Exploring Earth’s Final Frontier

What mid-ocean ridges reveal about tectonics and magmatism

By Jocelyn Fuentes, Third-Year Graduate Student

When most people think of the ocean, they imagine a vast expanse of calm blue water with little thought for what lies below, or they think of the water that fills the ocean basins. For many ocean scientists, however, what is most interesting lies beneath the water on the seafloor. Two-thirds of the geology of the planet is there, obscured by the water above. The most prominent feature of the seafloor is the mid-ocean ridge system, one of Earth’s most active tectonic, volcanic, and biologic features. There exist deep rifts that would dwarf the Grand Canyon, continuous volcanic eruptions, and giant hot springs teeming with biology unlike anything on land. The ocean ridge system is the largest continuous mountain chain on Earth, and it wraps around the globe for over 65,000 km and is the site of 80 percent of active volcanism. As divergent plate tectonic boundaries, ocean ridges are an essential part of the Earth system where the seafloor is constantly being created through magmatism and faulting.

Since the first map of the ocean floor was created, in 1977 by Marie Tharp and Bruce Heezen, many advances have been made in the field of marine geology and geophysics. In particular, our ability to map and image the seafloor has improved greatly. Unfortunately, these techniques generally require a ship, which is costly and time-consuming. The result is that approximately 90 percent of the seafloor has only been mapped by satellites, which have limited resolution under water. There are more accurate maps of the surface of Mars than there are of Earth’s seafloor. This leaves the majority of the ocean unexplored and unsampled by humans, including much of the mid-ocean ridge system. This is one

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Curricular CURRENTS

Food, Movies, Earthquakes, and Sailing
Freshman Seminars offer students—and EPS faculty—something different

They've been meeting since fall, exploring connections between climate and food security, looking specifically at the idea of drought and conflict in Syria and sub-Saharan Africa through analysis of climate and food data. Their class officially ended before the winter break, but the students and faculty member continue to gather, now with the addition of other undergraduate and graduate students, and now working on a paper to submit for publication.

"It's become a mini-research group," says Peter Huybers, professor of Earth and planetary sciences and environmental science and engineering, of the evolution of his Freshman Seminar, Food, Climate, and Data.

The depth of participants' involvement in the seminar is unusual—but not completely unheard of in Harvard's Freshman Seminars Program, where seminar students and faculty often form bonds that last through the students' college years (and beyond), meeting up for reunion meals, for example, long after their semester-long seminar has finished.

Freshman Seminars—established in 1963—are one of Harvard's best-loved academic traditions. Offered only to freshmen, the seminars bring together a faculty member with up to 12 students for two to three hours weekly to explore a topic of shared interest.

This coming year, Harvard will offer more than 140 Freshman Seminars, representing every school and every discipline, says Toni Trainor, department administrator of the program. The 2016–17 catalog was being finalized at the time of writing, but past EPS-related seminars range from the above-mentioned investigation into climate and food security, to looking at earthquakes as they've been studied throughout history, to delving into the mechanics and science of sailing, to exploring what's real—and what's not—in natural disaster movies.

Graded sat/unsat, the seminars draw freshmen of different interests and from different backgrounds to study a subject that might be outside their primary focus. (Though it might become their focus: Trainor knows of one career that was launched from a Freshman Seminar.) Faculty, too, enjoy the small-group setting and the opportunity to take on subjects outside normal Harvard College fare. "It's a chance for them to be creative," Trainor explains.

"Sometimes the seminar topic is the faculty member's hobby, sometimes it's their passion or research."

Brendan Meade's Freshman Seminar, On Broken Ground: The Science and Impact of Earthquakes, looks at the Earth through the lens of earthquake history and the impact of earthquakes on humans historically and today. Normally, Meade, professor of Earth and planetary sciences, teaches the General Education course "Natural Disasters" and graduate classes on earthquake science and tectonics; the seminar offers a different angle on earthquakes.

"The class represents an opportunity to see earthquakes not only as natural phenomena and objects of scientific inquiry but also as shapers of history. Modern earthquake science has deep roots preceding the plate tectonics revolution," Meade explains.

Trainor refers to Professor of Earth and Planetary Sciences Miaki Ishii's Freshman Seminar, GeoSciFi Movies: Real vs. Fiction, as an example of how Freshman Seminars are an opportunity for faculty to "try something new."

"I was looking for a good tool to teach Earth science to students who may not necessarily be interested in Earth science," says Ishii of her idea for the seminar.

"It was really fun. I am not a moviegoer, so viewing these sometimes unsettling scenes wasn't necessarily always enjoyable, but watching them critically to identify correct and incorrect features was interesting."

A copperplate, republished in 1909, of the destruction from the 1755 earthquake that devastated Lisbon.
The students were fantastic, and I learned a lot from them, too," Ishii says.

In addition to watching movies and discussing the science involved (for example, how many helicopters and firetrucks would really be needed to address the lava in the movie Volcano?), the course used the Montserrat role-playing game to act out government, scientists, and society responding to a volcano as well as the NOAA's role-playing game about Hurricane Island.

Ishii adds that her teaching methodology can be different because the class is longer and smaller. "I also didn't have set topics I needed to cover (which would be very different from a foundational course on, say, math), and that meant that I could focus more on making the class enjoyable and memorable."

And the classes are memorable. Comparing Freshman Seminars with other undergraduate offerings, Trainor says, "They are typically very different from other learning experiences in the first year in that they are more intimate, a lot more interactive, and hands-on, for the most part." She notes that seminars have taken field trips to the Arnold Arboretum, to the Mystic River in Medford, and even to Nantucket (for a seminar on Moby-Dick, of course) and to the American Museum of Natural History in New York City.

For Jeremy Bloxham, Mullinekrodt Professor of Geophysics and dean of science in the Faculty of Arts and Sciences, the Freshman Seminar he has led several times, The Science of Sailing, builds on his interests and a desire to "show freshmen how simple physics can be applied to real-world problems rather than simply solving the highly contrived problems that they may have encountered in high school."

Noting "fun and sometimes animated debate," Bloxham adds that the seminar also provides an opportunity to show them that the popular literature on a subject, for example, the generation of lift by a sail (or equally, the generation of lift by the wing of an airplane) is not always correct—misinterpretations of Bernoulli's principle abound. The seminar also considers basic meteorology, water waves, and tides, he says, none of which requires more than basic Newtonian mechanics.

Freshman Seminars are special for students, too. "For the students it's a great way to develop a relationship with a faculty member," Trainor says. "Here, there are 12 students; they're going to get to know the faculty member on a much more personal, intimate level. And, hopefully, that relationship will kindle mentorship and a relationship for their entire time at Harvard."

Faculty feel the same. Ishii says that in Freshman Seminars, "I really get to know the students and they get to know me."

Huybers agrees. "I get to know the students much better in such a small seminar format, appreciating better where they are coming from, how they are thinking, and what they can uniquely contribute to the course."

For example, one of the members of Huybers's seminar had experience farming in Kenya and had firsthand knowledge of growing maize; others had experience in computer programming and statistical analysis.

"A lot of faculty love the Freshman Seminars Program," says Trainor. "They develop personal relationships with the students. I think sometimes there can be learning from both faculty and students." And students, too, rate the program highly. "Normally the feedback is—when you ask seniors to reflect on their four years at the College—it's one of their favorite classes."

> Cathy Armer

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**An Old Title for a New Role**

*Meet the department's new preceptors: Esther James and Annika Quick*

You may see them setting up the rotation tank for weather demos in EPS classrooms or constructing volcanoes in front of the Museum of Natural History, find them accompanying student excursions to places like World's End (south of Boston), or stumble upon them mentoring college seniors writing theses or meeting with teaching fellows in the Faculty Lounge. You may see them teaching General Education (Gen Ed) sections, or pass them tucked away in their offices in the Geological Museum pondering the best methods for presenting course materials, carefully reviewing syllabi, or finessing course websites.

These ubiquitous new folks at EPS are Esther James and Annika Quick, department preceptors.

Preceptors? Evoking historic educational institutions like Oxford and Cambridge, or even somewhat mystical entities, such as the Knights of the Templar, preceptors exist in some Harvard departments providing language, skill-oriented, or other special instruction, and can also be found at a few other American universities, generally taking on the role of head TA. But at EPS, the role of preceptor is much greater: rather than focus on just one course, EPS preceptors assist broadly with a host of courses and curricular activities.

The department hired its first preceptor in 2009 (and expanded to two positions in 2013), and the role has evolved to become arguably the ultimate behind-the-scenes position, its academic support integral to the EPS experience. As department chair John Shaw notes, "Preceptors in EPS play a central role in enabling us to deliver exciting new learning opportunities in our classes. Many of us were drawn into Earth science through opportunities to be in the field, or..."