the impact of uplift and erosion on the carbon cycle. The chemical weathering of rocks on Earth's surface, in part, mediates the concentration of CO_2 in the atmosphere and, thereby, the planet's climate. Understanding the constraints of this process is critical to modeling Earth's evolution over geologic time scales and evaluating Earth's systemic response to natural and anthropogenic impacts. Since chemical weathering rates are largely controlled by the exposure of fresh minerals to the surface, mountain building and subsequent erosion are thought to play a crucial role in modulating atmospheric CO_2. However, the relationship between erosion and chemical weathering remains poorly understood. Previous studies have produced conflicting results and shown that increased weathering does not always result in the drawdown of CO_2. To evaluate the effect of erosion on chemical weathering, Aaron Bufe and colleagues compiled and analyzed four datasets that report water chemistry from small streams that sample wide erosion rate gradients with well-constrained climate controls. According to the findings, CO_2 drawdown from rock weathering peaks across a narrow window of erosion rates – 0.06 to 0.11 millimeters per year – which is much lower than the most active mountain ranges. Below these rates, weathering is limited by a lack of newly exposed minerals. Above these rates, CO_2 emissions from carbonate weathering by sulfuric acid contribute to the atmospheric CO_2 budget. Thus, Bufe et al. show that while landscapes with moderate uplift and erosion rates may bolster CO_2 drawdown in some locations, more active regions decrease drawdown or even contribute CO_2 to the atmosphere. The findings help to reconcile conflicting observations on the impact of chemical weathering on atmospheric CO_2.

Article title and Journal: **CO_2 drawdown from weathering maximized at moderate erosion rates,** *Science.* DOI: 10.1126/science.adk0957.

Earth's earliest forest revealed in Somerset fossils

EurekAlert! March 7, 2024
Source: University of Cambridge

A Forest of *Calamophyton* Trees
Credit: Peter Giesen/Chris Berry

The oldest fossilized forest known on Earth – dating from 390 million years ago – has been found in the high sandstone cliffs along the Devon and Somerset coast of South West England.

The fossils, discovered and identified by researchers from the Universities of Cambridge and Cardiff, are the oldest fossilized trees ever found in Britain, and the oldest known fossil forest on Earth. This fossil forest is roughly four million years older than the previous record holder, which was found in New York State.

The fossils were found near Minehead, on the south bank of the Bristol Channel, near what is now a Butlin's holiday camp. The fossilized trees, known as *Calamophyton*, at first glance resemble palm trees, but they were a 'prototype' of the kinds of trees we are familiar with today. Rather than solid wood, their trunks were thin and hollow in the center. They also lacked leaves, and their branches were covered in hundreds of twig-like structures.

These trees were also much shorter than their descendants: the largest were between two and four meters tall. As the trees grew, they shed their branches, dropping lots of vegetation litter, which supported invertebrates on the forest floor.

Scientists had previously assumed this stretch of the English coast did not contain significant plant fossils, but this particular fossil find, in addition to its age, also shows how early trees helped shape landscapes and stabilize riverbanks and coastlines hundreds of millions of years ago. The results are reported in the *Journal of the Geological Society*.

The forest dates to the Devonian Period, between 419 million and 358 million years ago, when life started its first big expansion onto land: by the end of the period, the first seed-bearing plants appeared and the earliest land animals, mostly arthropods, were well-established.

"The Devonian period fundamentally changed life on Earth," said Professor Neil Davies from Cambridge's Department of Earth Sciences, the study's first author. "It also changed how water and land interacted with each other, since trees and other plants helped stabilize sediment through their root systems, but little is known about the very earliest forests."

The fossil forest identified by the researchers was found in the Hangman Sandstone Formation, along the north Devon and west Somerset coasts. During the Devonian period, this region was not attached to the rest of England, but instead lay further south, connected to parts of Germany and Belgium, where similar Devonian fossils have been found.

"When I first saw pictures of the tree trunks I immediately knew what they were, based on 30 years of studying this type of tree worldwide" said co-author Dr Christopher Berry from Cardiff's School of Earth and Environmental Sciences. "It was amazing to see them so near to home. But the most revealing insight comes from seeing, for the first time, these trees in the positions where they grew. It is our first opportunity to look directly at the ecology of this earliest type of forest, to interpret the environment in which *Calamophyton* trees were growing, and to evaluate their impact on the sedimentary system."

The fieldwork was undertaken along the highest sea-cliffs in England, some of which are only accessible by boat, and revealed that this sandstone formation is in fact rich with plant fossil material from the Devonian period. The researchers identified fossilized plants and plant debris, fossilized tree logs, traces of roots and sedimentary structures, preserved within the sandstone. During the Devonian, the site was a semi-arid plain, criss-crossed by small river channels spilling out from mountains to the northwest.

"This was a pretty weird forest – not like any forest you would see today," said Davies. "There wasn't any undergrowth to speak of and grass hadn't yet appeared, but there were lots of twigs dropped by these densely-packed trees, which had a big effect on the landscape."

This period marked the first time that tightly-packed plants were able to grow on land, and the sheer abundance of debris shed by the *Calamophyton* trees built up within layers of sediment. The sediment affected the way that the rivers flowed across the landscape, the first time that the course of rivers could be affected in this way.

"The evidence contained in these fossils preserves a key stage in Earth's development, when rivers started to operate in a fundamentally different way than they had before, becoming the great erosive force they are today," said Davies. "People sometimes think that British rocks have been looked at enough, but this shows that revisiting them can yield important new discoveries."

The research was supported in part by the Natural Environment Research Council (NERC), part of UK Research and Innovation (UKRI). Neil Davies is a Fellow of Churchill College, Cambridge.

Journal: *Journal of the Geological Society,* 23-Feb-2024. DOI: 10.1144/jgs2023-204.

Study: Sinking land increases risk for thousands of coastal residents by 2050

One in fifty people living in two dozen coastal cities in the United States could experience significant flooding by 2050, according to Virginia Tech-led research

EurekAlert! (from AAAS), 6-Mar -2024
Source: Virginia Tech

Published in Nature, the study combines satellite-obtained measurements of sinking land, also known as subsidence, with sea-level rise projections and tide charts to provide a new comprehensive look at the potential for flooding in a combined 32 cities along the Atlantic, Pacific, and Gulf coasts. The study projects that in the next three decades as many as 500,000 people could be affected as well as a potential 1 in 35 privately owned properties damaged by flooding. The study also highlights the racial and socioeconomic demographics of those potentially affected.

"One of the challenges we have with communicating the issue of sea-level rise and land subsidence broadly is it often seems like a long-term problem, like something whose impacts will only manifest at the end of the century, which many people may not care about," said lead author Leonard Ohenhen, a graduate student working with Associate Professor Manoochehr Shirzaei at Virginia Tech's Earth Observation and Innovation Lab. "What we've done here is focused the picture on the short term, just 26 years from now."

Other increases compared to current estimates include:

- Between 500 and 700 more square miles of land flooded
- 176,000 to 518,000 more people affected

• 94,000 to 288,000 more properties exposed with an estimated value of $32 billion to $109 billion

"The whole purpose of this paper is to provide data to support decisions," Shirzaei said. "Every city, every county has a flood resiliency plan in place. They are required by law to create that. But it's likely nobody has received the entire picture until this study, which creates probably the first comprehensive picture of what's happen in the not-too-distant future."

Collaborators on the study include:

• Chandrakanta Ojha of the India Institute of Science Education and Research in Punjab, India

• Sonam Sherpa, a former Ph.D. student at Virginia Tech and a postdoctoral scholar at Brown University

•Robert J. Nicholls of the Tyndall Centre for Climate Change Research at the University of East Anglia, United Kingdom

"This study demonstrates that we can now measure vertical land motion at a sufficient scale to create a useful climate service that supports planning and management decisions on flooding," said Nicholls, a professor of climate adaptation. "This approach has the potential to be applied in any city around the world, really supporting adaptation."

Using highly accurate data points measured by space-based radar satellites, Shirzaei and his research team have built some of the world's first high-resolution depictions of the sinking land along the coast of the entire United States. Their work has previously revealed regions of the Atlantic coast to be sinking by as much as 5 millimeters per year.

This study revealed that 24 of the 32 coastal cities are currently sinking more than 2 millimeters per year and half of those cities have areas sinking more than global seas are rising. These numbers might seem small, but when combined with sea-level rise over time, it adds up to quite a significant shift, according to Ohenhen.

"The analogy I have found that is really helpful in helping people understand this change is to think about a sinking boat," he said. "Imagine you are in that boat with a steady leak, slowly causing the boat to sink. That leak symbolizes sea-level rise or broadly flooding. What would happen if it also starts raining? Even a minor rainfall or drizzle would cause the boat to sink more quickly than you thought it would. That's what land subsidence does — even imperceptible millimeter land subsidence exacerbates existing coastal hazards."

Along with the new flood projections, the study also revealed the 32 cities have a combined 131 flood control structures, such as levees, berms, or dikes, but that 50 percent of those are located on the California coast. Only three of the 11 Atlantic coast cities studied maintain levees or floodwalls.

"When we looked at it across the board, we found that there is a general unappreciation for flood protection, particularly on the Atlantic coast," Ohenhen said. "And even the levees there often protect less than 10 percent of the city, compared to other cities on the Pacific or Gulf coasts where up to 70 percent is protected."

Another first in the study is the consideration of racial and socioeconomic demographics related to the potentially affected areas.

In some cities examined, particularly those along the Gulf Coast, the potential increased exposure fell disproportionately on racial minorities. In other cities, the properties facing increased exposure were found to generally be of lesser value than the median property value of the area. And in a few cities, New Orleans and Port Arthur, Texas, particularly, these two demographics intersect, showing the areas with greatest potential risk to be disproportionately occupied by people of color who are also at an economic disadvantage when compared to the city as a whole.

"That was the most surprising part of the study," Ohenhen said. "We found that there is racial and economic inequality in those areas in that there was an overrepresentation of historically marginalized groups potentially impacted as well as properties with significantly lower value than the rest of the cities. It really multiplies the potential impact to those areas and their abilities to recover from significant flooding."

Shirzaei said he believes the study as a whole not only provides the clearest picture of potential flooding to date, but also should serve as a call to action for policymakers of those areas.

"Very often, we hear, 'Oh, we didn't know about land subsidence' or, 'We didn't know about that other factor,' but this study will take away those excuses from everybody," Shirzaei said.

Journal: *Nature*, 7-Mar-2024. Article Title: **Disappearing cities on US coasts.** DOI:10.1038/s41586-024-07038-3.

Researchers studying ocean transform faults, describe a previously unknown part of the geological carbon cycle

EurekAlert! February 12, 2024
Source: Woods Hole Oceanographic Institution.

Studying a rock is like reading a book. The rock has a story to tell, says Frieder Klein, an associate scientist in the Marine Chemistry & Geochemistry Department at the Woods Hole Oceanographic Institution (WHOI).

The rocks that Klein and his colleagues analyzed from the submerged flanks of the St. Peter and St. Paul Archipelago in the St. Paul's oceanic transform fault, about 500 km off the coast of Brazil, tells a fascinating and previously unknown story about parts of the geological carbon cycle.

Transform faults, where tectonic plates move past each other, are one of three main plate boundaries on Earth and about 48,000 km in length globally, with the others being the global mid-ocean ridge system (about 65,000 km) and subduction zones (about 55,000 km).

Carbon cycling at mid-ocean ridges and subduction zones has been studied for decades. In contrast, scientists have paid relatively scant attention to CO_2 in oceanic transform faults. The transform faults were considered "somewhat boring" places for quite some time because of the low magmatic activity there, says Klein. "What we have now pieced together is that the mantle rocks that are exposed along these ocean transform faults represent a potentially vast sink for CO_2," he says. Partial melting of the mantle releases CO_2 that becomes entrained in hydrothermal fluid, reacts with the mantle closer to the seafloor, and is captured there. This is a part of the geological carbon cycle that was not known before," says Klein, lead author of a new journal study "Mineral Carbonation of Peridotite Fueled by Magmatic Degassing and Melt Impregnation in an Oceanic Transform Fault," published in the Proceedings of the National Academy of Sciences (PNAS). Because transform faults have not been accounted for in previous estimates of global geological CO_2 fluxes, the mass transfer of magmatic CO_2 to the altered oceanic mantle and seawater may be larger than previously thought.

"The amount of CO_2 emitted at the transform faults is negligible compared to the amount of anthropogenic - or human driven - CO_2," says Klein. "However, on geological timescales and before humans emitted so much CO_2, geological emissions from Earth's mantle – including from transform faults – were a major driving force of Earth's climate."

As the paper states, "global anthropogenic CO_2 emissions are estimated to be on the order of 36 gigatons (Gt) per year, dwarfing estimates of average geological emissions (0.26 Gt per year) to the atmosphere and hydrosphere. Yet, over geological timescales, emissions of CO_2 sourced from Earth's mantle have been pivotal in regulating Earth's climate and habitability, as well as the C [carbon]-concentration in surface reservoirs, including the oceans, atmosphere, and lithosphere." Klein adds that "this is before anthropogenic combustion of fossil fuels, of course."

"In order to fully understand modern human-caused climate change, we need to understand natural climate fluctuations in Earth's deep past, which are tied to perturbations in Earth's natural carbon cycle. Our work provides insights into long-timescale fluxes of carbon between Earth's mantle and the ocean/atmosphere system," says co-author Tim Schroeder, member of the faculty at Bennington College, Vermont. "Large changes in such carbon fluxes over millions of years have caused Earth's climate to be much warmer or colder than it is today."

To better understand carbon cycling between Earth's mantle and the ocean, Klein, Schroeder, and colleagues studied the formation of soapstone "and other magnesite-bearing assemblages during mineral carbonation of mantle peridotite" in the St. Paul's transform fault, the paper notes. "Fueled by magmatism in or below the root zone of the transform fault and subsequent degassing, the fault constitutes a conduit for CO_2-rich hydrothermal fluids, while carbonation of peridotite represents a potentially vast sink for the emitted CO_2."

The researchers argue in the paper that "the combination of low extents of melting, which generates melts enriched in incompatible elements, volatiles and particularly CO_2, and the presence of peridotite at oceanic transform faults creates conditions conducive to extensive mineral carbonation."

The rocks were collected using human-occupied vehicles during a 2017 cruise to the area.

Finding and analyzing these rocks "was a dream come true. We had predicted the presence of carbonate-altered oceanic mantle rocks 12 years ago, but we couldn't find them anywhere," says Klein. "We went to the archipelago to explore for low-temperature hydrothermal activity, and we failed miserably in finding any such activity there. It was unbelievable that we were able to find these rocks in a transform fault, because we found them by chance while looking for something else."

Funding for this research was provided by the Dalio Ocean Initiative, the Independent Research & Development Program at WHOI, and the National Science Foundation.

About Woods Hole Oceanographic Institution:

The Woods Hole Oceanographic Institution (WHOI) is a private, non-profit organization on Cape Cod, Massachusetts, dedicated to marine research, engineering, and higher education. Established in 1930, its primary mission is to understand the ocean and its interaction with the Earth as a whole, and to communicate an understanding of the ocean's role in the changing global environment.

Journal: *Proceedings of the National Academy of Sciences.* Article Title: **Mineral Carbonation of Peridotite Fueled by Magmatic Degassing and Melt Impregnation in an Oceanic Transform Fault.** DOI: 10.1073/pnas.2315662121.

Utah's Bonneville Salt Flats has long been in flux

Salt crusts began forming long after Lake Bonneville disappeared, according to new U research that relied on pollen to date playa in western Utah.

EurekAlert! February 21, 2024
Source: University of Utah

Utah geology graduate student Jeremiah Bernau, on top, operates a coring device with Ben Marconi while extracting cores from the Bonneville Salt Flats in 2019. Both were University of Utah graduate students at the time. Credit: Elliot Jagniecki (Utah Geological Survey).

It has been long assumed that Utah's Bonneville Salt Flats was formed as its ancient namesake lake dried up 13,000 years ago. But new research from the University of Utah has gutted that narrative, determining these crusts did not form until several thousand years after Lake Bonneville disappeared, which could have important implications for managing this feature that has been shrinking for decades to the dismay of the racing community and others who revere the saline pan 100 miles west of Salt Lake City.

This salt playa, spreading across 40 square miles of the Great Basin Desert, perfectly level and white, has served as a stage for land-speed records and a backdrop for memorable scenes in numerous films, including "Buckaroo Banzai" and "Pirates of the Caribbean."

Relying on radiocarbon analysis of pollen found in salt cores, the study, published Friday in the journal Quaternary Research, concludes the salt began accumulating between 5,400 and 3,500 years ago, demonstrating how this geological feature is not a permanent fixture on the landscape.

"This now gives us a record of how the Bonneville Salt Flats landscape responds to environmental change. Originally, we thought this salt had formed here right after Lake Bonneville and it was a static landscape in the past 10,000 years," said the study's lead author, Jeremiah Bernau, a former U graduate student in geology. "This data shows us that that's not the case, that during a very dry period in the past 10,000 years, we actually saw a lot of erosion and then the accumulation of gypsum sand. And as the climate was becoming cooler and wetter, then the salt began to accumulate."

And even more intriguing, according to the researchers, is the sediments immediately under the salt are far older, predating even the existence of Lake Bonneville. In other words, the old lake bed had largely blown away, indicating this landscape is far more dynamic than previously understood.

"We can show that a lot of material was removed before the salt came in," said senior author Brenda Bowen, a geology professor and chair of the Department of Atmospheric Sciences who heads the U's Global Change and Sustainability Center. "That's really interesting when we think about what's happening right now with the Great Salt Lake's exposed lake beds and the potential for dust to be blown away and eroded."

The nearby Great Salt Lake, a surviving remnant of Lake Bonneville, has greatly receded over the past two decades thanks to drought and decades of upstream water diversions. The research offers a potential forecast of what might happen if the Great Salt Lake continues to shrink.

Since 1960, scientists have been monitoring the Bonneville Salt Flats, as a part of lease agreements and management plans overseen by the federal Bureau of Land Management. The playa lost about a third of its salt volume over the past six decades.

Today, the crusts are 5 feet at their thickest point and cover an area of 5 by 12 miles at the foot of the Silver Island Mountains. Bowen began measuring the salt in 2016 with a research team that included Bernau, who joined the Utah Geological Survey after completing his doctorate.

But they went deeper than others had previously, drilling into the sediments below the salt, which is difficult to core through.

"The salt is quite brittle," Bowen said. "You can't use fluids or water generally [to aid in drilling] because it would dissolve the sediments."

Instead, they used sonic drilling, which uses vibration.

"Once you get to the mud below the salt," she said, "it's like toothpaste and it just slides right through."

Bowen and Bernau collaborated with the U geography department's Records of Environmental Disturbance (or RED) Lab to drill additional cores in 2018 and 2020, this time using a device called a "vibracorer," built by Isaac Hart, a former construction worker and welder who was then a graduate student in anthropology.

The equipment consists of a 21-foot-long irrigation tube affixed to a concrete mixer motor.

"The vibration of the motor allows the tube to be pushed down into the ground if the sediment is relatively fine-grained and soft (like the floor of the Lake Bonneville basin), after which we fill the tube with water and cap it off to create a vacuum so the dirt doesn't drop out of the tube when we pull it out of the ground," said Hart, a

coauthor in the study, said in an email. He is now a field director for the international nonprofit American Center for Mongolian Studies.

Added Bernau: "This method was manually laborious, but we pulled out really gorgeous cores."

They shared these cores, varying in length from 10 to 13 feet, with Charles "Jack" Oviatt, a coauthor in the study, emeritus professor of geology at Kansas State University and a leading expert in Pleistocene lake beds, especially Lake Bonneville's. After examining the sediments, Oviatt concluded they bore little resemblance to the Bonneville lake bed elsewhere.

"That really gave us the hint that we had something interesting on our hands," recalled Bernau, who now works for private industry in Texas. To make sense of the cores, the researchers had to first pinpoint the ages of the salt crusts and their underlying sediments.

Scientists can determine. Applying this technique to the sediments, the researchers found dates going back more than 40,000 years, older even than Lake Bonneville itself, suggesting the prior presence of intermittent lakes.

Dating the overlying salt crusts was more tricky since radiocarbon dating requires organic material to analyze. In examining the salt cores under a microscope, however, researchers found what they needed to carbon date the salt: minute grains of pollen.

The team also examined sediment structures, mineralogy, diatoms and geochemistry to characterize the depositional record. Gypsum and carbonate strontium isotope ratio measurements were used to determine sources of water that carried the sediments to the salt flats.

"We threw all our tools into this study to get as much of a robust understanding of how this environment was changing through time," said Bowen, whose study constructs a revisionist history for this place.

Lakes have been coming and going for tens of thousands, if not hundreds of thousands, of years in response to climatic changes, disappearing and reappearing as conditions alternate between wet and dry periods.

The data indicate the area now supporting the salt flats hosted a series of three shallow lakes between 45,000 to 28,000 years ago, that is, prior to the arrival of Lake Bonneville. After 13,000 years ago, the lake bed was exposed to wind erosion.

Three to six feet of sediment blew away before the water returned around 8,300 years ago, bringing the brines that eventually formed the salt flats we see today. The study shows that the Bonneville Salt Flats are more ephemeral than many appreciate, offering insights into how this special place could be managed differently.

"Sometimes we manage for the current landscape thinking that's what it needs to be," Bowen said, "but actually, it needs to be able to adapt and change."

Journal: *Quaternary Research,* 16-Feb-2024. Article Title: **Lateral and temporal constraints on the depositional history of the Bonneville Salt Flats, Utah, USA.** DOI: 10.5281/zenodo.7271700.

New detection method aims to warn of landslide tsunamis

EurekAlert! 21-Feb-2024
Source: University Of Alaska Fairbanks

University of Alaska Fairbanks researchers have devised a way to remotely detect large landslides within minutes of occurrence and to quickly determine whether they are close to open water and present a tsunami hazard.

They write in a new paper that their method of determining a landslide's location, volume and potential impact is rapid enough to support the National Oceanic and Atmospheric Administration's goal of issuing a tsunami warning within 5 minutes of a landslide.

"The warming climate is causing glaciers to retreat, leaving behind valleys whose mountainsides and hillsides have lost their support," said research seismologist Ezgi Karasözen of the UAF Geophysical Institute. "This is important, especially in regions like southern coastal Alaska, because huge masses of land can and do spill into water and cause tsunamis."

Karasözen and Michael West, director of the Alaska Earthquake Center at the Geophysical Institute, detailed their method in a paper published Feb. 9 in the journal The Seismic Record. West also serves as Alaska state seismologist.

Their paper calls attention to the danger by pointing to a 2015 landslide that sent 100 million cubic yards of rock into Alaska's Taan Fjord, located off Icy Bay, 65 miles northwest of Yakutat. The slide created a tsunami that stripped vegetation as high as 620 feet above waterline.

A prototype system by Karasözen and West capable of real-time detection has been in place since August in the area of the Barry Arm of Prince William Sound. It uses data from seismic stations already in the Alaska network.

State and federal agencies fear a landslide and tsunami could occur at Barry Arm, where Barry Glacier has retreated and left behind an unsupported fjord wall that has slumped about 650 feet in recent decades. Retrospective analysis of seismic station data at Barry Arm revealed three landslides that occurred in 2020 and 2021.

Karasözen and West write that the instability "has prompted concerns that a catastrophic failure could

generate a tsunami with several meters of peak wave height reaching nearby communities in just 20 minutes."

The U.S. Geological Survey is leading the multifaceted interagency monitoring of the area.

"With an earthquake, there are instruments that measure ocean wave heights, and tsunami warning centers are on alert after an earthquake," Karasözen said. "But landslides aren't systematically monitored in Alaska or elsewhere in the world. If a landslide-triggered tsunami were to happen, we wouldn't know. That's a major concern."

The method by Karasözen and West involves quickly identifying a landslide's long-period waves amid a seismic record busy with short-period waves created not only by a landslide but also by nearby earthquakes and glaciers and by human-caused activity.

A landslide's initial onset generally registers as short-period waves; it isn't until the slide accelerates that the identifiable long-period waves materialize. Landslides produce disproportionately more long-period energy compared with other sources. Most earthquake ruptures last only seconds, while landslides routinely last a minute or more.

Coastal fjords present a significant challenge for landslide detection because glaciers can create hundreds of prominent seismic events daily, the researchers write.

Karasözen and West created an algorithm to continually scan seismic data from multiple seismic stations to look for a landslide wave signature. Finding a match, their system will estimate the slide's location and volume. In areas with good seismic station coverage, location can be estimated to within a few miles.

The goal is to have the system alert tsunami and seismology agency personnel, but more work remains before that can occur.

To create the algorithm, the two researchers analyzed data of the three recent Barry Glacier landslides and six additional landslides — five of them in Southeast Alaska and one on the west side of lower Cook Inlet, across from the Kenai Peninsula.

Other efforts have been tried over recent decades. Several researchers have shown that landslide seismograms can be used to estimate location and volume, but those efforts usually were unique to a region, required considerable fine-tuning and were not designed for real-time purposes.

Determining landslide location from distant seismic stations doesn't allow for real-time assessment, due to the time it would take for the seismic waves to reach those stations.

West said the research augments ongoing monitoring and alert efforts.

"The potential for real-time monitoring of large landslides is one important component of the interagency effort underway to address Alaska's landslide challenge," he said.

Journal: *The Seismic Record*, 9-Feb-2024. Article Title: **Toward the Rapid Seismic Assessment of Landslides in Coastal Alaska.** DOI: 10.1785/0320230044.

Geologists explore the hidden history of Colorado's Spanish Peaks

EurekAlert! March 4, 2024
Source: University of Colorado at Boulder

If you've driven the mostly flat stretch of I-25 in Colorado from Pueblo to Trinidad, you've seen them: the Spanish Peaks, twin mountains that soar into the sky out of nowhere, reaching altitudes of 13,628 and 12,701 feet above sea level.

In a new study, geologists from the University of Colorado Boulder have laid out a timeline for the emergence of these majestic but isolated mountains. The team's findings could bring scientists closer to answering one of the most enduring puzzles in Colorado geology: What made Denver, the Mile High City, a mile high?

"For geologists, the big question is: Why are Colorado's High Plains so high?" said Sabrina Kainz, who led the research as an undergraduate student studying geology at CU Boulder. The group published its findings March 1 in the scientific journal *Lithosphere*.

Colorado's craggy, snow-capped Rocky Mountains attract tourists and more. But for researchers like Kainz and CU Boulder geologist Lon Abbott, the High Plains that extend over much of eastern Colorado—the territory of tumbleweeds and prairie dogs—may be even more interesting.

Abbott explained that the world's highest places tend to be that way because of squishing and squeezing from tectonic plates—giant pieces of Earth's crust that slam together, crumpling up land masses and raising entire mountain ranges. But Colorado's High Plains, which are dominated by sedimentary rocks, aren't crumpled at all. They're one tall, flat stack of geological pancakes.

"The Colorado High Plains are anomalous, really, in the entire world," said Abbott, co-author of the study and teaching professor in the Department of Geological Sciences. "They're not formed the way that mountains are typically formed."

To get nearer to solving the mystery of the plains, the researchers collected and analyzed rocks from the Spanish Peaks east to Two Buttes, a geologic formation near the Kansas border.

They found that the rocks forming the Spanish Peaks injected into the crust below Colorado as magma around 24 million years ago, but remained miles underground until about 17 million years ago. What happened to bring them to the surface remains a mystery.

“We can answer when the plains around the Spanish Peaks got so high,” Kainz said. “The ‘why’ of the matter is a little more complicated.”

Colorado landmark

The Spanish Peaks have long been an important monument for generations of people who have called southern Colorado home.

The indigenous Comanche people referred to these formations as “Wahatoya,” which means “Double Mountain.” In the early 1800s, travelers following the Santa Fe Trail, which joined Missouri to what is now the southwestern U.S., formerly the northern reaches of New Spain and then Mexico, used the peaks as a landmark.

“They would spend weeks and weeks traveling in their wagons on the plains,” said Abbott, whose book “Geology Underfoot Along Colorado’s Front Range” is a primer for the state’s rockhounds. “Then, all of a sudden, they'd see those mountains, and they knew they were getting close.”

In 1913, hundreds of coal miners striking against the Colorado Fuel and Iron Company set up a tent camp not far from the mountains—a prelude to the Ludlow Massacre of 1914, which remains among the nation’s deadliest labor disputes.

The peaks have always been a bit mysterious. They are as tall as many of the Rocky Mountain summits to the west, but the Spanish Peaks formed at a different time and from completely different rocks.

For Kainz, now a doctoral student at the University of Washington in Seattle, getting to study those features as an undergrad was a dream come true. She began the project at the height of the Covid pandemic in 2020, and spent hours crammed into cars with dozens of rock samples.

The team included Rebecca Flowers, professor of geological sciences; undergraduate geology student Skye Fernandez; James Metcalf, manager of the Thermochronology Research and Instrumentation Laboratory (TRaIL); and Aidan Olsson, then a student at Fairview High School in Boulder now studying biology at CU Boulder.

The project hinged on an approach called thermochronology. Kainz noted that small chemical changes in the crystals within many rocks can give geologists clues about how hot or cold those samples were millions of years ago. Rocks buried deep below the Earth tend to be hotter than those closer to the surface.

More than a mile high

According to the team’s results, the Spanish Peaks first formed when magma welled up from deep within Earth’s crust but didn’t quite break through to the surface.

Then, something happened. In a very short span of time, geologically-speaking, huge tracks of land in southeastern Colorado vanished. Between roughly 18 and 14 million years ago, more than a mile of sedimentary rocks around the Spanish Peaks eroded away, then were swept into the Arkansas River.

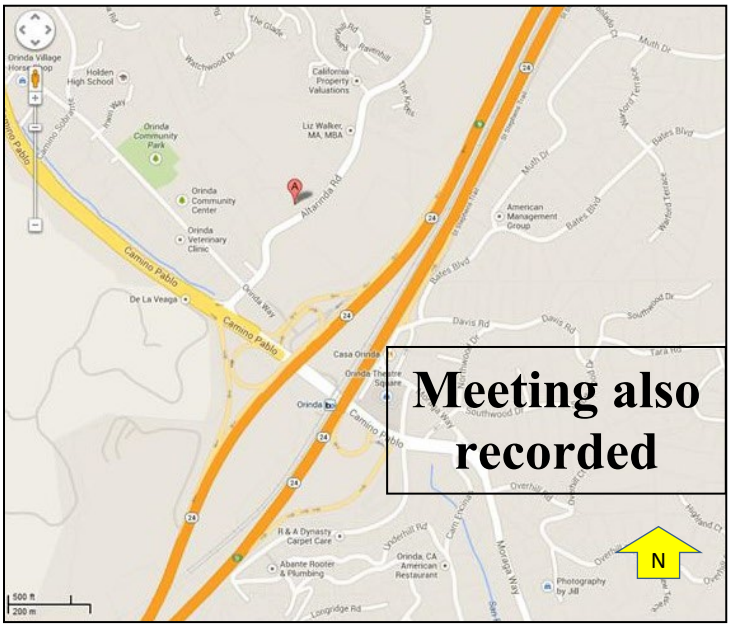
The researchers suspect that as-of-yet-unidentified geologic forces were pushing up southeastern Colorado from below—exposing previously underground rocks to rain and flowing water.

Abbott and his colleagues are now exploring how this disturbance may have fit into the broader evolution of Colorado’s plains. Their preliminary data, for example, suggests that the flat lands around what is now Denver may not have experienced similar upheaval at the same time.

But the study makes one thing clear: Colorado’s High Plains have long been something to behold.

“As high as the High Plains are today, they used to be a lot higher,” Kainz said. “They were as high as the Rocky Mountains are today.”

Journal: *Lithosphere*, 1-Mar-2024. Article Title: **Cenozoic Exhumation Across the High Plains of Southeastern Colorado from (U-Th)/He Thermochronology.** DOI: 10.2113/2023/lithosphere_2023_310.



jointly with seismic algorithms in the production system this spring. In this talk I will discuss this new ShakeAlert capability in more detail as well as possible future uses of real-time GNSS data for improved earthquake early warning.

Biography:

Jessica Murray is a Research Geophysicist at the U.S. Geological Survey Earthquake Science Center in Moffett Field, CA. She uses geodetic measurements, including data from Global Navigation Satellite Systems (GNSS), to quantify the spatial and temporal characteristics of crustal deformation related to earthquakes and faulting and to investigate the underlying causative processes. Most recently her research has focused on using GNSS data to improve real-time earthquake characterization and, in turn, ground motion estimates used by earthquake early warning (EEW) systems for issuing alerts. She has held leadership positions on the USGS Earthquake Hazards Program Council, the Southern California Earthquake Center Science Planning Committee, and the Board of Directors of the Seismological Society of America. She is currently the Geodetic Coordinator for ShakeAlert®, the U.S. West Coast EEW system, providing expertise on scientific and operational aspects of incorporating GNSS data within the ShakeAlert system. Jessica earned her Bachelor of Science in Earth Sciences from Dartmouth College and a Master of Science and Doctor of Philosophy in Geophysics from Stanford University.

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