



Newsletter - Issue No. 42, Spring 2019



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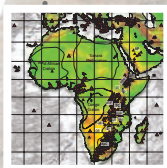
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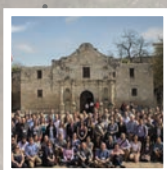
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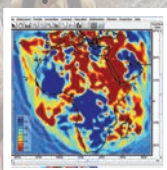
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From the Chair



I am pleased to introduce the Spring 2019 issue of the GeoPRISMS newsletter. As has been our custom, the Spring edition will be distributed in print and be available online; unlike previous years, we will forgo the Fall issue of the newsletter this year, in preparation for a special extended format Spring 2020 issue that will focus on the extraordinary legacy of the GeoPRISMS Program, and on synthesis and integration of science at primary sites and on cross-cutting themes. I invite you to bring your ideas for content to us, or volunteer to contribute to an article. Email the office at info@geoprisms.org!

We are fortunate to have an exciting set of science pieces and report from the field in the current edition, featuring summaries of ongoing projects in the Aleutians and EARS primary sites, and a report from the field from the HT-RESIST (regional EM survey) of the Hikurangi margin in New Zealand. In keeping with recent tradition, all of these pieces are authored by early career investigators. This issue also includes a number of updates on Fall 2019 AGU mini-workshops and student awards, descriptions of newly funded GeoPRISMS projects, and announcements about upcoming opportunities.

The past year has again been a highly active time for the GeoPRISMS office, steering & oversight committee (GSOC), and the community. At the Fall AGU meeting in Washington DC, we sponsored two mini-workshops (p. 32 and 34) and hosted our usual community forum event. The workshops included a morning session on investigating arc construction via the study of exhumed terranes, and an afternoon session on the broad range of ongoing and recent studies of the Hikurangi margin. As always, the meeting itself was also marked by numerous special sessions of interest to – and inspired by – the GeoPRISMS community.

This February, the community gathered for a major theoretical and experimental institute (TEI) held in San Antonio TX, focused on synthesis and integration (p. 20). The meeting provided an opportunity to assess progress on cross cutting themes in the science plan, to bring investigators together to identify outstanding and emerging questions that span primary sites, and to galvanize the community as we look forward to new opportunities. Thanks to Katie Kelley, Harm Van Avendonk, and the convener team for their monumental effort in organizing this important meeting!

I'd also like to thank the GSOC for their continued contributions to GeoPRISMS science, planning, and outreach activities. In addition to our annual GSOC meetings, the committee works behind the scenes to provide guidance to the office and to facilitate a wide range of community-led activities. As the GeoPRISMS program ramps down, the office will be scaling back our activities into the next year. The office itself will operate at a reduced level from November 2019 through October 2020, with a focus on ensuring the legacy of science and accessibility of data generated through the MARGINS and GeoPRISMS programs, and on positioning the community for new opportunities. To that end, we will hold two AGU mini-workshops this year aimed at taking the next key steps toward integration, synthesis, and bringing the community together to build upon the success of GeoPRISMS. These workshops will be organized around key themes identified during the 2019 TEI, coordinated by the GSOC, and led by early career scientists.

I look forward to the next several months as we enter this exciting next phase of the program – that of identifying future opportunities, assessing progress on key questions, and bringing the community together to integrate results that speak to fundamental processes on continental margins. I hope to hear from you, and to see you at our upcoming AGU events!

Demian Saffer
Chair, GeoPRISMS Program

Cover Photograph: Rough seas off New Zealand's North Island during the HT-RESIST cruise, in December 2018. Photo credit: Kerry Key.

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The GeoPRISMS Newsletter is published twice a year and is designed to provide summaries of recent GeoPRISMS activities and meetings, synthesis articles, editorials, and discussion of science opportunities. Archives of the Newsletter are available on the GeoPRISMS website.

Message from NSF

It's been a busy Spring at NSF! After recovering from a lengthy government shutdown, several of us attended the GeoPRISMS TEI in San Antonio, where we heard a lot about where our science has been, and where it should go in the future. The discussions held there helped inform the newest solicitation for GeoPRISMS.

The new solicitation, NSF 19-581 (<https://www.nsf.gov/pubs/2019/nsf19581/nsf19581.htm>), lays out three types of activities:

1. Integrative research projects,
2. Conferences and short courses,
3. Legacy products.

Proposals can be of one type, submitted individually, or could be a combination of types as part of one multi-faceted project. Postdoctoral Scholar proposals are still welcome, as well. It is important to keep in mind that these different proposal types have different Target Dates. If you are proposing an Integrative research project, it is due August 16, 2019. If you are proposing a conference (NSF's term for 'workshop'), short course series, or legacy product, those are due March 2, 2020. And keep in mind, the March 2 Target Date is just that - if you have conference or short course ideas that are ready to submit before then, proposals can come in anytime. As always, get in touch with the Program Directors if you have questions.

This is the last solicitation for the GeoPRISMS program, and we are excited to fund one more round of ground-breaking science, so send us your great ideas! The Divisions of Earth and Ocean Sciences are, as always, collaborating across other programs and strategizing for the future, so that we may continue to support science focused on geodynamic processes at rifting and subducting margins. Stay tuned over the coming year to learn more about how NSF and the GeoPRISMS Office will celebrate the future, and the 20+ year legacy of MARGINS and GeoPRISMS.

Some other news-worthy items from NSF that should interest the GeoPRISMS community:

- The Future of Marine Seismics Workshop was held at NSF in early April. The workshop report is available on the UNOLS website at <https://www.unols.org/committee/marine-seismic-research-oversight-committee-msroc>
- The National Academies of Sciences, Engineering, and Medicine (NASEM) has embarked on "Catalyzing Opportunities for Research in the Earth Sciences (CORES): a Decadal Survey for NSF's Division of Earth Sciences." The committee in charge will provide NSF with input to help set priorities and strategies for Earth Science research investments over the coming decade. You can keep an eye on upcoming events and other ways to engage here. Community engagement is essential to ensuring an impactful report.

Best wishes for a successful season of science!

Jennifer Wade & Debbie Smith

GeoPRISMS Program Directors, National Science Foundation

Geo

PRISMS



WINNER
GeoPRISMS Photo Contest



Photo by Ellen Knappe



Photo by Noel Bartlow



Photo by William Hoover



Thank you to all contestants who have participated in the fourth edition of the GeoPRISMS Photo Contest at the 2018 AGU Fall Meeting. Learn more about the contest and all participants at: <http://geoprisms.org/geoprisms-photo-contest/>

Congratulations to James Muirhead, winner of the GeoPRISMS Photo Contest at the 2018 AGU Fall Meeting

A torn landscape on Gelai volcano in the Natron basin, Tanzania. In this sector of the East African Rift System, magmatic-tectonic interactions culminate in volcanism, earthquakes, and release of large carbon dioxide volumes. This image, taken in May 2018, illustrates such interactions, where Professor Tobias Fischer investigates a fissure resulting from dike-induced faulting occurring about eleven years before. Small volcanic cones (<100 m high) of the Naibor Soito field are observed in the mid ground. The much larger Kerimasi (left) and Oldoinyo Lengai (right) composite volcanoes are in the background, with the latter erupting explosively during this volcanic-tectonic crisis in 2007-2008.

Photo credit: James Muirhead

Complex upper mantle structure beneath the East African Rift System

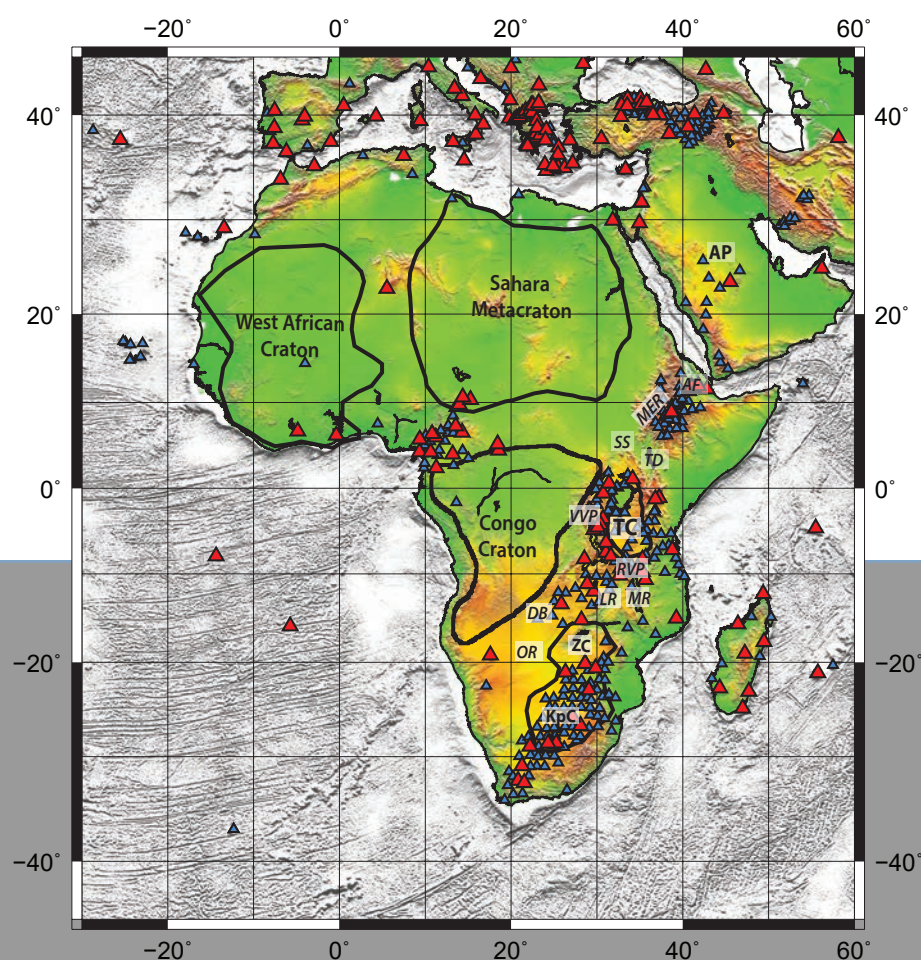
Erica Emry (New Mexico Tech), Andrew Nyblade (Penn State University), and Yang Shen (University of Rhode Island)

The East African Rift System (EARS) was one of the GeoPRISMS primary sites within the theme of Rift Initiation and Evolution, because of the variety of rifting stages and styles exhibited along this margin and because of the number of science questions that can be addressed there. Along this margin and in neighboring regions of Africa, Europe, and the Middle East, many broadband seismic instruments have been previously deployed, and numerous studies have explored the subsurface structure over a broad range of scales. However, there is often a disjoint between features that had been previously imaged through smaller-scale, regional tomographic inversions and those imaged by larger-scale inversions. In a recent tomographic study of the upper mantle beneath Africa, we used a full-waveform tomography method, constrained by long-period signal from ambient seismic noise to image the upper mantle beneath Africa to the top of the mantle transition zone (Emry et al., 2019). We found good agreement with prior models, at both large and regional scales, and we imaged new features in higher detail beneath more poorly resolved segments of the EARS. Here, we highlight the overall patterns along the EARS and focus on the complexity observed beneath the Turkana region.

What did we do?

We gathered continuous seismic data for more than 800 seismic stations and extracted Rayleigh waves from ambient seismic noise at periods as high as 340 seconds (Shen et al., 2012). Long period signal is valuable, because it is sensitive to structure deeper in the upper mantle and allows us to resolve down to about 350 to 400 km. Of the more than 800 seismic stations, we identified stations that provided clear signal at 40-340 seconds and used them to constrain our inversion (Fig. 1). This was a new set of data that had not yet been used to image the deeper lithosphere and asthenosphere beneath Africa.

Figure 1. Station map modified from Emry et al. (2019). Cratons are outlined in thick black lines. Blue triangles denote stations for which ambient noise data were collected and red triangles show stations that were used to invert for tomography. Abbreviations are as follows: AF-Afar, AP-Arabian Peninsula, DB-Damara Belt, KpC-Kaapvaal Craton, LR-Luangwa Rift, MER-Main Ethiopian Rift, MR-Malawi Rift, OR-Okavango Rift, RVP-Rugwe Volcanic Province, SS-South Sudan, TC-Tanzania Craton, TD-Turkana Depression, VVP-Virunga Volcanic Province, ZC-Zimbabwe Craton.



Although other seismic phases are often used to constrain full-waveform tomographic models, we used Rayleigh waves, as it is the principal phase extracted from seismic ambient noise. We used high-performance computing (HPC) clusters at the University of Rhode Island Graduate School of Oceanography to simulate waves propagating through a laterally variable Earth structure. Once synthetic waveforms were calculated for each seismic source in the model, we measured misfit between synthetic Rayleigh waves and those extracted from the data, determined the volume of Earth that influences the traveling wave, and inverted to identify a better-fitting model. For each new model, these steps were repeated until minimal change was made to the model. Our final results provide the absolute, isotropic, shear wave velocity (Fig. 2).

New results from the East African Rift System

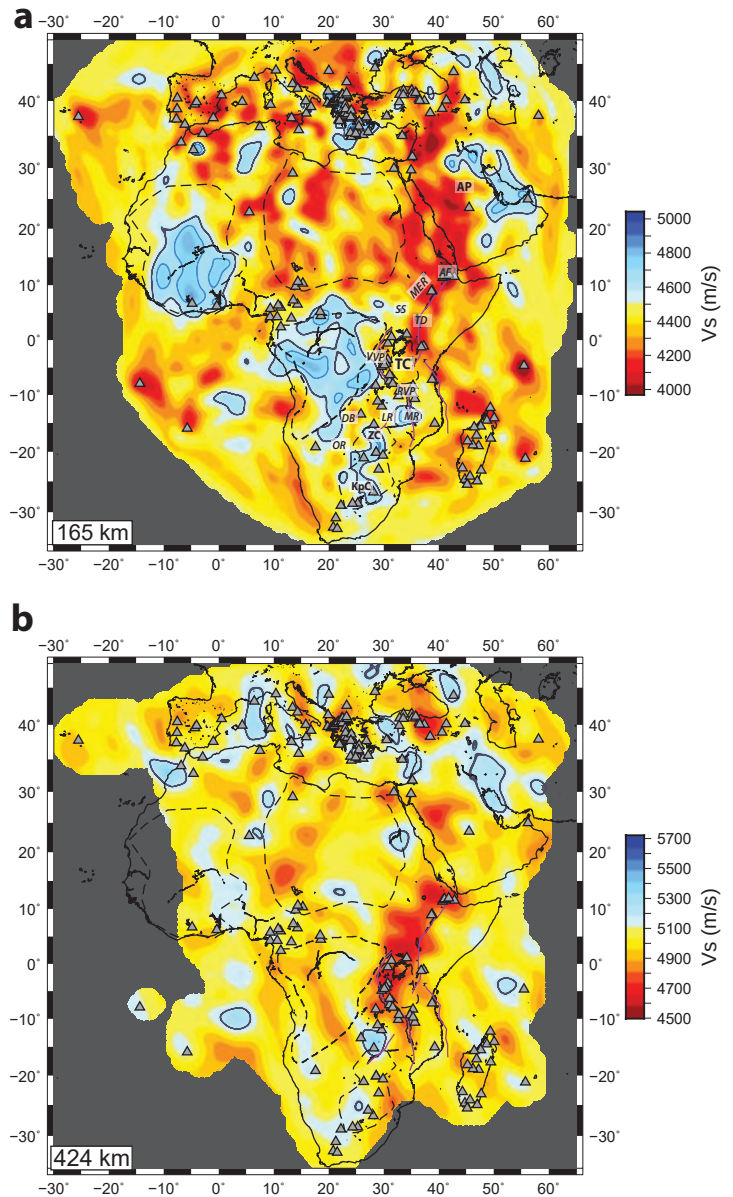
There were many similarities between our results and prior studies of the EARS in regions where dense seismic or magnetotelluric arrays have been previously located (Benoit et al., 2006; Bastow et al., 2008; Adams et al., 2012; Mulibo and Nyblade, 2013; O'Donnell et al., 2013; Civiero et al., 2015; Gallacher et al., 2016; Accardo et al., 2017; Yu et al., 2017; Sarafian et al., 2018). As in prior models, we saw abundant indications for mantle upwellings or plumes as well as a pattern of lower velocities at shallow upper mantle depths in the northern EARS and higher velocities at shallow depths in the southern EARS. However, in our results, the patterns of low-velocities at middle upper mantle depths were laterally discontinuous along the full length of the EARS, and we imaged variable lithospheric topography that may influence the shallow flow of mantle upwellings.

Segmented upwellings beneath East Africa

Beneath the EARS, we imaged low-velocities at mantle transition zone (MTZ) depths, but at middle upper mantle depths, we imaged persistent patterns of separation between low-velocity features. While we have confidence in the pattern of separation within the upper mantle, we cannot resolve small features at deep depths and therefore cannot be certain whether the separation at shallower depths continues into the MTZ. At the shallowest upper mantle depths, the low-velocities appear to be overall more connected than at the middle upper mantle and are located mostly beneath the rift axis. In many regions, at shallow and middle upper mantle depths, the low-velocity anomalies are located adjacent to or between high-velocity features.

This pattern provides an overall sense that distinct buoyant upwellings, presumably of a thermal or thermochemical nature, are rising through the upper mantle and that their paths are likely influenced at shallow depths by rigid, presumably lithospheric, structures. Ultimately, it appears that these upwellings are sourced from MTZ depths. Such a pattern of secondary upwellings could be sourced by a deeper, ponded anomaly at or beneath the mantle transition zone, as has been previously suggested for the EARS from seismic and geochemical observations (Kieffer et al., 2004; Furman et al., 2006; Bastow et al., 2008; Huerta et al., 2009; Mulibo and Nyblade, 2013; Civiero et al., 2015). This pattern of buoyant upper mantle upwellings appears to be occurring along much of the

Figure 2. Two depth slices showing shear velocity at a) 165 km and b) 424 km, modified from Emry et al. (2019). For each depth, the color scale (m/s) is centered around the shear velocity in AK135 for that depth. Coastlines are shown as thin black lines, gray and blue lines indicate velocities that are 1.7% and 5% greater than AK135 model. Gray triangles show stations that inform the inversion. Abbreviations are as in Figure 1.



EARS, and also in some other regions of Africa, however we note that fewer upwellings were imaged beneath the less evolved southern and western segments. In our view, this may be due to the history of upwellings or to the generally thicker lithosphere in the south and west that may act to divert upwellings.

Complex upper mantle beneath Turkana

One region that is most suggestive of a complex upwelling and diversion process is beneath the Turkana and South Sudan region. Here, the upper mantle has been difficult to image due to a lack of broadband seismic instrumentation. The Turkana segment is part of the primary EARS focus site and is particularly unique with regards

to other segments of the EARS, because of the broad, diffuse rifting pattern and history of previous rifting oblique to the current-day trend (Brune et al., 2017; Ebinger et al., 2017).

Beneath this region, the indication of a low-velocity anomaly at deep upper mantle and mantle transition zone depths was most prominent (Fig. 3c). Directly above this, at middle upper mantle depths, a high-velocity feature was identified in the west beneath South Sudan, and the lowest velocities at these depths were located immediately adjacent to the high-velocity feature, to the north and to the southeast and southwest (Fig. 3b). Above this, at the shallowest upper mantle depths, the lowest velocities were imaged to the east beneath Lake Turkana. At these shallowest depths to the west beneath South Sudan, slightly slow to average upper mantle velocity was observed, while the fastest structure was located to the south and southwest beneath the laterally continuous Uganda and Bomu-Kibalan Cratons (Fig. 3a).

This pattern may suggest that rising asthenosphere is being diverted north and south around a lithospheric structure within the middle upper mantle beneath South Sudan. However, it is difficult to be certain of the spatial relationship and possible connection between this high-velocity feature and the Uganda and Bomu-Kibalan Cratonic roots located at shallower depths to the south and southwest. At this point we can only speculate whether the structure is part of a stable, deep lithospheric root or whether it is sinking or foundering lithosphere (see discussion in Emry et al., 2019). However, we expect that this feature may affect the style of rifting, patterns of magma-rich vs. magma-poor extension, and connections between the Main Ethiopian Rift and the Eastern and Western Branches.

Summary

Overall, the EARS shows variability in lithospheric topography and reveals regions where the lithospheric structure may be affecting the path of upwellings at shallow and middle-upper mantle depths. However, there is also a clear sense of distinct upwellings within the upper mantle that might be sourced from a common, deeper anomaly. Our results of the upper mantle and mantle transition zone are useful in understanding the spatial relationships and possible connections between different segments and we hope that they will aid the overall goal of synthesis.

Acknowledgments

We thank the NSF Earth Sciences Postdoctoral Fellowship program for supporting this research (EAR-1349684). The shear velocity model from Emry et al. (2019) is available through the IRIS-EMC at: <http://ds.iris.edu/ds/products/emc-africaantemry-et-al2018/> and through the GeoMapApp tool at: <http://www.geomapapp.org/>. We thank Manocher Bahavar from the IRIS-EMC and Andrew Goodwillie from IEDA-GeoMapApp for helping to format the model and make it available.

Because our data came from ambient seismic noise, it was necessary that stations had temporally overlapping records. In this regard, the sparsely distributed long-term seismic deployments, such as the GSN, GEOSCOPE, AfricaArray (see photos on the right), and MedNet were irreplaceable, and allowed us to also incorporate several 1-2 year ('PASSCAL-type') seismic deployments throughout Africa and the surrounding regions. ■

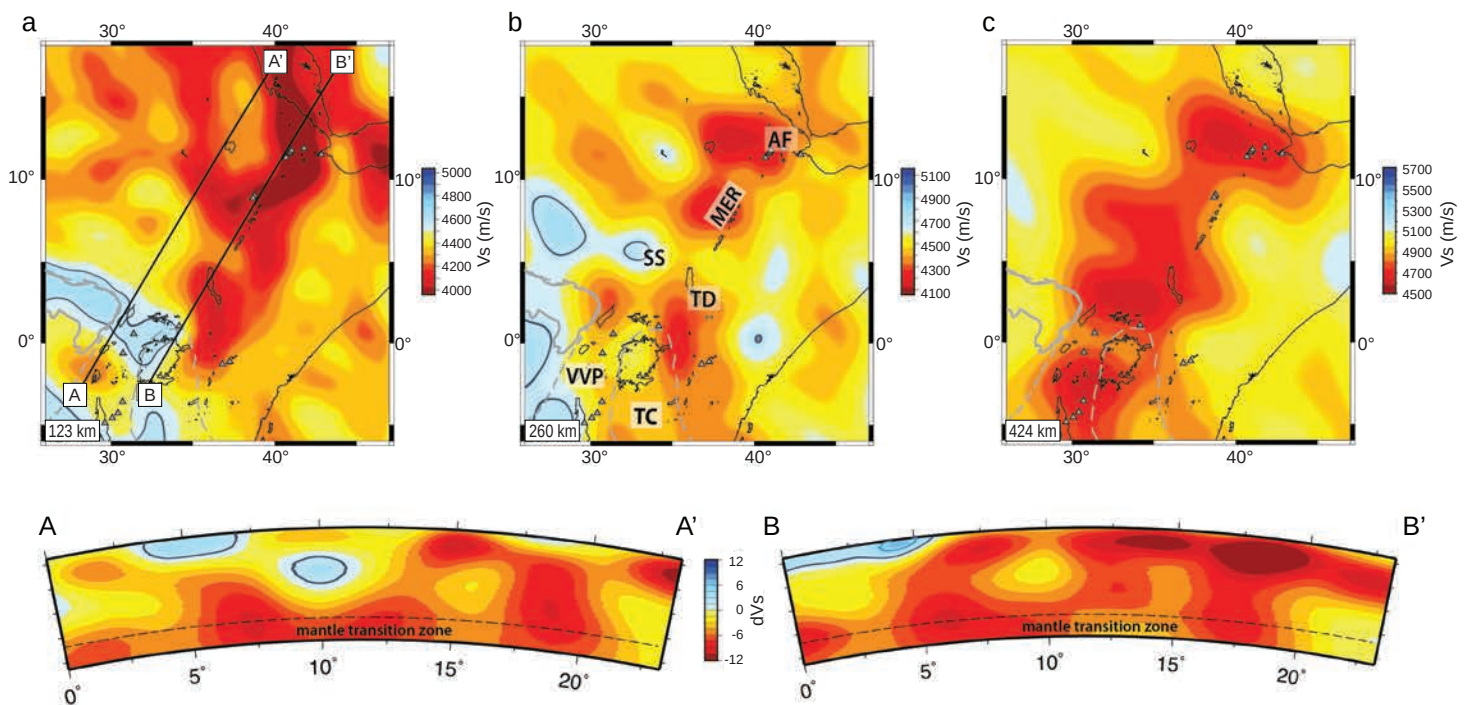


Figure 3. Three depth slices from the Turkana-South Sudan and Ethiopian Plateau regions showing shear velocity at a) 123 km, b) 260 km, and c) 424 km, modified from Emry et al. (2019). Cross-sections correspond to lines plotted on a. Abbreviations explained in Figure 1.

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AfricaArray seismic stations in Dodoma, Tanzania (top left) and Zomba, Malawi (top right and bottom). Top right photo was taken looking down into the 3-m deep seismic vault shown in photo at left at the Geological Survey in Zomba, Malawi. Top left photo was taken looking down into the 4-m deep vault at the Geological Survey in Dodoma, Tanzania. Photos credit: Andy Nyblade.



The Aleutian arc through and through: How subduction dynamics influence the generation, storage, and eruption of volatile- bearing magmas

Daniel Rasmussen (LDEO, Columbia University), Terry Plank (LDEO, Columbia University),
Diana Roman (Carnegie Institution)

Does the volcano know about the slab? Our work in the central-eastern Aleutian arc seeks to address this question. Spanning from Seguam volcano (west) to Shishaldin volcano (east), our corridor is marked by significant variations in magmatic water contents, seismicity, deformation, and style and frequency of volcanism. By contrast, most subduction parameters, such as slab age and velocity, remain constant. One significant exception is the depth of the slab below the frontal arc volcanoes, which transitions from a near global minimum in the west (~65 km BSL) to a more typical depth in the east (~100 km BSL). This makes our corridor an ideal locality to isolate the role of slab depth in driving magmatic processes. After a one-year-long seismic deployment, forty five-gallon buckets of new rock samples, and one PhD dissertation, we are arriving at some answers.

The broad strokes of arc magma genesis are well established: hydrated sediment and oceanic lithosphere subduct and release fluids and/or solids that drive melting of the overlying mantle wedge, generating hydrous arc magmas that ascend to regions of melt coalescence either within or beneath the crust. However, understanding transport and storage of magmas in the crust represents a fundamental challenge to the study of evolution and eruption of arc magmas. Recent development of several geochemical and geophysical tools enables us to closely track the path of magma through the crust, particularly in the upper crust. We are employing these tools to illuminate the development and eruption of upper crustal reservoirs and link these processes to arc magma genesis.

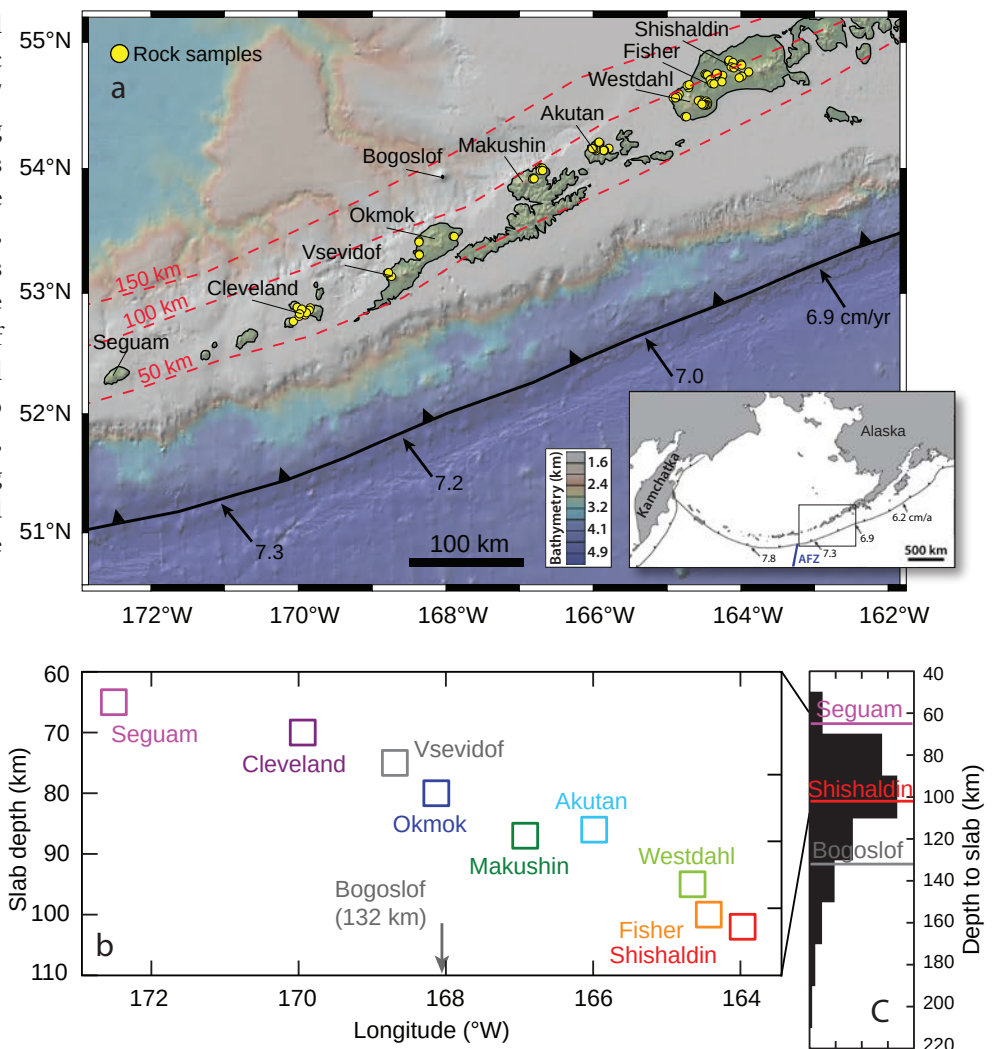


Figure 1. The central-eastern Aleutian arc. (a) Map of our field area with historically active volcanic centers labeled. Dashed lines are slab contours from Syracuse and Abers (2006). The Amlia Fracture Zone (AFZ) is shown in the inset map. (b) Results of our new slab depth analyses for volcanoes studied here (colored symbols) and other volcanic centers (gray symbols). (c) Histogram of slab depths beneath arc frontal arc volcanoes worldwide from Syracuse and Abers (2006).



Figure 2. Photo of the 2016 fieldwork group on the *Maritime Maid*.

This work bridges the gap between the origin of volatile-bearing magmas and crustal magmatic processes, two big picture problems normally approached separately. We have gone to the central-eastern Aleutian arc to address these problems, capitalizing on the GeoPRISMS platform for Alaskan research and working in close collaboration with the Alaska Volcano Observatory and Deep Carbon Observatory. Our project combines melt-inclusion analysis, diffusion chronometry, gas geochemistry, and earthquake location and source-mechanism analysis to address several key questions:

1. How do magmas transit the crust prior to eruption?
2. Where do magmas stall and why?
3. How do subduction parameters influence primary magma compositions?

Slab depth may be an important subduction parameter controlling magmatic processes. Variation in slab depth below frontal arc volcanoes worldwide (60 km to more than 150 km; Syracuse and Abers, 2006) leads to profound variations in the sub-arc thermal structure of the slab and mantle wedge, controlling H_2O flux from the slab and melt production. For example, increased slab depth leads to progressive slab H_2O loss (van Keken et al., 2011) and hotter fluids that transport more silicate (Hermann et al., 2006), if melt transport is predominantly vertical. Thus, slab depth likely modulates the composition of arc magmas, which in turn may control their path through the crust. An ideal location to isolate the role of slab depth in arc magmatism is the central-eastern Aleutians (Seguam to Shishaldin, 172.5-164 °W; Fig. 1). Our new work shows that slab depth varies from a near global minimum of ~65 km (Seguam) to a more typical value of ~100 km (Shishaldin), consistent with earlier work (Syracuse and

Abers, 2006). Other subduction parameters (e.g., slab age, velocity) do not vary significantly (<10%). Magmas in this corridor have long been known to exhibit a wide range of chemical composition, seismicity, and eruptive behavior (Larsen, 2016). How much of this variability might originate in the slab?

While the Aleutians provide an ideal laboratory for the study of tectonic and magmatic processes, a dearth of relevant rock samples and seismic data exist due to the remote locations. This motivated our field campaigns in the summers of 2015 and 2016.

Our objectives were fourfold:

- Deploy twelve broadband seismometers in the vicinity of Cleveland volcano for one year,
- Collect tephra along the entire corridor,
- Measure volcanic gas emissions,
- Avoid the bears.

Cleveland is a focal point for our work because it is both highly active and highly understudied. Our work was facilitated by the R/V *Maritime Maid*, which moved us between islands and provided logistical support, and a helicopter from *Maritime Helicopter*, which carried us to our field sites (Fig. 2). Despite challenging weather and field conditions, our fieldwork was an enormous success. We retrieved over 170 rock samples, six lake cores, gas data from the actively degassing volcanoes, and a year of seismic data that spanned multiple eruptive episodes at Cleveland volcano.

We have taken a top-down approach to our research, first focusing on how magmas transit the crust in the months, days, and hours before volcanic eruption.

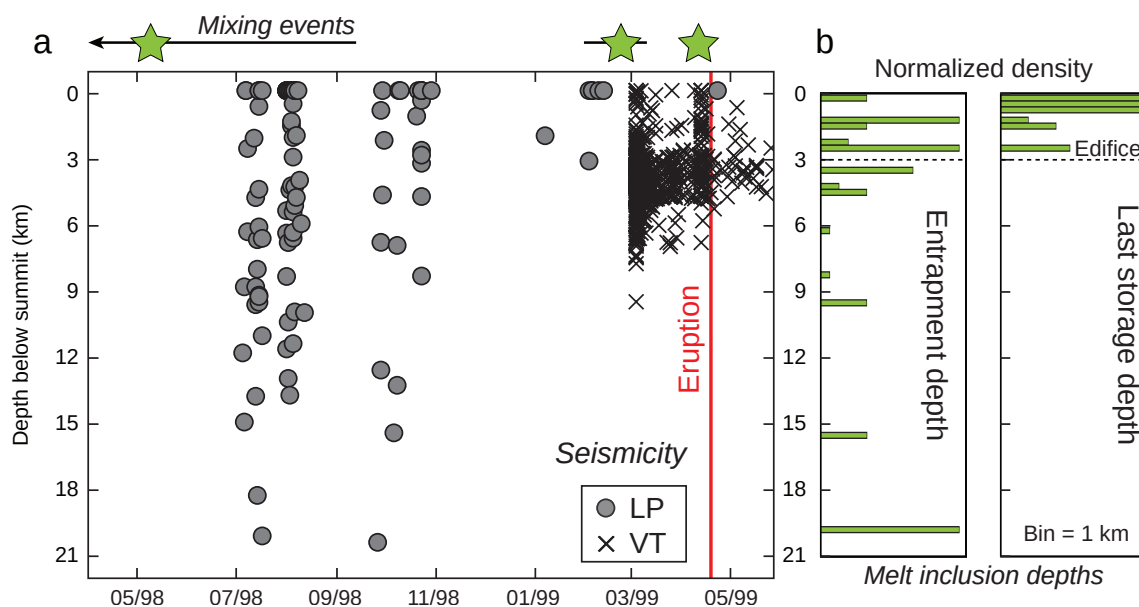


Figure 3. Run-up to the 1999 eruption of Shishaldin volcano, simplified after Rasmussen et al. (2018c). (a) The timing of mixing events inferred from crystal clocks (green stars) coincides with long-period (LP) and volcano-tectonic (VT) seismicity leading up to the eruption. (b) Depths determined from melt inclusions indicating that magmas coalesced at <3 km depth (in the edifice).

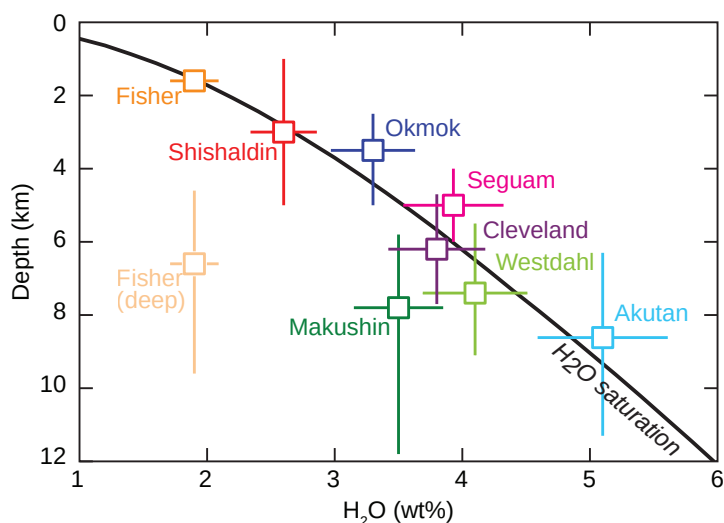
We conducted a focused study of the 1999 eruption of Shishaldin volcano (Rasmussen et al., 2018c), which is compelling for multiple reasons. This sub-Plinian eruption had an unusually long phase of seismic activity preceding the eruption, and, despite the 43 million m³ of tephra ejected, InSAR data recorded no discernable eruption-related deformation. We established a close temporal link between increased seismicity, stress field changes inferred from shear-wave splitting analysis, and magma mixing recorded by crystal clocks, confirming that precursory seismicity tracked the priming of the magmatic system for eruption by delivery of new magma (Fig. 3). Our study was the first to connect timescale information recorded in chemical zonation patterns in crystals with depth information recorded in melt inclusions, which we used along with geophysical data to interrogate a previously enigmatic magmatic plumbing system. We found that a shallow magmatic system located largely within the edifice (<3 km below the summit) persists between eruptions. Prior to the 1999 eruption, the shallow magmatic system was recharged with deep (>20 km) magma. InSAR observations at Shishaldin are insensitive to deformation emanating from the shallow and deep parts of the system, in part explaining the lack of an observed deformation signal. These results improve our understanding of eruption triggers and magmatic plumbing systems. But this work raises the question, is the magmatic system at Shishaldin unusually shallow?

Broadening our scope, we evaluated magma storage depths throughout our corridor (Rasmussen et al., 2018b). Geophysical constraints indicate these depths vary significantly (~2-8 km below the edifice; Fig. 4). The cause of such variability is poorly understood. Some have argued for the importance of intrinsic (e.g., buoyancy, viscosity) controls (Annen et al., 2006), while others have emphasized the importance of extrinsic (e.g., crustal structure) controls (Chaussard and Amelung, 2014). We investigated the influence of magmatic water content, a key intrinsic variable, on magma storage depth. Water is thought to be important because decompression-induced degassing during magma ascent results in an increase in melt viscosity and magma crystallinity, both promoting stalling. We estimated magmatic water content by measuring large suites of melt inclusions and taking

the maximum observed water contents, which minimizes the influence of diffusive leakage of water. Water contents are variable (~2-5 wt.%) and correlate positively with geophysically determined magma storage depths, falling along the water-saturation curve (Fig. 4). The maximum water contents of melt inclusions often correlate with non-volatile trace elements, indicating diffusive leakage is not a major factor. Thus, our data support a model in which intrinsically drier magmas (like those that feed Shishaldin) degas and crystallize shallower than wet magmas, resulting in shallower storage prior to eruption. So, what controls primary water content?

Now in the final leg of our pursuit to understand the slab-volcano connection, we are focusing on the extent to which slab depth relates to the composition of arc magmas (Rasmussen et al., 2018a). We have collected major, trace, and volatile element data in melt inclusions and bulk rock samples from the eight target volcanic centers in our corridor (Fig. 1). These data exhibit systematic trends with slab depth (Fig. 5).

Figure 4. Relationship between the maximum water content of melt inclusions and geophysically determined magma storage depths, which are referenced to the volcano summits (Rasmussen et al., 2018b).



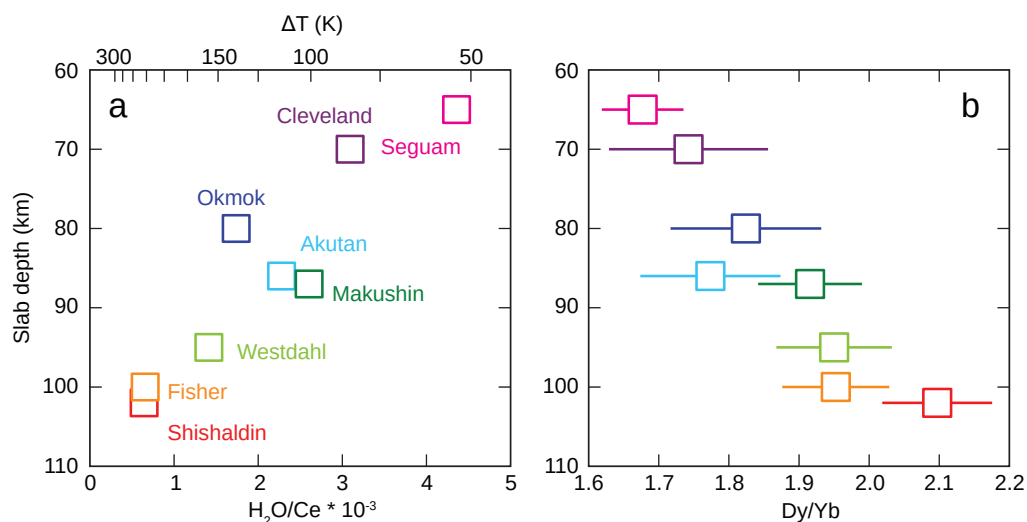


Figure 5. Variation in volatile and trace element compositions of magmas with slab depth (Rasmussen et al., 2018a). (a) H_2O/Ce and H_2O/K_2O (agrees with H_2O/Ce , but not shown) are proxies for slab surface temperature. Temperature relative to the wet sediment solidus (ΔT) is calculated using the thermometer of Plank et al. (2009). (b) Increased Dy/Yb may indicate an increased role of garnet.

For example, Shishaldin has the greatest slab depth, and its magmas have the lowest H_2O/Ce and highest Dy/Yb. This relationship holds overall, where H_2O/Ce (1000-4500) and H_2O/K_2O (2-9), both proxies for slab surface temperature (Plank et al., 2009), negatively correlate with slab depth. This implies slab temperatures are just above the H_2O -saturated sediment solidus at 65 km depth and $\sim 250^\circ C$ above the solidus at 100 km depth. Greater temperatures of the slab would predict melting deeper into the slab, which might explain the observed increase in Dy/Yb with slab depth. Interestingly, the volcanoes are generally larger and closer together where the slab depth is greater, possibly suggesting melt flux is greater in these locations. These results indicate that slab depth has a strong influence on the generation of arc magmas. Armed with this understanding, our final efforts on this

project will focus on the missing link between the mantle melting process that is driven by slab inputs and the water contents of magmas that control magmatic plumbing systems.

Our work is a prime example of the strength of the GeoPRISMS Program in facilitating multi-disciplinary research to understand dynamic processes occurring at plate boundaries. Additionally, this work has been propelled forward by close partnerships with the Deep Carbon Observatory and Alaskan Volcano Observatory, which has led to several new active collaborations. Finally, our work has benefited from additional funding provided by the Don Richter Memorial Scholarship awarded by the Alaska Geological Society and the Jack Kleinman Grant for Volcano Research awarded by the Community Foundation for Southwest Washington and USGS. ■

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GeoPRISMS Postdoctoral Scholarship
Proposal Target Date: August 16, 2019
For details, visit the GeoPRISMS website:

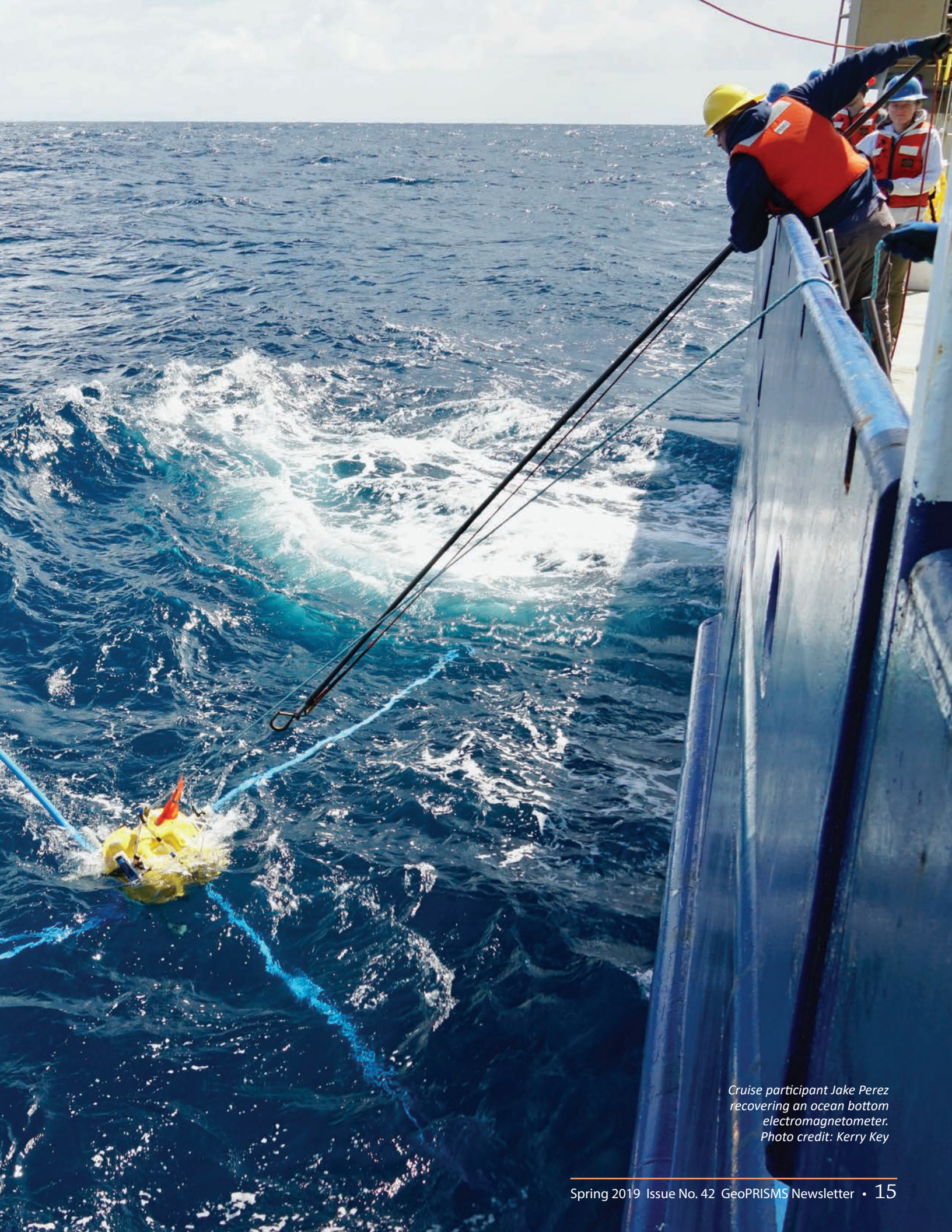
<http://geoprisms.org/education/geoprisms-postdoctoral-fellowship/>

HT-RESIST Hikurangi Trench Regional Electromagnetic Survey to Image the Subduction Thrust

Christine Chesley with Samer Naif and Kerry Key
LDEO, Columbia University

Because New Zealand's north island lies at the juncture between the converging Pacific and Indo-Australian plates, it is not surprising that the area experiences earthquakes. A unique feature of the Hikurangi margin, the name of New Zealand's subduction zone, is that its earthquake slip behavior varies from north to south along strike. The northern Hikurangi margin is characterized by shallow slow slip events (SSEs) and weak seismic coupling while the southern margin exhibits deeper SSEs and stronger coupling. The host of other properties that change along this subduction zone have motivated the question, "What controls the along-strike variation in megathrust behavior at the Hikurangi margin?"

One key element of this question lies in quantifying the porosity and fluid budget along the margin. Marine electromagnetic (EM) methods are well-suited for imaging fluids and fluid pathways within the lithosphere. Of course, a major caveat to any geophysical survey of convergent margins is the challenge of collecting good data on the seafloor beneath a deep ocean. So that is what we set out to do on 16 December 2018.



*Cruise participant Jake Perez
recovering an ocean bottom
electromagnetometer.
Photo credit: Kerry Key*

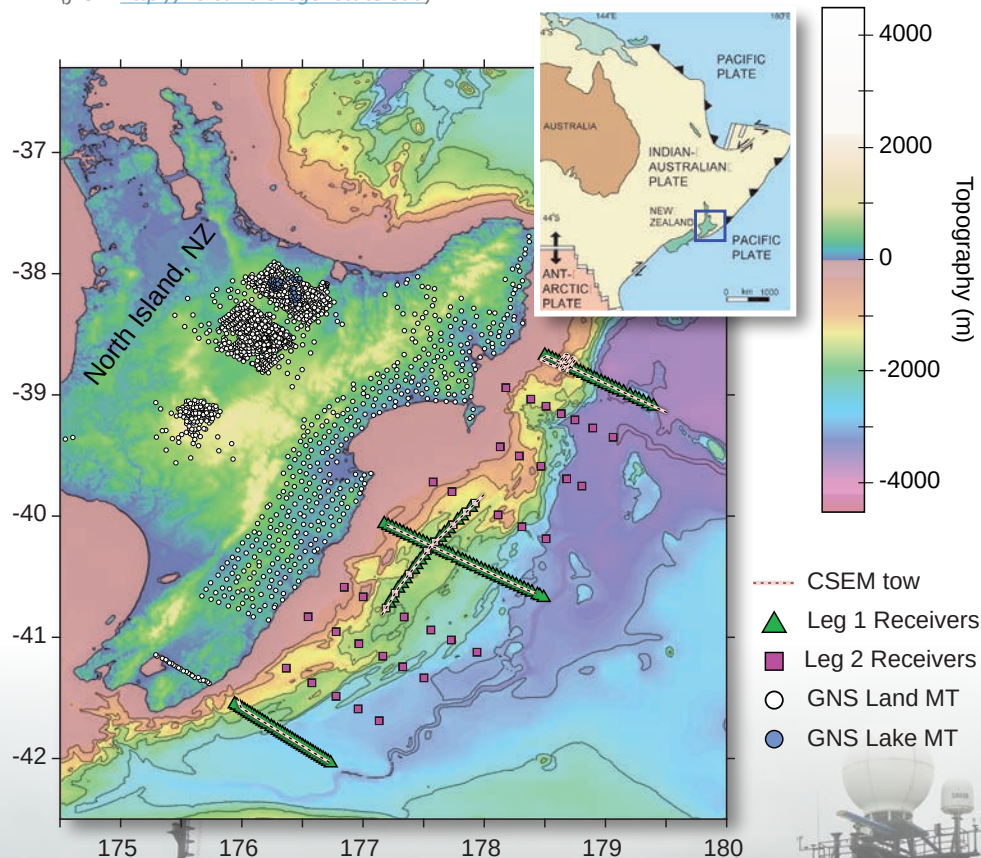
“We know about earthquakes here in Wellington,” asserted a waiter at the Thistle Inn. After a satisfying meal, my colleague and I were giving an abridged rundown of our cruise objectives to this excited employee. It was a day or so before we would leave for a month-long voyage to deploy ocean bottom electromagnetometers (OBEMs) for controlled-source electromagnetic (CSEM) and magnetotelluric (MT) imaging of the seafloor off New Zealand’s north island. Curious about our business in New Zealand, our waiter warned us that talking about earthquakes was making people anxious in his country. Somehow, it was refreshing to find a non-geophysicist who thought our work was important. But it also impressed upon me the urgency to make this cruise a success.

The cruise itself was divided into two legs, both of which were carried out on the *R/V Roger Revelle*. The first and longer of the two legs involved the collection of the four lines of CSEM data shown in Figure 1, in addition to the deployment of 42 OBEMs for collection of passive MT data.

I had never been to sea for more than a few hours - as a geophysics PhD student, I would spend most of my days in front of a computer rather than performing manual labor. I am pretty accustomed to having stable ground beneath my feet and a bed that doesn’t rock at night.

Everything about the experience was new for me.

Figure 1. Survey map showing location of leg 1 OBEM deployments (green triangles), leg 2 OBEM deployments (magenta squares), CSEM tows (peach lines), and GNS land receivers (white and blue circles). Inset shows regional tectonics (from <http://volcano.oregonstate.edu>).



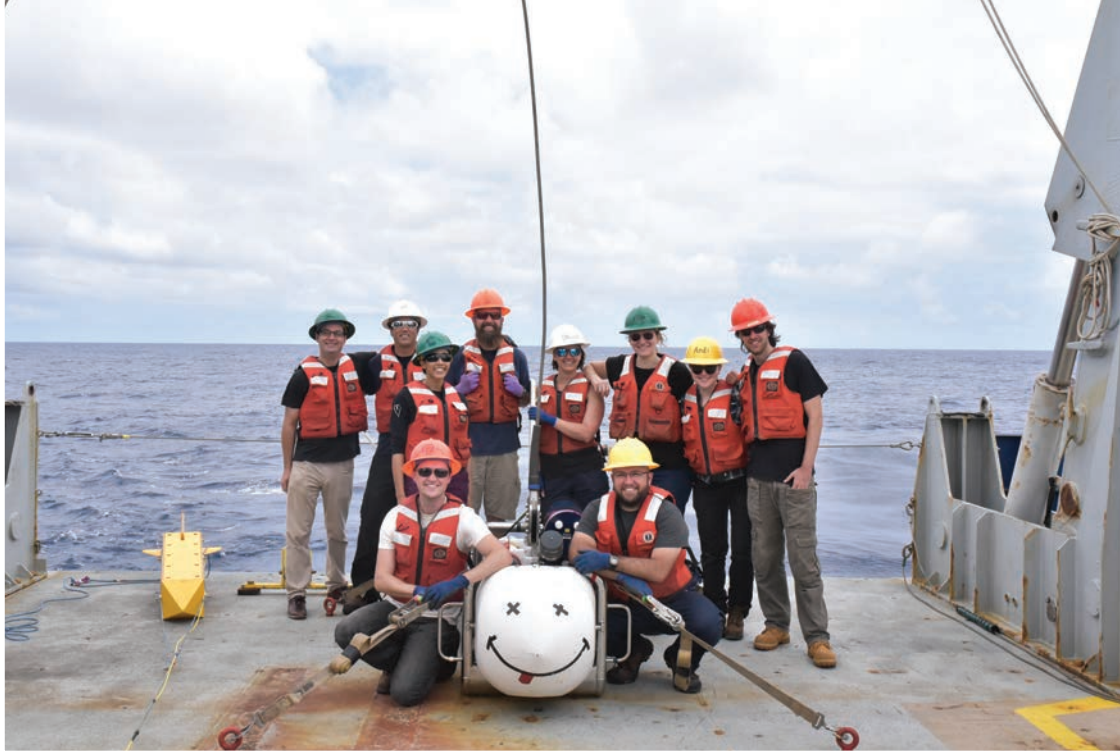
“It was very educating and fun to work with instruments other than the ones I am used to from my institute. I also took home some ideas for organizing science on research vessels, which might benefit my work group.”

- Gesa Franz

Right page: The Scripps Undersea Electromagnetic Source Instrument (SUESI) with leg 1 participants. Back left to right: Chief Scientist Samer Naif, Eric Attias, Christine Chesley, Chris Armerding, Dallas Sherman, Gesa Franz, Andi Adams, and Bar Oryan. Front kneeling left to right: Daniel Blatter and Jake Perez. Photo credit: Samer Naif

Left: *R/V Roger Revelle*. Photo credit: Kerry Key





Before the cruise, I had only ever read about how our marine EM group collects data. Getting a firsthand look at the process has given me a tremendous amount of respect for how much effort goes into data collection, especially when things don't go according to plan.

During the first leg of the cruise, the science crew consisted of eight researchers - five PhD students, two postdocs, and our Principal Investigator, Samer Naif, who led this cruise for the first time as Chief Scientist. The crew also included two Scripps EM Lab technicians and two Research Technicians to operate the cranes and supervise our actions on deck, making sure we were following safety protocols. Each twelve-hour shift counted six extremely hardworking individuals. Steady seas and mild to warm weather persisted for the majority of the first cruise, helping us ease into our sea legs and avoid seasickness.

Though we faced noteworthy obstacles in securing each line of CSEM data, the first line has given every one of us an answer to that age old interview question on describing a challenge we overcame. We began by deploying 38 of the Scripps OBEMs in just 24 hours, a nontrivial task as only five members of our entire team had ever assembled these receivers before the cruise. Receivers are the heart and soul of any data collection survey, and the Scripps OBEMs are broadband systems that continuously measure the horizontal components of natural and induced electromagnetic field energy. Such energy propagates through the Earth's lithosphere in a manner that should depend on its electrical conductivity, which in turn depend in part on variations in fluid content. Proper assembly of the receivers is the first step to ensuring quality data recovery. I appreciated the inexhaustible patience shown by our Scripps EM Lab technicians, Jake Perez and Chris Armerding. From explaining to re-explaining how to use a torque wrench, test the acoustics on our receivers, properly affix electrodes, or attach a concrete block to the base of the receiver, Jake and Chris transformed our group of

mostly inexperienced grad students into capable field workers. They showed us the multifaceted usefulness of 3M Scotch 35 electrical tape and cable ties that held electrodes, copper, or wires in place and always seemed to find a home in the pockets of my work pants.

Still jet-lagged and adjusting to twelve hours of manual labor per day, the first line of deployments was the most taxing. Nevertheless, the successful deployment of the receivers provided some reprieve as the next step was to tow our active source instrument, SUESI, the Scripps Undersea Electromagnetic Source Instrument. SUESI's sharklike body tows behind it both long (~300 m) and short (~10 m) antennas terminated by thirty meter copper electrodes. By attaching SUESI to the ship's winch using a standard oceanographic 0.680" coaxial deep-tow cable, we can send an alternating electric current from the ship to SUESI. SUESI then rectifies the signal and converts it from high voltage to a high current rectangular waveform that gets injected into the seawater across the copper electrodes. Thus, SUESI's antennas behave as an EM dipole whose energy propagation can be used to probe the shallow lithosphere. As we started deploying SUESI, Poseidon decided it was time to pay for the nice weather and brisk pace we had enjoyed until then. After the arduous process of assembling, deploying, and lowering SUESI into the depths of the ocean, one of her copper antennas partially snapped. We had to haul SUESI back on board, repair the antenna, and deploy her down into the ocean again, a process that took several hours of deckwork. Hopefully, that was enough excitement to last the entire month. But no. The next day brought with it an inexplicable malfunction that led to yet another retrieval of SUESI. Perhaps she did not like the west Pacific water all that much. Thankfully, our Chief Scientist Samer Naif and lab techs Jake and Chris had planned for the unexpected and brought SUESI's sister along, as a spare. We had better luck with the second SUESI and ended up relying on her for the remainder of the cruise.

Upon recovering SUESI at the end of the tow, it was time to retrieve the OBEMs to use them for the second line. Even with a heavy concrete block to carry the receivers to the seafloor (Fig. 1), ocean currents can move the OBEMs laterally away from the drop site during their descent through the water column. Once on the seafloor, it is necessary to know the exact location of the OBEM to accurately model the CSEM data. This is achieved by measuring the time it takes for an acoustic pulse sent from the ship to be repeated by the OBEM receiver. Similar to a game of “Marco Polo,” the ship sends and receives these acoustic signals at multiple locations until we have enough information to deduce where the receiver resides. We then send a specially coded acoustic signal to release the OBEM from its concrete block. Once the receiver floats to the surface, the team must act quickly to fish it out of the water. For me, retrieving the surfaced OBEMs was the most nerve wracking part of the process. What if we didn’t throw the grappling hook far enough? What if we couldn’t hook the receiver to the crane? What if the GPS buoy malfunctioned and the receiver couldn’t be located? Despite these worries, we managed to recover every single OBEM that we deployed for CSEM data, not only for the first line but for each of the next three as well - a total of 128 stations.

And what beautiful data we retrieved.

Between steak nights and fish tacos, rom coms and Coen Brothers movies, podcasts on olive oil and speculations about giant squids breaking our instruments, we collected three more lines of CSEM data following a similar routine of deploy-tow-recover. We learned to tie bowlines, clove hitches, and square knots. We watched sunrises, sunsets, witnessed dolphins playing with the bow and participated in safety drills of varying theatrics. And when all was said and done, we would manage to gather 20% more CSEM data than initially planned.

With the CSEM portion of the cruise over, we deployed all 42 OBEMs for the passive source MT portion of the project. Though broadband OBEMs can simultaneously collect CSEM and MT data, we left the receivers on the seafloor for about one month to collect higher quality, long-period MT data. This allows us to look deeper into the Earth to learn about the lithosphere-asthenosphere system.

The second leg of the cruise in February 2019 involved recovering the OBEMs from the MT deployment phase. This leg included thirteen participants, five of whom were based in New Zealand. Though I did not participate in the second cruise, I was thrilled to hear that all 42 receivers were recovered despite the gnarly weather the team encountered. Taken together with the first cruise, it means a perfect recovery rate for all 170 deployments.

Combined data with the land MT sites collected by GNS Science, New Zealand, this is the largest amphibious EM dataset to date. I am thrilled to be working on this tremendous amount of data for the remainder of my PhD and excited to find what secrets they will unlock about the nature of the Hikurangi margin. ■

Rough seas during the second leg of the cruise, make for some epic nail biting recoveries but also spectacular scenery.
Photo credit: Kerry Key





Even when the waves were high and we could surf in a chair inside the *Roger Revelle* it was an amazing personal and scientific experience. In my particular case, as a person used to coding and doing mathematics, to do 'real' science was very inspiring.

- Julen Alvarez-Aramberri

Doing fieldwork at sea gave me a whole new sense of what it means to do science, to be a scientist. It is so much more than analyzing or modeling data on a computer in the mundane safety of an office. We were out on deck in 40 knot winds and six meter seas. Science tests your body and your resolve, not just your mind. Just being on a research vessel dedicated solely to advancing our understanding of our amazing planet was inspiring. And then, of course, there were the sunrises, the stars, and the dolphins.

-Daniel Blatter

Report on the 2019 GeoPRISMS Synthesis and Integration Theoretical and Experimental Institute

ORGANIZING COMMITTEE

LEAD CONVENERS: Harm Van Avendonk (University of Texas, Austin) & Katherine A. Kelley (University of Rhode Island)

CO-CONVENERS: Josef Dufek (University of Oregon), Rob Harris (Oregon State University), Ikuko Wada (University of Minnesota), Jessica Warren (University of Delaware), Phil Skemer (Washington University), Kyle Straub (Tulane University), Demian Saffer (The Pennsylvania State University; ex officio)

EARLY CAREER SYMPOSIUM CONVENERS: Taryn Lopez (University of Alaska) & Eric Mittelstaedt (University of Idaho)

The GeoPRISMS Synthesis & Integration Theoretical and Experimental Institute (TEI) was held at the Menger Hotel in San Antonio, TX from Feb 26-Mar 1, 2019, fittingly the same site as the MARGINS Successor Planning Workshop that initially defined the scope of the GeoPRISMS program in 2010. Objectives of the meeting included summarizing progress on GeoPRISMS science over the past decade, defining the future efforts needed to integrate and synthesize the multi-disciplinary outcomes of the program, and positioning the community for an engaging and sustainable future beyond the end of GeoPRISMS.

To achieve these goals, we assembled a diverse team of conveners, speakers, and group leaders, and developed an agenda that focused on science themes common to both the Rift Initiation and Evolution (RIE) and Subduction Cycles and Deformation (SCD) Initiatives of the GeoPRISMS program. The meeting attracted 170 participants, seventy of whom were students and post-docs. More than a hundred participants brought posters for presentation in the evenings or during coffee breaks during daytime sessions.

The meeting structure aimed to bring the RIE and SCD communities together through a series of paired keynote talks under unifying themes of Deformation at all Timescales, Mass Fluxes, and Geohazards. Early-career participants engaged in a half-day pre-TEI symposium, and led breakout discussions and reporting to the main group during the TEI. Together, this mix infused the meeting with both legacy and fresh perspectives on how far our science has come and where our community should go in the future. Short talks on allied science programs, data legacy, education and outreach, and models/programs for future community engagement set the stage for discussions of GeoPRISMS synthesis and consideration of ways our community could move forward.



64 students, post-docs, and pre-tenured faculty attended the Early Career Symposium organized the day before the TEI. Photos Credit: Eric Mittelstaedt

Science overview

EARLY CAREER SYMPOSIUM

A half-day Early Career Symposium (ECS) served as a lead-up to the TEI. This event provided opportunities for early-career TEI participants to participate in networking and to offer advance exposure to TEI themes and questions in order to promote and enhance participation in group discussions during the main TEI. The ECS attracted 64 early-career participants ranging from undergraduates to pre-tenured faculty, spanning a range of expertise including rock mechanics, geodynamic modeling, seismology, geochemistry, structural geology, geodesy, and magnetotellurics. The symposium included a series of talks and group breakout sessions. A multi-disciplinary team of three to four ECS participants assembled each talk through pre-meeting interactions. Following each talk, the participants split into pre-assigned discussion groups to ensure representation from all three TEI themes, and were tasked with addressing two questions: 1) what are the remaining or emerging science questions related to this TEI theme, and 2) what infrastructure, data and/or synthesis do we need to address the core questions? Within each group, first participants paired up to discuss the question, then each pair would join another pair for discussion among four participants, then eight participants, and finally the entire group. During each discussion interval the pair or group selected the most important question or synthesis goal. This style of breakout group provided opportunity for all voices to contribute to discussions and to help narrow the range of questions/objectives discussed to a manageable number. In the end, each breakout group identified four primary or key points that address the above questions and then reported these responses to the group. The responses were synthesized by the ECS organizers and presented to the larger TEI participant group.

MAIN MEETING

Day 1 | The TEI launched with two summary talks by Donna Shillington and Sarah Penniston-Dorland, summarizing the diverse array and current status of studies funded by GeoPRISMS in the RIE and SCD Initiatives, respectively. These overviews incorporated outcomes of the two previous initiative-specific TEI workshops that took place in recent years. Eric Mittelstaedt and Taryn Lopez summarized the outcomes of the ECS to set the stage for further TEI discussions. Short talks from allied science organizations also helped to frame ideas for community engagement beyond GeoPRISMS. Ben Phillips (NASA Earth Science) gave an overview of the Earth-focused programs at NASA with particular emphasis on remote sensing capabilities and how these dovetail with GeoPRISMS science themes. Joan Gomberg and Nathan Miller (USGS) addressed natural collaborations with the GeoPRISMS community with regard to natural hazard assessment and mitigation. Sue De Bari updated the group on the connections between IODP and GeoPRISMS science under the current IODP science plan, and also opportunities to influence future IODP science priorities as they develop a science plan for post-2023. Suzanne Carbotte (IEDA) also spoke about the resources available for GeoPRISMS-related data preservation and access through the IEDA Data Repository.

The central structure of the workshop drew upon paired keynote talks that addressed themes common to both the RIE and SCD initiatives. Under the theme of *Deformation at all Time Scales*, keynote speakers Jolante van Wijk (RIE) and Mark Reagan (SCD) addressed the role of structural inheritance in plate tectonic events, and Cindy Ebinger (RIE) and Jeff Freymuller (SCD) spoke on topics relating to reconciling strain budgets at different time scales. Following these talks, four separate breakout groups, led mostly by early-career participants, discussed shortcomings of current data sets and Earth models, goals of a GeoPRISMS synthesis, and setting the stage for future community-driven science.

Day 2 | The second day of the TEI began with summaries of the discussions from breakout sessions from the previous day, given by early-career participants in each session. Under the TEI theme *Mass Fluxes*, keynote talks from Tobias Fischer (RIE) and Terry Plank (SCD) addressed major findings and new directions of research in fluid and volatile fluxes at plate boundaries and Donna Shillington (RIE) and Jim Gill (SCD) spoke about the evolution of crustal composition at rifting and subducting plate boundaries. Overview talks from PIs and coordinators of three NSF-funded Research Coordination Networks (RCN) offered perspectives on focused efforts to develop new connections within the community and move GeoPRISMS-aligned science forward. Harold Tobin updated the participants on the status of the SZ4D RCN, which strives to develop a new decadal program supporting subduction zone science. Gabriel Lotto spoke about the Modelling Collaboratory for Subduction Zone Science RCN, which aims to build a multi-scale, multi-physics numerical modeling community. Tobias Fischer informed the group about the Community Network for Volcanic Eruption Response (CONVERSE).

170 participants from the RIE and SCD communities attended the TEI to summarize ten years of GeoPRISMS multi-disciplinary science and discuss future efforts needed for synthesis and legacy. Photos credit: Anaïs Ferot



An afternoon breakout session asked groups to identify topics or themes for a future synthesis workshop, and to articulate a clear rationale for why the community needs a focused effort to synthesize the topic, including the role of GeoPRISMS data sets. Groups further discussed other activities, beyond workshops, that would help to accomplish GeoPRISMS synthesis or enhance interpretations of existing data, and specifically addressed the key aspects of the GeoPRISMS program that would be essential to preserve beyond the end of the program. Early-career participants presented the outcomes of these discussions to the main group, and from these emerged a set of key science topics that further informed the final discussions of the TEI on Day 3.



In the late afternoon, a final science session of keynote talks addressed topics under the theme *The Stability of Margins and Geohazards*. Doug Edmonds (RIE) and Juli Morgan (SCD) addressed feedbacks between tectonics, surficial processes, sediment transport and deposition, and Brandon Dugan (RIE) and Sue Bilek (SCD) presented overview talks on geohazards from the perspectives of landslides and great earthquakes.

Day 3 | The final day of the TEI opened with a breakout session focused on the suite of science topics that emerged from the previous sessions. Participants were asked to self-organize under one of the topics on the list, and to choose an early-career participant in the group to be their leader, with the goal of producing one slide that illustrates a way to motivate synthesis of the chosen topic. Later in the morning, these leaders presented the outcomes of their breakout topic discussion to all the TEI participants.

The late morning session provided opportunities for discussion of MARGINS and GeoPRISMS data legacies. A panel discussion led by Juli Morgan, Sarah Penniston-Dorland, Jeff Marshall, and Bob Stern provided insight into the Education & Outreach efforts accomplished under MARGINS, as well as informative overviews of E&O efforts underway through GeoPRISMS.

Following breakout session reports, the full group discussed the potential of workshops, or a coordinated series of related workshops, to help achieve GeoPRISMS science synthesis, in addition to other strategies that could further the community's desire to remain cohesive and inclusive, accomplish cutting-edge science, and broadcast our collective achievements as broadly as possible.

Group picture in front of the Alamo, San Antonio, TX.

Thank you to all participants for making the 2019 Synthesis & Integration TEI such a success!



Integration of GeoPRISMS science results from various disciplines

Discussion related to the integration of GeoPRISMS science results was lively and enthusiastic. Overall the value of integrative projects was emphasized. Discussion centered around two main topics, the process of integrating results, and outcomes. Most discussion focused on the need for workshops. Rationale for both geographically focused and topically focused workshops were recognized. There was acknowledgment that GeoPRISMS has collected an impressive combination of data sets at each Primary Site and that one good way to integrate and synthesize these results, thereby capitalizing on the focus site approach, would be through site specific workshops. Key goals of these workshops could be to present preliminary results by addressing what data we have, what we have learned, and what data gaps remain. These workshops would also provide opportunities for scientists working at the same focus sites to connect across different experiments and learn from other perspectives. Because funding for each focus site was phased, the focus site workshops might be similarly phased. A nested approach was also suggested with each focus site having their own workshop and then a combined workshop for SCD and RIE focus sites.

Some common themes that emerged from discussions of topical workshops included the water and carbon cycle in the solid Earth, fluid transport and volatiles, interpretation of seismic attributes, deformation at plate boundaries, the impact of structural inheritance on tectonics, and rock physics. Important themes for each of these topical discussions would be strategies for spatial and temporal integration. Topical workshops have the potential of integrating a lot of knowledge across a range of disciplines.

Discussion of outcomes focused on educational material at all levels, K to graduate school. At the K-12 level, publically available websites and other educational materials synthesizing results are recognized as a need. At higher educational levels discussions about the relative advantages and pitfalls of developing textbooks versus so-called 'living' documents that are updated frequently, such as Wikipedia, were discussed. Thematic journal collections, in which papers on a topic are compiled in a single source but published promptly when they are ready, offer the advantages of a well-organized volume, but with a short lead time for publication. The merit of animations as an educational tool and the benefits of taped lectures in facilitating classroom discussions were also considered.

Participants discussed the importance of accessible and citable data and samples, crucial to future work. These data sets can be used for multiple applications and purposes. Access to processed data was also highlighted.

Steps necessary for synthesis of GeoPRISMS

Synthesis of the GeoPRISMS program requires the analysis of data, and the organization of these analyses into a framework of internally-consistent interpretations. This type of synthesis is beyond the scope of any PI or even a small group of PIs. Indeed, the breadth of disciplines involved in GeoPRISMS research necessitates a careful, inclusive, and iterative approach. In addition, the staged funding approach for the five primary sites has helped the community organize field projects, but it also means that the science results in Cascadia and the Aleutians are more mature than in the EARS and New Zealand, where data acquisition is just ending. The goals of the RIE and SCD Initiatives can only be met by combining the outcomes of all these primary sites.



Poster sessions and break out groups organized throughout the meeting allowed the attendees to discuss and articulate the community needs for integration, synthesis and legacy of the GeoPRISMS program. Photos credit: Andi's Ferot.

Participants in the GeoPRISMS TEI agreed that synthesis of GeoPRISMS data will require continued investment in small conferences and workshops. These workshops may focus on topics of regional importance, for example one or more of the GeoPRISMS primary sites. Additional workshops may direct interdisciplinary focus towards key processes. The objective of these workshops would be to identify where the observations and interpretations of disparate stakeholders agree or disagree. Diagrammatically, these workshops should appear as a web, with individual participants encouraged to attend several workshops crossing disciplinary boundaries. Additional synthesis and engagement of early career scientists would be facilitated by longer format meetings, such as a CIDER-style summer program. A CIDER-style program would encourage students and postdocs to interact with faculty at all career stages to define new projects that exploit data collected during the GeoPRISMS program. Managing these conferences would require some infrastructure.

Steps necessary to keep the community engaged beyond the GeoPRISMS program

Over the course of the TEI, discussions among scientists and students showed that there is a great interest in the community to investigate geological processes at plate boundaries with an interdisciplinary approach. In the last breakout session of the TEI, participants organized in several groups to explore how focused working groups may carry on GeoPRISMS-related research, using all possible data and modeling approaches. Each of these groups produced a short overview of the science questions of interest, possible target areas for research, and a plan to organize the community.

1. Origin and evolution of plate boundaries. Which factors control the origin and evolution of plate boundaries? Research can focus on any subduction zones, transform boundaries and continental rifts.

2. Linking geophysical images to Earth's composition, state, and physical properties. Imaged seismic and electrical properties can be used by experimentalists and theoreticians to investigate state variables, such as composition, temperature, fluid phase and content, grain size, and deformation mechanisms.

3. Fluids, metamorphism, rheology, and exhumed records of plate margins. How does the rheology of the plate interface evolve through the seismogenic zone and beyond?

4. Fluid and volatile migration. What controls the pathways and mechanisms for fluid transport?

5. Feedbacks between tectonic deformation and magmatism. What is the cause and effect in interactions between lithospheric deformation and magmatic processes?

6. The pace and mechanics of magma supply. What controls the location of magma generation and flux to the surface? What observations can we use as a proxy for magma flux?

7. From slow slip to mega-earthquakes. How do we link stress state, fault strength and the mode of slip at plate boundaries? What is the role of sedimentary structures in plate coupling?

8. Coupling of geodynamics and surface processes. Geohazards on passive-aggressive margins. What feedbacks between tectonic and surface processes produce the observed sediment flux, stratigraphy, at different spatial and temporal scales?

In each of these discussions, scientists emphasized the need to maintain the connections that the GeoPRISMS office has provided for our community over the past ten years. Focused workshops will help to set new science goals and to forge collaborations between scientists and students from different disciplines. Given the complexity of the research topics, future multidisciplinary studies of Earth's plate boundaries will be essential to move the science forward.

The detailed workshop report is available on the GeoPRISMS Website at:

<http://geoprisms.org/tei-2019/>

Questions? Contact the GeoPRISMS Office at info@geoprisms.org



VOLUNTEER

GeoPRISMS Student Prize
AGU Fall Meeting



Are you willing to help us
judge student presentations
at the AGU Fall Meeting?

Contact us at
info@geoprisms.org



The GeoPRISMS Office will organize its final best student presentation award at the 2019 AGU Fall Meeting. The competition is open to all students who work on GeoPRISMS- or MARGINS-related research.

Students will compete for a best poster and a best talk award. Both awards carry a \$500 cash prize. Awardees and runners up will be featured on the website and in the Spring newsletter.

The competition is always very popular. You can help!

We hope that if you attend the AGU Fall Meeting this year that you will be able to help us evaluate the student award. We generally ask judges for their assessment of no more than three presentations.

For more information and to sign up as a judge, contact us at info@geoprisms.org

Thank you for your help with this important effort



2019 GeoPRISMS NSF Awards

All GeoPRISMS NSF Awards are available at
<http://geoprisms.org/research/list-of-awards/>

NSF Awards 1850713, 1850786, 1850634 1850683, 1850634

Collaborative Research: Constraining the thermal conditions of the subduction interface by integrating petrology and geodynamics

Besim Dragovic (dragovic@vt.edu), Sarah Penniston-Dorland (sarahpd@umd.edu), Peter van Keken (pvankeken@carnegiescience.edu), Ikuko Wada (iwada@umn.edu)

NSF Awards 1850699, 1850711

Collaborative Research: Fluid-mobile element cycling (halogens, boron, lithium) through the forearc of Costa Rica

Joost de Moor (mdemoor@unm.edu), Jaime Barnes (jdbarnes@jsg.utexas.edu)

NSF Award 1850779

GeoPRISMS Postdoctoral Scholar: Unravelling monogenetic volcanism in the Cascades Volcanic Range

Adam Kent (adam.kent@geo.oregonstate.edu)

NSF Award 1850685

GeoPRISMS Postdoctoral Scholar: Refining GPS-acoustic processing to measure Cascadia subduction

David Schmidt (dasc@uw.edu)

NSF Award 1850606

Assessing the relationship between strain localization and magmatism during rift evolution

Tyrone Rooney (rooneyt@msu.edu)

NSF Award 1850831

Elucidating the mechanics of tsunami generating earthquake rupture with long period seismology

Miaki Ishii (ishii@eps.harvard.edu)

NSF Awards 1852610, 1852680

Collaborative Research: Melange-peridotite interactions in the source of arc magmas

Véronique Le Roux (vleroux@whoi.edu), Mark Behn (mark.behn@bc.edu)

NSF Award 1848824

Rheology and microstructural evolution of serpentine

Philip Skemer (pskemer@wustl.edu)

NSF Award 1850832

Synmagmatic crustal thickening and the importance of garnet fractionation in making continental crust

Cin-Ty Lee (ctlee@rice.edu), Ming Tang

NSF Award 1849700

Mantle volatiles and attenuation in the East African Rift

Maryjo Brounce (mbrounce@ucr.edu)

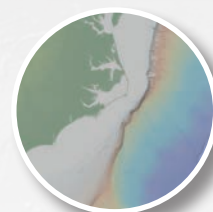


Photo by Timm Lopez

5th GeoPRISMS Photo Contest

GeoPRISMS Science through the lens of the Community

2019 AGU Fall Meeting | San Francisco, CA



Geo
PRISMS

Share with the GeoPRISMS Community what your GeoPRISMS-related research looks like, whether you are working in the field, or in the lab. Submit your photo now!

The winner's photo will be highlighted on the GeoPRISMS Website and in the GeoPRISMS Newsletter.

The GeoPRISMS Photo Contest is open to anyone whose research is related to GeoPRISMS.

For more information about the contest and guidelines, please visit the GeoPRISMS website at:

<http://geoprisms.org/geoprisms-photo-contest/>

Status Report on the GeoPRISMS Data Portal: April, 2019

Andrew Goodwillie and the IEDA Database Team

Lamont-Doherty Earth Observatory, Columbia University

The GeoPRISMS data portal (<http://www.marine-geo.org/portals/geoprisms/>) was established in 2011 to provide convenient access to data and information for each primary site as well as to other relevant data resources. Since the last newsletter report, highlighted below are recent contributions of data sets and field program information of interest to the GeoPRISMS community. Many of the data sets described are also available in GeoMapApp (<http://www.geomapapp.org/>) under the *Focus Site* and *DataLayers* menus.

East African Rift System

Grids of upper mantle isotropic seismic velocity structure beneath Africa were contributed by Erica Emry. Derived using new full-wave seismic tomography techniques on ambient noise and earthquake data the grids shed light on relationships between mantle flow, cratonic lithosphere and surface processes. The data set has been added to GeoMapApp (Fig. 1).

As part of an integrated study of tectonic and magmatic processes during the onset of rifting, also now available in the data portal is the active-source seismic shot data from the 2015 SEGMeNT survey on Lake Malawi (Fig. 2). Led by Shillington et al. the survey focused upon the northern Malawi (Nyasa) rift, a region of early-stage rifting in strong, cold lithosphere, and imaged sedimentary and crustal structure within and around the lake. The data set is available at http://www.marine-geo.org/tools/search/entry.php?id=EARS_SEGMeNT

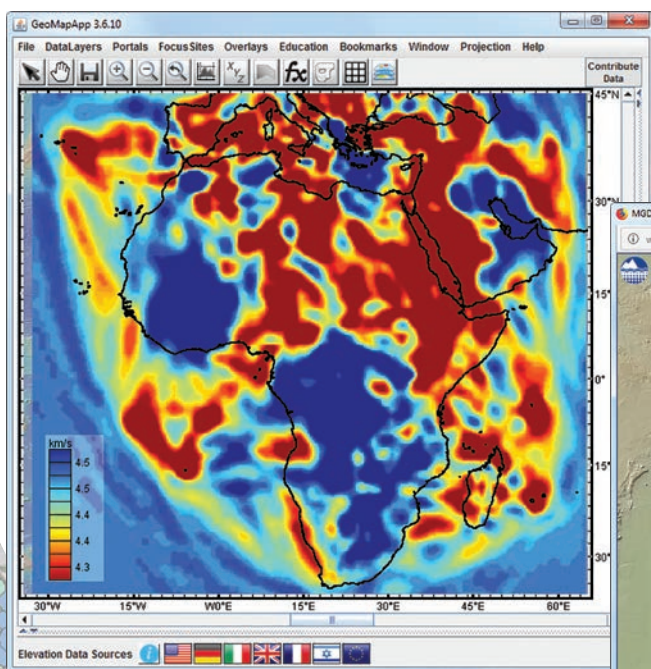


Figure 1. Shear-wave velocity structure at 123 km depth from Emry et al. (2018). This, and similar grids for depths between 105–424 km are provided in GeoMapApp. They reveal segmented, low-velocity upper mantle underlying the magmatic northern and eastern sections of the East African Rift System. Shallow parts of the southern and western sections are dominated by high-velocity upper mantle which transitions at depth to low velocities. The image is made with GeoMapApp.

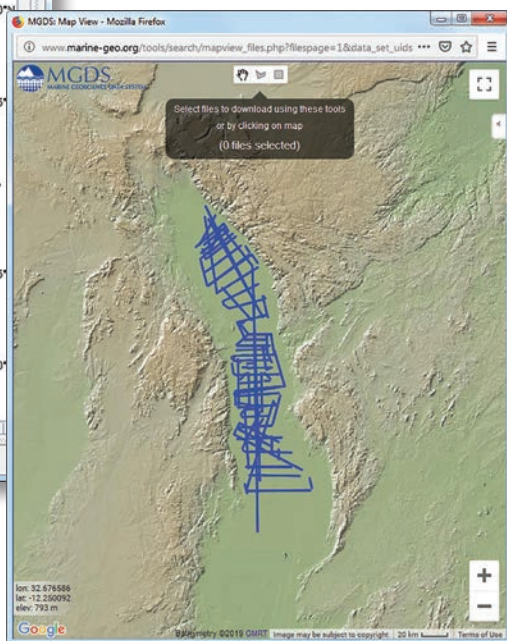


Figure 2. Map showing the active-source multi-channel seismic profile lines collected during the Shillington et al. 2015 EARS SEGMeNT survey. The background map is the Global Multi-Resolution Topography (GMRT) synthesis. Lake Malawi is the even green feature underlying the profile tracks

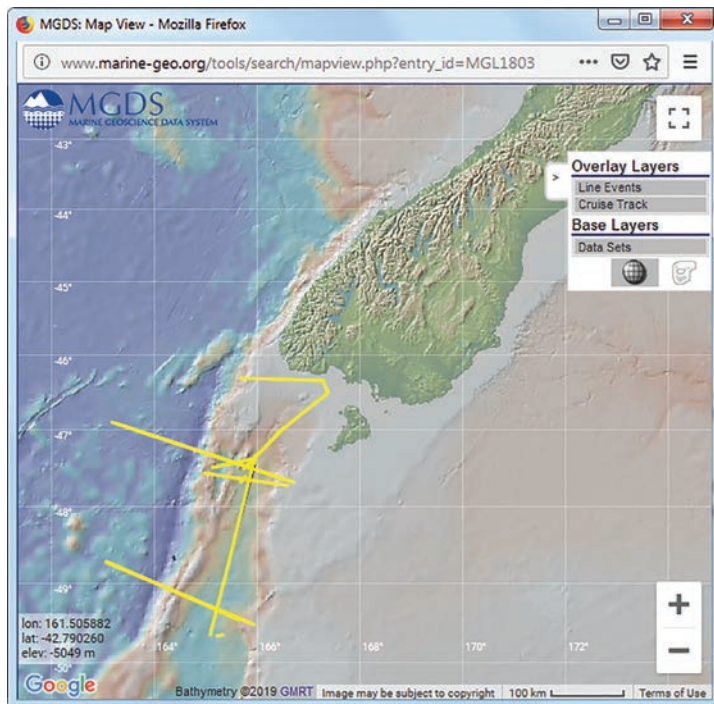
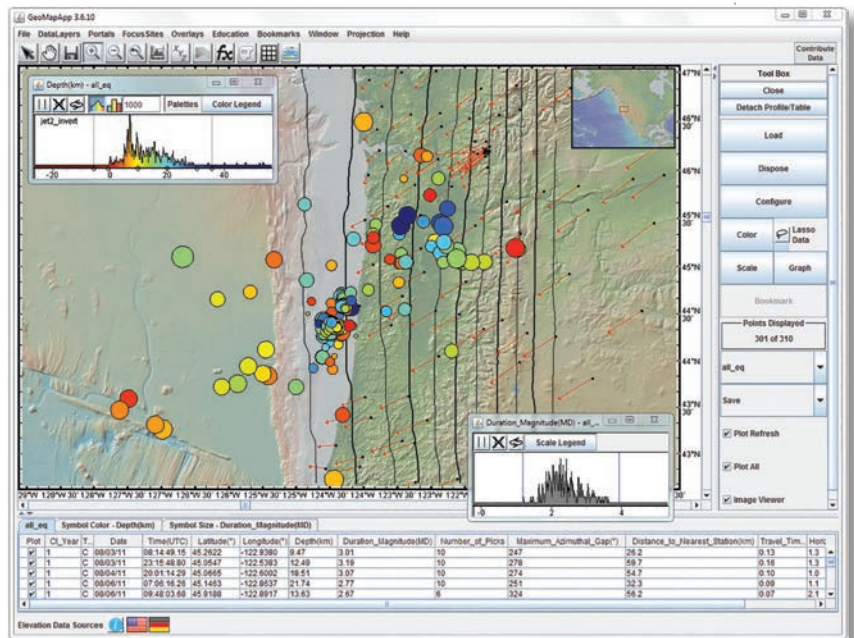
The GeoPRISMS Data Portal team is here to serve the community

Please contact us at info@marine-geo.org

Cascadia

Derived from Cascadia Initiative OBS data, Emily Morton and Sue Bilek contributed a new microseismicity catalogue of earthquakes detected and located offshore central Oregon for the period 2011-2015. The catalog (Fig. 3) was generated using a subspace detection technique and includes hypocentral locations and duration magnitudes. The data set is available at http://www.marine-geo.org/tools/search/entry.php?id=Cascadia_Morton

Figure 3. This Cascadia region image shows 10 km contours of depth to the subduction slab interface from McCrory et al. The microseismicity catalogue from Emily Morton is displayed as dots coloured on focus depth and scaled on duration magnitude. The red arrows are geodetic velocity vectors from the UNAVCO EarthScope PBO solutions in the IGS08 reference frame, with 10mm of arrow length equivalent to a velocity of 10 mm/year. The image is made with GeoMapApp. The geodetic data is available under the GeoMapApp Portals menu.



New Zealand

To better understand the forces that drive early-stage subduction, investigators Mike Gurnis, Sean Gulick, Joann Stock, Harm Van Avendonk and Rupert Sutherland conducted a 2-D active-source survey of the Puysegur segment of the Macquarie Ridge Complex (Fig. 4). The 2018 Langseth cruise, dubbed "SISIE", collected multi-channel seismic reflection data sets which may be viewed at: <http://www.marine-geo.org/tools/search/entry.php?id=MGL1803>. This Puysegur-Fiordland boundary south of New Zealand's South Island represents a type-example of incipient subduction.

Figure 4. Seismic survey lines (bright yellow) from the 2018 SISIE survey of Gurnis et al. The background elevation map is the Global Multi-Resolution Topography (GMRT) synthesis.

GeoPRISMS Data Portal Tools and Other Relevant IEDA Resources

Search For Data - (http://www.marine-geo.org/tools/new_search/index.php?funding=GeoPRISMS) The GeoPRISMS search tool provides a quick way to find GeoPRISMS data using parameters such as keyword, NSF award number, publications, and geographical extent.

Data Management Plan tool - (www.iedadata.org/compliance) Generate a data management plan for your NSF proposal. The online form can be quickly filled in, printed in PDF format, and attached to a proposal. PIs can use an old plan as a template to create a new plan. We also have developed a tool to help PIs show compliance with NSF data policies.

GeoPRISMS Bibliography - (<http://www.marine-geo.org/portals/geoprisms/references.php>) With more than 90 GeoPRISMS-funded citations, many tied to data sets, the references database can be searched by primary site, paper title, author, year, and journal. Submit your papers for inclusion in the bibliography – just the DOI is needed! http://www.marine-geo.org/portals/geoprisms/ref_submit.php

Contribute Data - (<http://www.iedadata.org/contribute>) The web submission tools support PI contributions of geophysical, geochemical, and sample data. Once registered within the IEDA systems, the data sets become available to the broader community immediately or may be placed on restricted hold. Additionally, PIs can choose to have a DOI assigned to each submitted data set, allowing it to become part of the formal, citable scientific record. ■

GeoPRISMS Steering and Oversight Committee Highlights

Spring 2019

April 29-30, 2019, NSF Headquarters, Alexandria, VA

Edited by Anaïs Férot, GeoPRISMS Science Coordinator & Demian Saffer, GeoPRISMS Chair

The annual 2019 GeoPRISMS Steering and Oversight Committee Meeting provides GSOC members and NSF the opportunity to share updates on GeoPRISMS activities, research funding and outcomes, and to address program issues and planning. This year's GSOC meeting specifically addressed plans for legacy and integration for GeoPRISMS science, and strategizing to best position the GeoPRISMS community at the end of the Program to develop new directions and identify new opportunities.

NSF and GeoPRISMS office updates

GeoPRISMS Chair Demian Saffer (Penn State) welcomed members and attendees to the meeting, which was held in the NSF Building in Alexandria, VA. Recently appointed OCE Division Director Terry Quinn welcomed and thanked the GSOC members for their service to the community. Quinn reminded GSOC that NSF, across divisions, stays strongly committed to GeoPRISMS science. GeoPRISMS is an exemplary program that spans the EAR and OCE divisions, and sets high standards for research programs in general. EAR Division Director Lina Patino added her welcome to the meeting attendees. EAR GeoPRISMS Program Director Jenn Wade then summarized the current state of NSF-GeoPRISMS, including recent awards from the FY19 solicitation (these awards are listed on the GeoPRISMS website at: <http://geoprisms.org/research/list-of-awards/>). Wade noted that the 2019 solicitation (for FY20) will be the last for the GeoPRISMS program. At the time of the GSOC meeting, the GeoPRISMS solicitation was still a work in progress, and NSF was working to incorporate the community's needs, as articulated at the San Antonio TEI, including support for focused workshops designed around synthesis, integration, and/or development of new research directions.

GeoPRISMS Science Coordinator Anaïs Férot then provided a brief overview of Office activities, including management of the website; communication with the large GeoPRISMS community; publication of the bi-annual newsletter; coordination of workshops and meetings – including the major synthesis & integration TEI and AGU events; coordination of the distinguished lectureship program (DLP); administration of a Student Prize at the AGU Fall Meeting; and hosting of apply to sail and web presence for community projects (e.g., ExTERRA; AACSE). For the TEI, the Office managed to support more participants than initially planned (~170, vs. 100 originally budgeted), including a large cohort of early career investigators. The 2018-2019 DLP marks the final tour for the program; thanks to speakers Jaime Barnes (UT Austin), Anne Bécél (LDEO), Cindy Ebinger (Tulane), and Abhijit Ghosh (UC Riverside). The impact of the DLP is high: since the beginning of the lecture series in 2010, the office has received 500 applications. Of these, 225 received a speaker. 57 speakers have toured the US. We estimate that more than 9000 people have attended a DLP lecture.

NSF funded a supplement request to extend the GeoPRISMS Office for one year to support streamlined core office activities. These activities will include Fall 2019 AGU mini-workshops, one potential GSOC meeting in 2020, work on a legacy “celebration” newsletter and website, and, in general, to continue communication and work to position the community for after the end of the Program.

Workshop, meeting, and community project reports & updates

Two GeoPRISMS mini-workshops were sponsored by GeoPRISMS at the 2018 AGU Fall Meeting. Both mini-workshops were

organized the Sunday before AGU. The reports of the mini-workshops are available on the GeoPRISMS website at: <http://geoprisms.org/meetings/mini-workshops/> and are published in this issue of the newsletter (p. 32, 34). GSOC members Mark Caddick and Luc Lavier provided brief reports on the two miniworkshops, aimed at the construction of arc crust via exhumed terranes, and at highlighting research results from recent studies at the Hikurangi subduction zone (New Zealand), respectively.

Lead conveners Katie Kelley and Harm Van Avendonk then called in remotely to the GSOC meeting to provide a report on the synthesis & integration TEI (report available from the meeting website at: <http://geoprisms.org/tei-2019/>; also published in this newsletter on p. 20). The goals of the meeting were to identify emerging directions and science questions and to engage early career scientists and students in a cross-disciplinary exchange of expertise and results. An important aspect of the meeting was to position the GeoPRISMS community for future opportunities and to define and articulate the future of the GeoPRISMS science. The final goal was to develop concrete ideas for legacy products or activities in science and Education & Outreach. Ensuing discussion among the GSOC made it clear that focused workshops are needed in the near future to synthesize ongoing work, and to facilitate discussion of new directions and opportunities in core thematic and/or geographical areas. The GSOC agreed that framing AGU mini-workshops around the key topics raised on the last day of the TEI would be an ideal way to catalyze discussion and potentially (a) proposal(s) for a coordinated suite of workshops to advance GeoPRISMS science.

Geoff Abers (Cornell), co-PI of the Alaska Amphibious Community Seismic

GeoPRISMS Program Solicitation NSF 19-581

The program has delineated three types of activities, which may be submitted individually, or combined as part of one multi-faceted project. The types are:

1. INTEGRATIVE RESEARCH PROJECTS
2. CONFERENCES AND SHORT COURSES
3. LEGACY PRODUCTS

Postdoctoral Scholar proposals are still welcome and no longer require two letters of reference.

Proposal Target dates: August 16, 2019 (Type 1 & Postdoc) | March 02, 2020 (Type 2 & Type 3)

Questions should be directed to Program directors Jennifer Wade in EAR (jwade@nsf.gov; (703) 292-4739) or Debbie Smith in OCE (dksmith@nsf.gov; (703) 292-7978)

<https://www.nsf.gov/pubs/2019/nsf19581/nsf19581.htm>



Photo by Kristina Walowski

Experiment (AACSE) Team, called in to provide updates on the project. This is a community experiment (all data will be openly available), designed to study the entire system from the outer rise to the arc and back-arc. The deployment ran from late spring 2018 through fall 2019, and included an onshore broadband array and large OBS deployment, as well as several complementary instruments and experiments. For both the deployment and planned recovery (May 2019) activities, there have been several apply to sail berths for students, early career scientists and non-specialists, and two berths for K-12 Teachers.

Andrew Goodwillie then provided an update on the status of the GeoPRISMS Data Portal. Users can access the Data Portal via the website (<http://www.marine-geo.org/portals/geoprisms/>) or via the GeoPRISMS website (<http://geoprisms.org/geoprisms-data-portal/>). When available, data are linked to the awards page on the GeoPRISMS webpage: <http://geoprisms.org/research/list-of-awards/>. This update was followed by vigorous discussion about long-term plans needed to ensure data legacy, stability, and discoverability for programs like – but not exclusive to – GeoPRISMS. This discussion

then transitioned to a broader conversation about content to be maintained as part of a GeoPRISMS Program legacy website, and particularly ways to make hard-won datasets most useable and accessible. One outcome of this discussion was the need for a more detailed, focused workshop on data legacy and archiving.

Discussion and planning for upcoming activities

The GSOC discussed plans for 2019 AGU mini-workshops, in light of the preceding agenda items and the TEI outcomes. The consensus was that these mini-workshops should be coordinated by the GSOC, and serve as a platform for transitioning from the TEI towards positioning the community for opportunities beyond GeoPRISMS. The GSOC agreed that one session should focus on the topical themes that arose at the end of the TEI (this issue, p. 24), with the goal of identifying key next steps in synthesizing results, and/or addressing emerging questions. A second session should focus on data, legacy products, and E&O, and could serve as a forum for preliminary discussion that feeds in to a planned data legacy and archiving workshop.

The GSOC then held a broad discussion about potential legacy and synthesis products focusing on both E&O and science. Detailed discussion focused on identifying specific types of contributions that would:

- Provide a clear record of accomplishments and value of shoreline-crossing, interdisciplinary science;
- Highlight newly arising questions and directions; and
- Point the way forward for the community

The GSOC recognized that some key products (e.g., a final extended format “celebration” newsletter; the program website; EOS article; coordination of a special symposium in Washington DC) can and should be developed by the Office or GSOC, many legacy products would require members of the community to take leading roles – particularly those related to coordinated thematic issues in journals, production of E&O materials, or development of apps. The meeting adjourned following detailed discussion of key elements of these legacy products, and agreement that this plan should be further developed by the office, in consultation with the GSOC, over the coming months.

GeoPRISMS at AGU Fall Meeting - Mini-Workshop Reports

December 10-14, 2018 AGU Fall Meeting, Washington, DC

GeoPRISMS provides the opportunity for groups of researchers to meet and discuss GeoPRISMS Science or planning activities at the AGU Fall Meeting. Here are the reports from the Mini-Workshops organized at the 2018 AGU Fall Meeting.

ExTerra: Evolution of Arc Crust

Conveners: Stacia Gordon (University of Nevada-Reno), Alicia Cruz-Urbe (University of Maine)

On Sunday, December 9th, 34 scientists from a variety of institutions from the US and abroad gathered in Washington, D.C. prior to the start of the AGU Fall Meeting to discuss arc systems and, in particular, the major questions that still surround the evolution of arc crust and the tools and methods that will best answer these questions. With the nearing end of GeoPRISMS, the workshop built upon the energy of this program and the discussions and questions that it has opened. This workshop was also motivated by ExTerra, a group within the Geoscience community that studies Exhumed Terranes. The ExTerra community has organized multiple workshops on exhumed terranes, and scientific questions concerning what can be learned from exhumed crustal arc sections have been included within the overall ExTerra framework. A 2016 ExTerra White Paper laid out a broad array of research themes linked to exhumed terranes. This GeoPRISMS workshop was intended to take the ExTerra White Paper one-step further by having a focused discussion among the subset of the ExTerra community particularly interested in arc systems.

GeoPRISMS Chair Demian Shaffer first gave a brief introduction to familiarize the attendees with the GeoPRISMS program. Sarah Penniston-Dorland and Maureen Feineman, lead organizers of ExTerra and Principal Investigators on an ExTerra Field Institute and Research Endeavor grant, then summarized the goals of

ExTerra. They also highlighted the recent success in obtaining funding for a highly collaborative, multiple PI project through the NSF Partnerships in International Research and Education (PIRE) program. Workshop leaders Stacia Gordon and Alicia Cruz-Urbe presented an overview of the arc system - from the subducting plate to the volcanic components - which combined provide critical details on the evolution of arc crust. They also laid out some of the major questions concerning arc systems that had been included in past white papers. Finally, to stimulate ideas and lead into group discussions, Oliver Jagoutz (MIT) and his PhD student, Benjamin Klein, presented a keynote talk on their geochemical, geochronological, and structural results from the Sierra Nevada batholith and the Kohistan Arc, and the knowledge that has been gained about arc crust through these exhumed terranes.

Participants and conveners at the pre-AGU GeoPRISMS mini-workshop ExTerra: Evolution of Arc Crust



The main goals of this workshop were to encourage significant discussion by creating an environment where all participants felt comfortable sharing their opinions, and to provide a networking opportunity for junior scientists to interact with more senior personnel. Attendees divided into four groups based on different areas of scientific interest within the broader arc system. Early Career Investigators were charged with leading the discussion and recording notes: Emily Chin (UCSD) for the subduction/mantle interface group; Barbara Ratschbacher (Cal Tech) for the plutonic plumbing system; Martin Jutzeler (U. of Tasmania) for the volcanic components; and Besim Dragovic (Boise State) for the metamorphic components. The workshop leaders provided topics for the groups to discuss.

Following the breakout session, each group leader provided a summary of the discussion. The subduction/mantle interface group reported that many questions addressing the processes and properties that control the stress state of the downgoing slab and the role of volatiles other than H₂O in subduction zones still need to be answered. The plutonic group discussed how magma transport, ascent, and emplacement mechanisms vary with depth and how space is created during the movement of magma. The volcanic group questioned how eruption periodicity and the processes controlling eruptions could be estimated and how pre-existing crustal thickness and the local stress field influence volcanism. The metamorphic group focused on the arc crustal section, the distribution of water, and how oxygen fugacity and thermal structure change throughout the arc crustal section and through time.

Two main topics were then discussed among all participants:

1. Should there be a focus site for arc crust research? and
2. What is the best way to move forward and promote ExTerra and the arc crust community?

Most participants were opposed to choosing a single field locality because it would be difficult to select one arc crustal terrane that would 'best' answer the questions discussed by the four groups. Focus sites can also potentially exclude and limit the number of scientists involved.

Discussion among participants then focused on how the community should move forward and secure funding for arc crust research. Most were not in favor of a field institute for the same reason invoked for the choice of a single focus site. Instead, a larger meeting targeting the arc crust community was proposed as the best mechanism to engage a larger group of scientists, and demonstrate the high level and breadth of interest in arc processes. The group discussed that this next meeting could be a CIDER-type workshop that would involve both faculty and students.

The workshop attendees included a large number of graduate students, postdocs, and early career faculty members who were able to network with a variety of US and international scientists at all different stages of their career. Feedback from student participants indicated that the opportunity to participate in the workshop, and in many cases meet scientists whom they knew only through reading their papers, was invaluable for them. Many important questions concerning the evolution of arc crust were discussed, and many of the students, postdocs, and junior faculty expressed interest in being involved in future events surrounding arc crust. The workshop leaders will encourage these junior scientists to take the lead on developing proposals and on being part of planning for a future workshop.

*Visit the GeoPRISMS website for more information about the Mini-Workshops at the AGU Fall Meeting at:
<http://geoprisms.org/meetings/mini-workshops/>*

GeoPRISMS Data Portal

Visit the GeoPRISMS Data Portal to find information for each Primary Site:

- Pre-existing data sets and field programs
- Data sets ready for download
- Links to partner programs and resources
- References database with papers tied to data

GeoPRISMS references database of relevant publications is now available:

<http://www.marine-geo.org/portals/geoprisms/references.php>

To submit missing data sets, field programs or publications to the GeoPRISMS portal, contact info@marine-geo.org

Investigating subduction processes at the Hikurangi margin, New Zealand

Laura Wallace (GNS Science, New Zealand, Univ. Texas Institute for Geophysics), Dan Bassett (GNS Science, New Zealand), Samer Naif (Lamont-Doherty Earth Observatory, Columbia University), Patrick Fulton (Cornell University), Heather Savage (Lamont-Doherty Earth Observatory, Columbia University), Shuo Shuo Han (Univ. Texas Institute for Geophysics)

A mini-workshop to discuss the latest research results from the Hikurangi subduction zone (New Zealand), was held on Sunday afternoon before Fall AGU began in Washington, D.C. The mini-workshop had a record turnout, with 116 registrants from ten different countries. A particular priority of this workshop was to get the broader community up to speed on the range of research activities and major experiments underway to better understand the Hikurangi subduction zone, and to facilitate discussion to better integrate results between these projects.

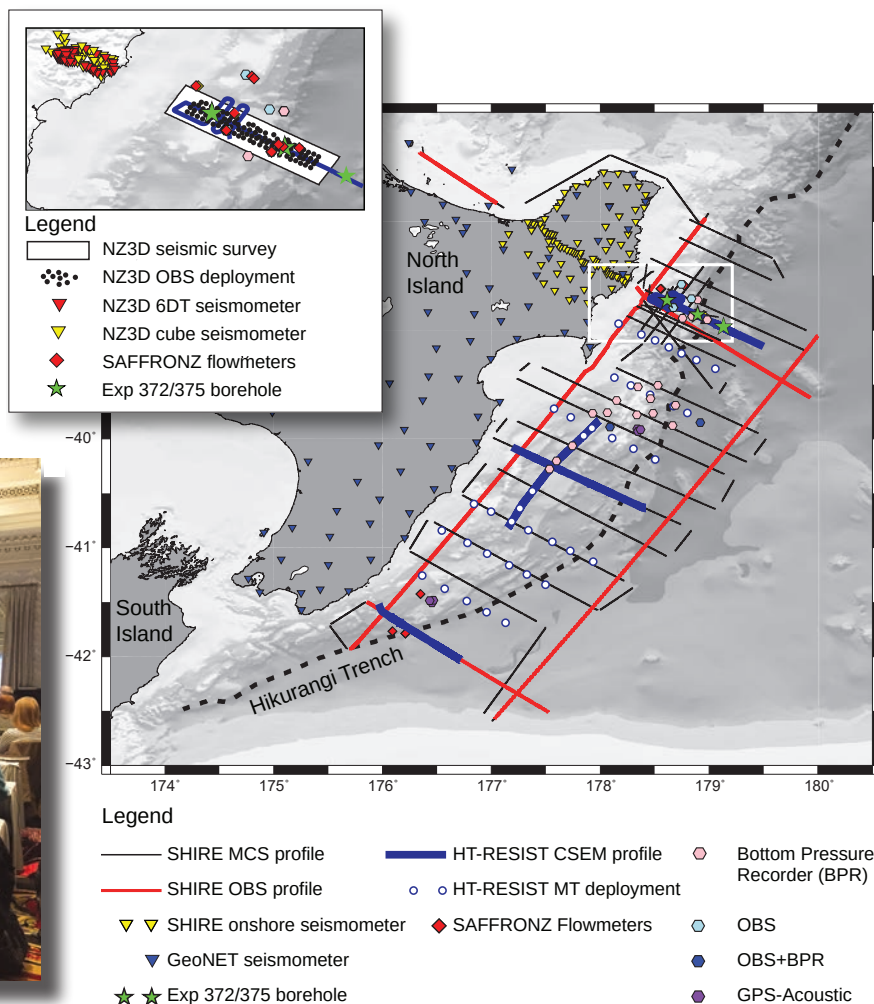
Subduction of the Pacific Plate beneath New Zealand's North Island occurs at the Hikurangi subduction margin. The Hikurangi margin offers an outstanding opportunity to address many of the key topics of the GeoPRISMS Subduction Cycles and Deformation initiative, as outlined in the New Zealand primary site implementation plan.

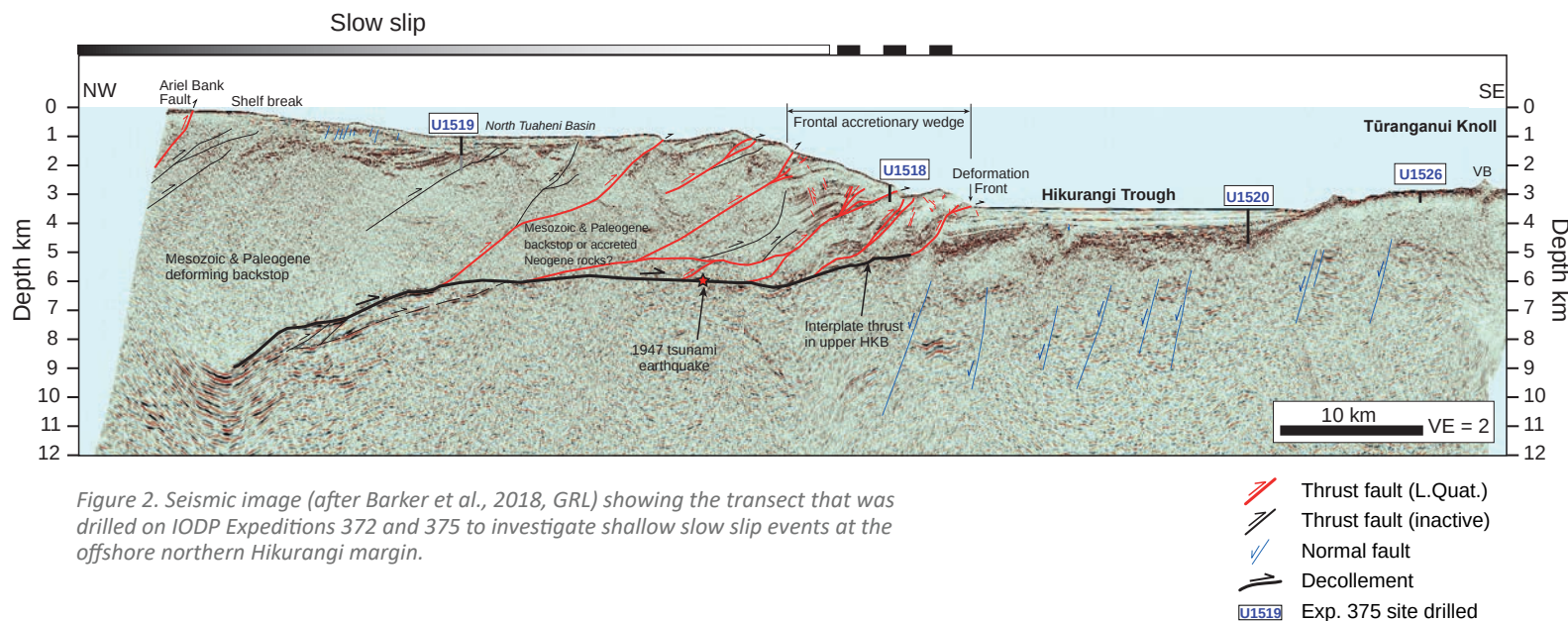
In particular, the strong along-strike variations in megathrust behavior and characteristics make it an ideal location to investigate the physical controls on subduction margin deformation and slip behavior.

Data acquisition and analysis at the Hikurangi margin are ongoing by scientists from New Zealand, the United States, Japan and Europe. Major experiments to investigate Hikurangi subduction processes have taken place in the last year, including two Integrated Ocean Discovery Program (IODP) drilling expeditions to investigate slow slip processes (Expeditions 372 & 375), and two seismic experiments with the R/V *Langseth* and R/V *Tangaroa* to investigate controls on plate coupling and slow slip (Fig. 1). Additional NSF and New Zealand-funded experiments have taken place in the first few months of 2019.

Figure 1. Map of the North Island and offshore Hikurangi subduction zone with a summary of some instrumentation and recent offshore and onshore experiments undertaken at the Hikurangi subduction margin over the last 3 years.

More than a hundred attendees from ten countries participated in the pre-AGU GeoPRISMS mini-workshop to discuss the subduction processes at the GeoPRISMS Focus Site New Zealand Hikurangi Subduction Zone.





The meeting began with an overview from Jamie Howarth (Victoria University of Wellington) on paleoseismological studies to establish a record of, and evidence for, large subduction zone earthquakes at the Hikurangi margin. Ongoing efforts in this area involve both onshore proxies for paleo-earthquakes, as well as offshore (turbidite) studies. Demian Saffer (Penn State) overviewed the results of recently completed IODP drilling (Fig. 2), and discussed the implications of these results for controls on slow slip events. A number of active source seismic imaging investigations took place in 2017/2018 (Fig. 1). Nathan Bangs (UTIG), Ryuta Arai (JAMSTEC), and Rebecca Bell (Imperial College, London) presented an overview of the 3D multi-channel seismic survey (NZ3D) to image the shallow slow slip region at north Hikurangi in unprecedented detail. Nathan Bangs also presented preliminary results of the first phase of the SHIRE experiment to image along-strike variations in properties of the subduction zone. Stuart Henrys (GNS Science) overviewed plans for the final, onshore phase of SHIRE that was successfully completed in early March 2019. The first part of the mini-workshop concluded with an overview from Donna Shillington on parallels between the Hikurangi margin megathrust and aspects of the megathrust in Alaska. There are striking parallels between Hikurangi and Alaska, offering clear research opportunities for the future.

The second half of the mini-workshop focused on future plans at the Hikurangi margin. Laura Wallace (GNS Science/UTIG) overviewed ongoing and upcoming seafloor geodetic experiments (Fig. 1) to clarify the nature of offshore interseismic deformation and the distribution of slow slip events on the shallow megathrust. Evan Solomon (University of Washington) discussed plans for an experiment to undertake sampling of sediment and fluids from offshore seeps, acquire heat flow data, and deploy seafloor flow-rate meters (Fig. 1) to evaluate the role of fluids in Hikurangi megathrust behavior (the SAFFRONZ project). The SAFFRONZ cruise was successfully completed on the R/V *Revelle*, in February of 2019. Samer Naif (LDEO) overviewed their recently completed

HT-RESIST experiment (December 2018/March 2019; Fig. 1) to deploy offshore MT instruments and undertake controlled-source electromagnetic (CSEM) surveys to map along strike variations in fluid content and the relationship of this to megathrust behavior. All of these studies are supported by a combination of NSF/GeoPRISMS funding, and funding from international partners in New Zealand, Japan, and the U.K. Following the talks we had short pop-up talks from a number of participants to overview additional investigations at Hikurangi.

Large portions of the mini-workshop were devoted to discussion of using these new observations from the New Zealand focus site, to develop an integrated understanding of subduction margin processes from geophysical, geological, and geochemical field perspectives. Many of the themes discussed included:

1. The state of the incoming plate and the role of incoming sediment and basement properties in subduction thrust behavior and margin evolution;
2. Physical properties of the forearc and megathrust, and the influence of this on megathrust behavior;
3. Fluid sources and fluxes, with emphasis on the forearc;
4. The relationship between micro-seismicity, slow slip events, and tremor.

Overall, there are close to one hundred scientists from several different countries involved in GeoPRISMS-related studies on the Hikurangi subduction zone. The mini-workshop at Fall AGU offered the first opportunity for many of these scientists to gather and discuss the results of these recent major experiments, and their implications for deformation and earthquake cycle processes at the Hikurangi margin. It also provided an important opportunity to coordinate efforts for the additional upcoming experiments in 2019, and to explore synergies between the various research groups working there.

GeoPRISMS Student Prize for Outstanding Presentations

2018 AGU Fall Meeting, Washington DC

Congratulations to the winners of the GeoPRISMS 2018 AGU Student Prize! As in previous years, the judges were greatly impressed by the quality of the entrants and awarding individual prizes to just a few in such an outstanding field was very difficult. Here we honor two prize winners and four honorable mentions. Thank you to all the entrants and judges for making this contest possible and worthwhile.

Poster Presentation Winner

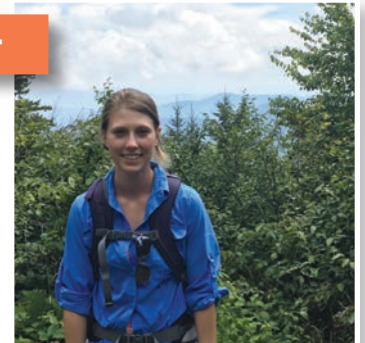
KIRSTIE HAYNIE | University at Buffalo, SUNY

Assessing the generation of the 1964 Great Alaska Earthquake in terms of the dynamics of a Fore-arc Sliver System

COAUTHOR: M. Jadamec

FROM THE JUDGES: Kristie gave an excellent poster presentation. She explained her research clearly, motivated her work with important implications, had a well designed poster and answered questions well. She had all the components of a great presentation and exhibited a deep understanding of her research.

FROM THE STUDENT: I am extremely honored and excited to have received the GeoPRISMS best student poster award for my 2018 AGU presentation! I am thankful that the GeoPRISMS community is dedicated to supporting student research and interdisciplinary collaboration. I look forward to future involvement within the Subduction Cycles and Deformation Initiative.



Oral Presentation Winner

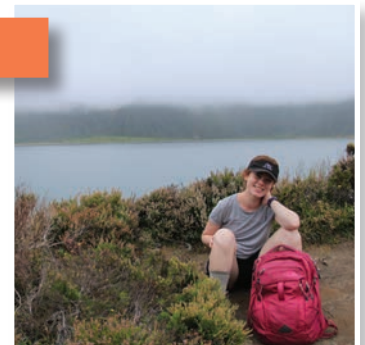
RACHEL MARZEN | Columbia University

Refraction seismic constraints on less extensive CAMP magmatism localized by prior extension in the Southeastern United States

COAUTHORS: D. Shillington, D. Lizarralde, S. Harder, J. Davis

FROM THE JUDGES: Rachel gave a very clear presentation on the influence of CAMP on the evolution of the South Georgia Rift Basin. The research problem was well stated // This talk was clearly articulated; Rachel has command over the seismic refraction approach. She spoke clearly and with confidence.

FROM THE STUDENT: I am so grateful to have received this award. The research goals posed by GeoPRISMS have impacted my research from the time I was an undergraduate, and GeoPRISMS events have been a valuable source of feedback and insights from other people's work. I look forward to continued engagement with this amazing and diverse community.



PARTICIPATE

GeoPRISMS is offering two \$500 prizes for Outstanding Student Poster and Oral Presentations on GeoPRISMS-related science at the AGU Fall Meeting to highlight the important role of student research in accomplishing GeoPRISMS-related science goals, and encourage cross-disciplinary input. The contest is open to any student whose research is related to the objectives of GeoPRISMS. More information will become available closer to AGU on the GeoPRISMS website, stay tuned!



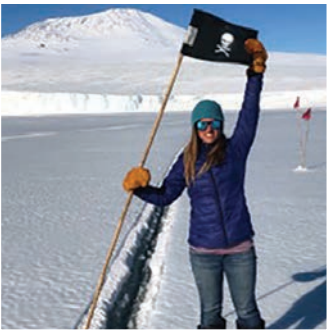
ANDREW GASE | University of Texas at Austin

Crustal structure of the northern Hikurangi margin and Bay of Plenty from marine seismic reflection imaging and double-sided onshore-offshore seismic tomography

COAUTHORS: H. Van Avendonk, N. Bangs, D. Okaya, S. Henrys, D. Barker, K. Jacobs, S. Kodaira, G. Fujie

FROM THE JUDGES: This was a very crisp, clear, and efficient talk. Importance of studying northern Hikurangi margin was well established, and the new active source data (both reflections and velocities) were walked through in sequence to show interesting new observations throughout the subduction system // Andrew gave a very competent talk summarizing early results from his analysis of SHIRE seismic reflection and refraction data traversing the northern Hikurangi margin. His talk covered well the background motivation for SHIRE, the new data acquired and results from his initial analysis.

FROM THE STUDENT: Thank you to all the judges and the GeoPRISMS community for supporting and highlighting graduate research. I am grateful for this recognition.



TIEGÁN HOBBS | Georgia Institute of Technology

Investigating apparent anticorrelation of repeating aftershocks and afterslip in Nicoya, Costa Rica

COAUTHORS: D. Yao, A.V. Newman, Z. Peng, M. Protti

FROM THE JUDGES: Clear and polished presentation; excellent graphics/slides; effectively organized and easy to follow; clear command of the science and goals of the study; presented the significance of the main findings at the beginning and end of the presentation clearly and effectively; the results of the work were very impactful to the community; the student handled questions excellently by clarifying the question for the audience and answering in a clear and thoughtful manner.

FROM THE STUDENT: I am incredibly appreciative to receive an honorable mention for my presentation at AGU, given the excellent work being done by so many students in GeoPRISMS. Thank you to the organizing committee, and all those who volunteer as judges. I look forward to continuing to participate in the GeoPRISMS community.



EMMANUEL NJINJU | Virginia Tech

Investigating seismic anisotropy beneath the Malawi Rift, East Africa with geodynamic modeling

COAUTHORS: D.S. Stamps, S. Fishwick

FROM THE JUDGES: Emmanuel had a great poster presentation, with a clearly defined problem, and was able to explain his methods and the importance of his project quite clearly.

FROM THE STUDENT: I am honored to have my research recognized by GeoPRISMS. I appreciate the efforts of the organizers of this program and the opportunity given to young scientists to participate. I look forward to continuing participation in GeoPRISMS research.



BRANDON SHUCK | University of Texas at Austin

From rifting to subduction: Evidence for the role of past tectonics influencing subduction initiation at the Puysegur Trench, New Zealand

COAUTHORS: S. Gulick, H. Van Avendonk, M. Gurnis, J. Stock, R. Sutherland, E. Hightower, J. Patel, S. Sastrup

FROM THE JUDGES: Brandon's presentation was extremely well done. He was cognizant of work being done in the same field area, as well as in different GeoPRISMS focus sites, which I think demonstrates a very mature sense of awareness. Very enthusiastic, interesting project, and excellent presentation // Knowledgeable and engaging presentation of the results. Brandon sought out ways to combine multi-disciplinary constraints, consistent with the GeoPRISMS scientific goals.

FROM THE STUDENT: I am very honored and greatly appreciate this recognition from GeoPRISMS. As a student, I feel exceptionally supported by the GeoPRISMS community and I am sincerely thankful for the fruitful collaborations and research expeditions made possible by GeoPRISMS.

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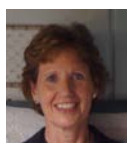
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SAVE
— the —
DATE

GeoPRISMS 2019 AGU Mini-Workshops

December 8, 2019 | Hotel Grand Hyatt Union Sq

www.geoprisms.org/meetings/mini-workshops/



Please save the date and attend the GeoPRISMS
Mini-Workshops at the 2019 AGU Fall Meeting!

December 8, 2019 | Grand Hyatt Union Square, 36th Floor

8:30 - 12PM | DATA LEGACY, E&O, AND SCIENCE LEGACY PRODUCTS

Convened by A. Goodwille, A. Ferot

This workshop will focus on ensuring the long-term legacy of the GeoPRISMS program, through development of stable, robust Data Management strategies, and Education & Outreach and Legacy Products.

12 - 1:15PM | LUNCH TO BE PROVIDED

1:15 - 5:30PM | STRATEGIES FOR SYNTHESIS, INTEGRATION, AND FUTURE OPPORTUNITIES

Convened by the GeoPRISMS Steering & Oversight Committee

This mini-workshop will focus on:

1. Reviewing key advances on core topical questions identified at the recent TEI;
2. Defining needs, including data and knowledge gaps and opportunities for integration across disciplines; and
3. Identifying paths forward, emerging opportunities, and activities to position the community in coming years.

6 - 9PM | EVENING CELEBRATION/CASH BAR

All mini-workshops are free of charge and open to all.

Registration and more information will be soon available on the GeoPRISMS website.
Stay tuned!

<http://geoprisms.org/meetings/mini-workshops/>

Questions? Contact the GeoPRISMS Office at info@geoprisms.org

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Photo credit: James Muirhead



SAVE THE DATE

Attend the GeoPRISMS Mini-Workshops at the 2019 AGU Fall Meeting:

8:30 - 12pm | Data Legacy, E&O, and Science Legacy Products

1:15 - 5:30pm | Strategies for Synthesis, Integration, and Future Opportunities

For more info, visit the GeoPRISMS website at www.geoprisms.org