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A Vision for NSF Earth Sciences 2020-2030: **Earth in Time**

presented by Andrea Dutton to the AGeS Workshop
October 8, 2022

NSF Organization

**Directorate for
Geosciences
(GEO)**

Earth Sciences (EAR)

**Division of
Ocean Sciences (OCE)**

**Division of
Atmospheric and
Geospace Sciences (AGS)**

**Office of
Polar Programs (OPP)**

DISCIPLINARY PROGRAMS

**Geobiology and
Low-Temperature Geochemistry**

**Geomorphology and
Land Use Dynamics**

Geophysics

Hydrologic Sciences

Petrology and Geochemistry

**Sedimentary Geology and
Paleobiology**

Tectonics

DIVISION-WIDE PROGRAMS

Frontier Research in Earth Sciences

Critical Zone Collaborative Network

INFRASTRUCTURE

Instrumentation

Facilities

Geoinformatics

Education and Human Resources

Postdoctoral Fellows Program

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Statement of Task

NASEM will help provide advice that EAR can use to set priorities and strategies for its investments on research, infrastructure, and training in the coming decade. The report will include:

1. A concise set of **high-priority scientific questions** that will be central to the advancement of Earth sciences over the coming decade and could help to transform our scientific understanding of the Earth.
2. (A) **Identification of the infrastructure needed** to advance the high-priority Earth science research questions from task #1, (B) **discussion of the current inventory** of research infrastructure supported by EAR and other relevant areas of NSF, and (C) **analysis of capability gaps** that would need to be addressed in order to align B with A.

Statement of Task, cont.

3. **A discussion of how EAR can leverage and complement the capabilities, expertise, and strategic plans of its partners** (including other NSF units, federal agencies, domestic and international partners), encourage greater collaboration, and maximize shared use of research assets and data.

The ad hoc committee will consider these tasks within the context of the present EAR budget.

In addition, the National Academies convened **a workshop to address different management models for future seismological and geodetic facility capabilities**, providing additional information for Task 2 of the CORES study.



Committee Roster

Jim Yoder (Chair), Woods Hole Oceanographic Institution

Greg Beroza, Stanford University

Tanja Bosak, Massachusetts Institute of Technology

Bill Dietrich, University of California, Berkeley

Tim Dixon, University of South Florida

Andrea Dutton, University of Wisconsin–Madison

Diana Elder, Northern Arizona University (*resigned*)

Lejo Flores, Boise State University

Michael Foote, University of Chicago

Shemin Ge, University of Colorado Boulder

George Gehrels, University of Arizona

Doug Hollett, Melroy-Hollett Technology Partners

Bruce Houghton, University of Hawaii at Manoa

Kate Huntington, University of Washington

Steve Jacobsen, Northwestern University

Dennis Kent, Rutgers University

Carolina Lithgow-Bertelloni, University of California, Los Angeles

Paul Olsen, Columbia University

Don Sparks, University of Delaware

Donna Whitney, University of Minnesota

Study Process

- 7 in-person committee meetings
- Closed committee meetings to deliberate and write the report
- Workshop on management models for future seismological and geodetic facility capabilities
- Open meeting topics:
 - Sponsor expectations
 - Early-career science needs
 - Energy sector
 - Diversity, equity, inclusion
 - Facilities and infrastructure
 - Federal partnerships
 - Cyberinfrastructure

Outline

- Vision
- Science priority questions
- Infrastructure & initiatives
- Partnerships

Vision

- EAR can enhance support for Earth research as an integrated system
- This is an “all hands on deck” moment; we need
 - Diverse, inclusive groups
 - Individuals, teams, and collaborative networks
 - Cutting-edge analytical, computational, and field-based methods

Science Priorities – Approach



Information-gathering

- Literature review
- Community input questionnaire
- Listening sessions/town halls
- Workshops held previously by community groups
- Interviews with colleagues
- Invited discussions during committee meetings

Developing priorities

- Generating “long list”
- Merging similar questions
- Examining the scientific importance and likelihood of transformative impact
- Framing the questions

Identify specific questions that are **poised for major advances** in next 10 years

Some questions have long been of great interest

Field gear.

Science Priorities

Integrating Themes

- Earth system components interact over time and space
- Connections between Earth spheres increasingly important
- Technological advances enable new observations and modeling
- Societal relevance of fundamental Earth science research



Person conducting fieldwork.

- Key insights come from a strong disciplinary research program
- There will be unanticipated discoveries with profound effects

Science Priority Questions



How is Earth's internal magnetic field generated?



When, why, and how did plate tectonics start?



How are critical elements distributed and cycled in the Earth?



What is an earthquake?



What drives volcanism?



What are the causes and consequences of topographic change?



How does the critical zone influence climate?



What does Earth's past reveal about the dynamics of the climate system?



How is Earth's water cycle changing?



How do biogeochemical cycles evolve?



How do geological processes influence biodiversity?



How can Earth science research reduce the risk and toll of geohazards?

What is an earthquake?

Deformation of the Earth occurs over a spectrum of rates and in a variety of styles, leading geoscientists to reconsider the very nature of earthquakes and their dynamics.



Surface rupture from the Ridgecrest earthquake

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Facilities & Infrastructure Approach

- Task 2A: Describe future infrastructure needed to address science questions
- Task 2B: Describe current infrastructure and show connections to science questions
- Task 2C: Capability gaps

Portion of a table showing connections between existing infrastructure and questions

	Geomagnetics	Tectonics	Critical Elements	Earthquakes	Volcanoes	Topography	Critical Zone	Climate	Water Cycle	Biochemistry	Biodiversity	Geohazards
Geophysics												
SAGE												
GAGE												
IRM												
ISC												
CMT												
Material Characterization												
GSECARS												
COMPRES												
Geochemistry/Geochronology												
PRIME												
Wisc SIMS												
UCLA SIMS												

Facilities & Infrastructure Approach

- Describe available infrastructure (EAR, GEO, NSF, NASA, USGS, DOE, etc.)
- Establish connections between infrastructure and science questions
- Challenging to evaluate how well the needs of EAR research communities are met
 - *information needed to perform this type of assessment was not available*

Recommendation: EAR-supported facilities and the entire portfolio of EAR-supported infrastructure should be regularly evaluated using stated criteria in order to prioritize future infrastructure investments, sunset facilities as needed, and adapt to changing science priorities.

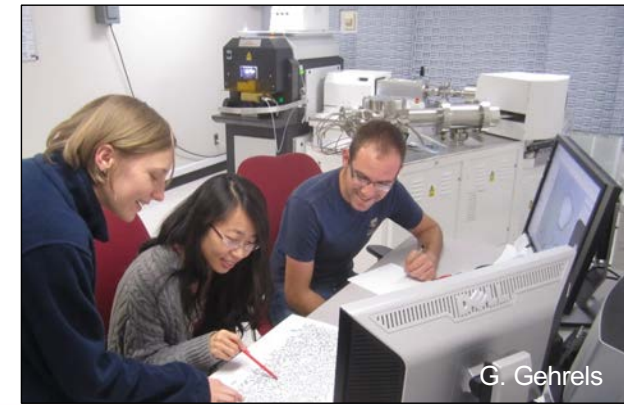
Facilities & Infrastructure Approach

Analyzed three components of infrastructure:

- Instruments
- Cyberinfrastructure
- Humans



(NSF 10 Big Ideas)



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Synchrotron and people
in lab working.

Possible New Initiatives

- Originate from EAR research communities - based on questionnaire responses, community white papers, presentations in public sessions
- Funding will require either a source of new funds and/or sunsetting some current programs

Recommendations for New Initiatives

- EAR should fund
 - a National Consortium for Geochronology
 - a Very Large Multi-Anvil Press User Facility
 - a Near-Surface Geophysics Center
- EAR should support continued community development of the SZ4D initiative, including the Community Network for Volcanic Eruption Response.

Recommendations for New Initiatives

- EAR should encourage the community to explore
 - a Continental Critical Zone initiative
 - a Continental Scientific Drilling initiative
- EAR should facilitate a community working group to develop mechanisms for archiving and curation of currently existing and future physical samples and for funding such efforts.

Cyberinfrastructure Recommendations

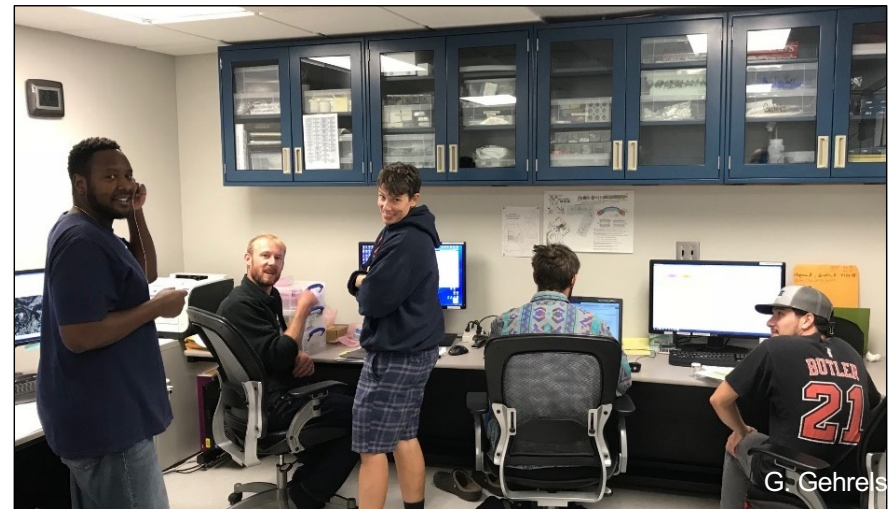
- EAR should initiate a community-based standing committee to advise EAR regarding cyberinfrastructure needs and advances.
- EAR should develop and implement a strategy to provide support for FAIR practices within community-based data efforts.



Hand with computer code.

Human Infrastructure Recommendations

- EAR should commit to long-term funding that develops and sustains technical staff capacity, stability, and competitiveness.
- EAR should enhance its existing efforts to provide leadership, investment, and centralized guidance to improve diversity, equity, and inclusion within the Earth science community.



Lab team at the Arizona Laserchron Center.

Final Thoughts

- EAR's mission is more important and urgent than ever
- Science priority questions illustrate the significance, breadth, and magnitude of the challenges and opportunities for Earth science research in the next decade
- Implementing cyber and human infrastructure recommendations will require not just a commitment of funding, but significant changes to “business as usual” for the community
- EAR already leads investigation of Earth as an interconnected system and is poised to launch the next decade of innovative research

Thank You



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