Science Initiative: From the Bottom Up: Interconnections between earth's interior and surface

EAPS is an international leader in research of Earth's rigid lithosphere, its interactions with the deeper, hotter, and weaker asthenosphere, and the evolution of Earth's surface which responds to events in the Earth's interior. Our expertise arises from a unique set of research laboratories focused on thermochronology and the characterization of geochemical and geophysical properties of Earth materials, the ability to model Earth processes using numerical and analogue techniques, and robust field programs in geology, hydrology, and seismology. This wide array of expertise provides us the ability to work on research problems that scale a wide array of spatial and temporal scales from the early Earth to contemporary processes. For example, geophysical imaging provides detailed information on the structure and composition of the Earth's crust and mantle. Geochemical and geochronological studies determine the composition of rocks and minerals, where they originated, and constrain the evolution of the Earth through time. Measurements of rock physical properties and analogue experiments allow us to predict how rocks respond to changing conditions through time.

With a significant investment in new geology and geophysics faculty, EAPS is now positioned to take on broader interdisciplinary problems of great interest to the geoscience community, most notably in the evolution of lithospheric systems and their influence on all other aspects of our planet through time.

Initiatives

1. **Evolution of lithospheric systems, emphasizing interconnections between the mantle and the surface**

   The Earth's continental crust is produced over geological time by the interactions of tectonic processes, weathering, erosion, sedimentation, and the evolution of the earth's biosphere. It continuously evolves from active plate margins to stable interiors. Active plate margins are regions where the continental crust is currently being generated, modified, and destroyed. Transform plate margins are critical for understanding active margins because they transport plate-scale crustal fragments hundreds to thousands of kilometers, pose significant earthquake hazards, and are closely linked to the evolution of both subduction zones and extensional tectonic regimes. Over geological time, active plate margins stabilize to form plate interiors, and the formation of large sedimentary basins and passive margins that host much of the earth's natural resources. Eventually, rifts and extensional tectonic environments significantly modify and ultimately rupture the continental lithosphere leading to the formation of ocean basins and new active margins.

   All of this activity can be understood in terms of lithospheric systems, in particular how processes within the Earth's mantle and at its surface are interconnected. However, much remains to be learned of these connections including: At subduction zones, what are the mechanisms that control the evolution of magmatic arcs, forearc and foreland basins, and accretionary prisms? What are the geological and geophysical characteristics associated with tectonic boundary evolution between tectonic regimes (e.g., from subduction to translation)? How does an active plate margin evolve into basins, stable continental crust, and cratons that can survive for billions of years? How do surface processes like subduction, mountain building, erosion, and deposition influence the Earth's interior? To help EAPS progress in addressing these basic questions, a number of tasks are planned:

   Key Implementation Tasks:

A. Conduct yearly seminars with faculty and graduate students to review literature on lithospheric systems with the aim of developing well-focused research questions/plans that can lead to proposals.
B. Develop collaborative proposals targeted at mid-scale NSF funding opportunities (i.e. core EAR programs) and larger-scale opportunities, such as the Frontier Research in Earth Sciences program.
C. Seek out leadership opportunities for EAPS faculty within existing community-wide initiatives, like SZ4D, EarthRates, and Gordon Research Conferences.
D. Hire an igneous geochemist who utilizes ICP-MS in their research to provide analytical capability current lacking in the department.
E. Capitalize on recent investment in data science at Purdue and recent loss of geodesy expertise in the department by hiring someone in the field of geodesy (e.g., INSAAR, LiDAR, GPS).
F. Ensure the longevity of our research infrastructure and analytical capabilities in geochronology/geochemistry by ensuring long-term support for laboratory staff.

2. **The co-evolution of tectonics, surface environments (including hydrosphere, climate), and life on Earth**

Earth's hydrosphere, atmosphere, and biosphere are intimately linked to its tectonic and geophysical evolution. The compositions of Earth's rivers, oceans and atmosphere are regulated by chemical processes at active plate margins and volcanoes and by weathering of continental rocks. These processes are critical for life, controlling the bioavailability of essential nutrients at Earth's surface and maintaining the long-term stability of Earth's climate system. The climate system in turn affects solid Earth processes (e.g., via ice loading during glacial periods or through precipitation patterns that affect erosion and chemical weathering of rocks). At the same time, life influences both climate and the solid Earth by impacting physical and chemical weathering rates in soils and by generating and altering sediments that are recycled into the interior at subduction zones. Understanding these complex, multi-directional relationships is central to understanding not only the evolution and resilience of Earth's present-day climate, soils, and environment, but also Earth's long-term habitability and whether plate tectonics or a similar geophysical phenomenon may be a requirement for enduring habitability on other worlds.

A major issue in Earth history is resolving when modern-style plate tectonics began, with estimates varying wildly over billions of years of Earth history, and reconstructing how the onset of plate tectonics impacted the cycling of elements in the Earth system (e.g., via subduction zone volcanism). More generally, how has the development of continents, and their redistribution at Earth's surface through time, affected Earth's life and climate systems (e.g., changes in large-scale atmospheric and oceanic circulation patterns, sea level, and weathering and sedimentation rates)? Once life was established, how has biological innovation such as the rise of land plants modified the relationship between surface conditions, biology, and the solid Earth? Resolving these issues requires interdisciplinary collaborations among traditionally distinct disciplines, including geophysicists, geochemists, and geobiologists, working to better understand both modern processes and those in deep time.

Key Implementation Tasks:

A. Conduct yearly seminars with faculty and graduate students to review literature on co-evolution of tectonics, surface environments, and life on Earth with the aim of developing well-focused research questions/plans that can lead to proposals.

B. Develop collaborative proposals within the department targeted at mid-scale NSF funding opportunities (i.e. core EAR programs) and larger-scale opportunities, such as the Frontier Research in Earth Sciences program, NASA's Exobiology and Habitable Worlds programs, and/or geobiology grants from the Agouron Institute.

C. Explore opportunities for cross-disciplinary collaborations within the department and broader collaborations with members of other departments at Purdue (e.g. Biology, Chemistry, Ag)

D. Seek out leadership or other opportunities for EAPS faculty within existing community-wide initiatives, like the Geological Research through Integrated Neoproterozoic Drilling (GRIND) ICDP initiative, EarthRates, Gordon Research Conferences.

E. Hire a sedimentary geochemist who studies Earth history, with a particular focus on interpreting geological archives such as fossil, mineral, molecular, or isotopic tracers of biological innovation, ocean-atmosphere composition, climate, weathering, and/or tectonic processes.

Key Goals and Metrics:

1. Completion of initiative-focused seminars.
2. Successful submission of collaborative proposals associated with each initiative.
3. Make a successful tenure-track hire that contributes to this Strategic Plan (igneous geochemist, sedimentary geochemist, or geodesist).