A review of EarthScope activities related to this workshop (or, what do you need to know about EarthScope to get by in this meeting)

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With thanks to Maggie Benoit (College of New Jersey)

EarthScope - #1 Most Epic Project!

PHOTO GALLERIES

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Big Science: The Universe's Ten Most Epic Projects

By Gregory Mone, Brooke Borel, Katherine Bagley and Jennifer Abbasi Posted 7.16.11 at 8:06 pm 12 Comments

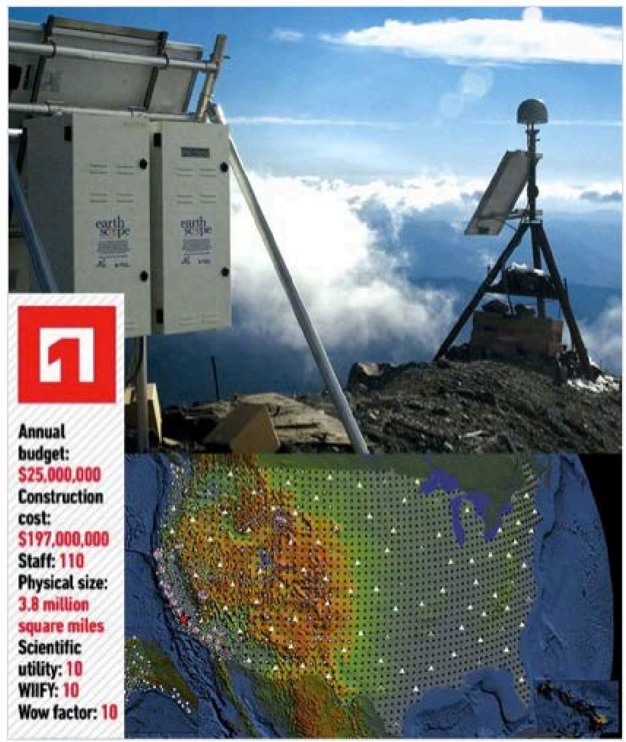


IMAGE 10 OF 10

1: The Earthscope

EarthScope

A telescope to peer deep into the heart of our planet

Designed to track North America's geological evolution, EarthScope is the largest science project on the planet. This earth-sciences observatory records data over 3.8 million square miles. Since 2003, its more than 4,000 instruments have amassed 67 terabytes of data—that's equivalent to more than a quarter of the data in the Library of Congress—and add another terabyte every six to eight weeks

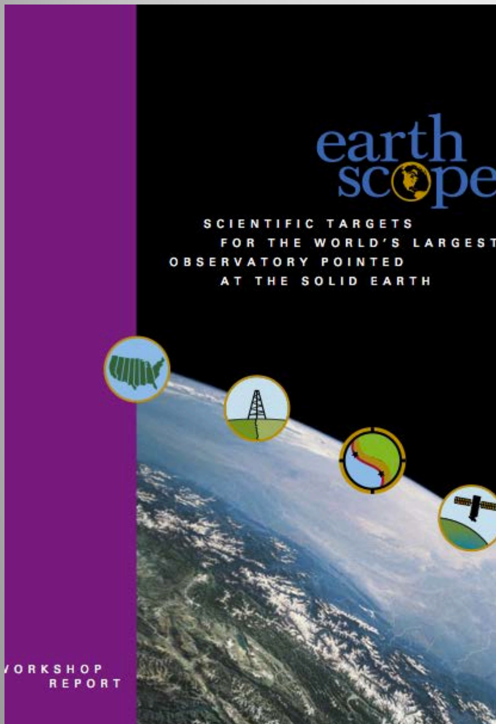
Scientific Utility

Researchers are using EarthScope, which consists of many kinds of experiments, to examine all facets of North America's geological composition. Across the continental U.S. and Puerto Rico, 1,100 permanent GPS units track deformations in the land's surface caused by tectonic shifts below. Seismic sensors next to the active San Andreas Fault in California record its tiniest slips, while rock samples pulled from a drill site that extends two miles into the fault reveal the grinding and strain on the rocks that occur when the two sides of the fault slide past each other during an earthquake. And over the course of 10 years, small crews have hauled a moveable array of 400 seismographs across the country using backhoes and sweat. By the time the stations reach the East Coast next year, they will have collected data from almost 2,000 locations.

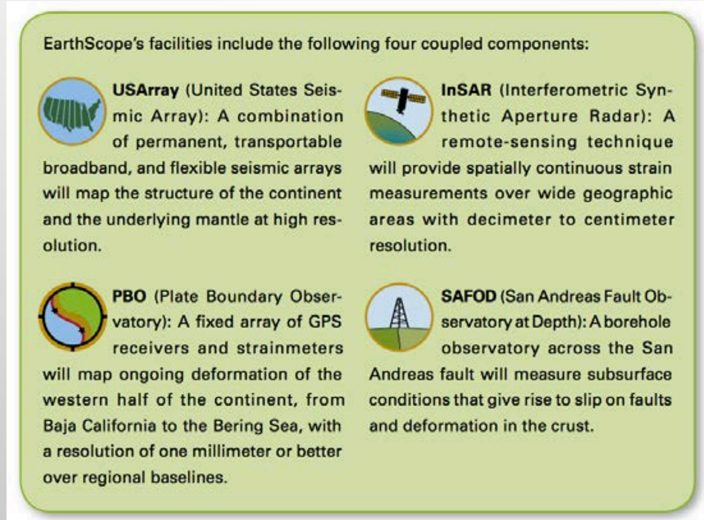
What's In It For You

Collectively, EarthScope's measurements could help explain the forces behind geological events such as earthquakes and volcanic eruptions, leading to better detection. So far, data from the project has shown that rocks in the San Andreas Fault are weaker than those outside it and that the plume of magma under Yellowstone's supervolcano is even bigger than previously suspected.

What is EarthScope?



Snowbird, 2001



EarthScope's facilities include the following four coupled components:

USArray (United States Seismic Array): A combination of permanent, transportable broadband, and flexible seismic arrays will map the structure of the continent and the underlying mantle at high resolution.

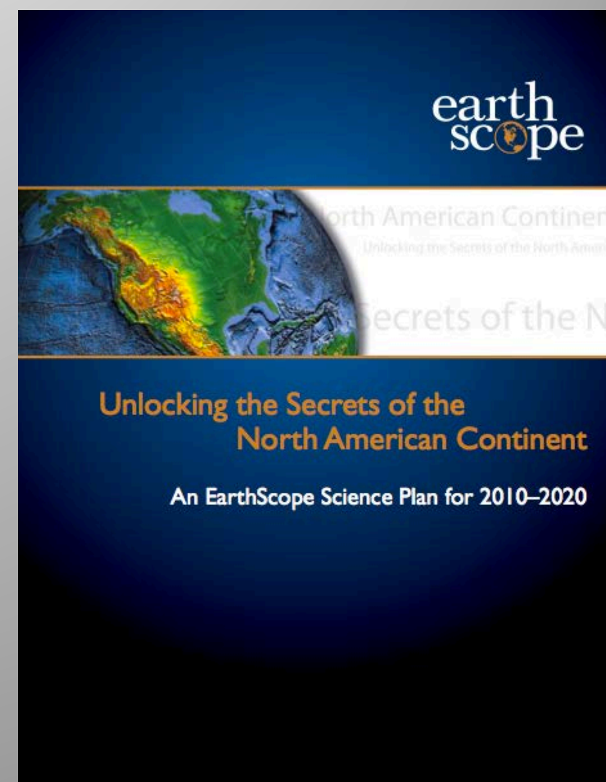
InSAR (Interferometric Synthetic Aperture Radar): A remote-sensing technique will provide spatially continuous strain measurements over wide geographic areas with decimeter to centimeter resolution.

PBO (Plate Boundary Observatory): A fixed array of GPS receivers and strainmeters will map ongoing deformation of the western half of the continent, from Baja California to the Bering Sea, with a resolution of one millimeter or better over regional baselines.

SAFOD (San Andreas Fault Observatory at Depth): A borehole observatory across the San Andreas fault will measure subsurface conditions that give rise to slip on faults and deformation in the crust.

Facility development and improvement are a big part of EarthScope

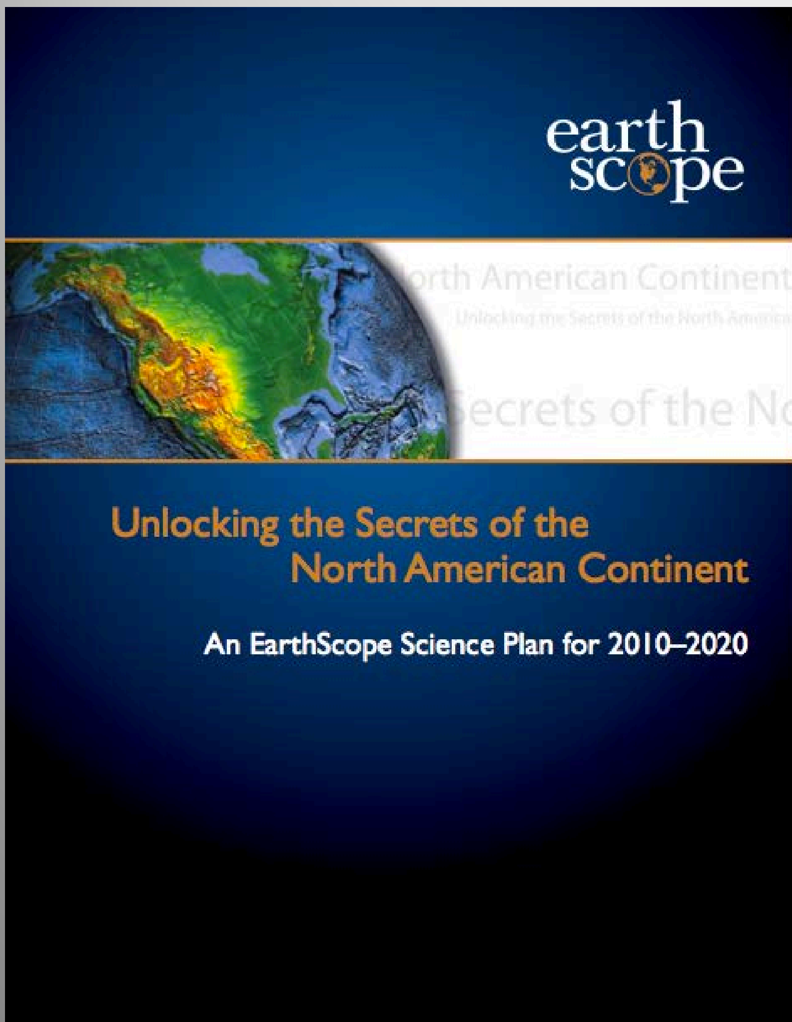
Snowbird, 2009



2001 → Today

EarthScope's vision is to use North America as a natural laboratory to gain fundamental insight into how Earth operates.

Community Driven Science in EarthScope

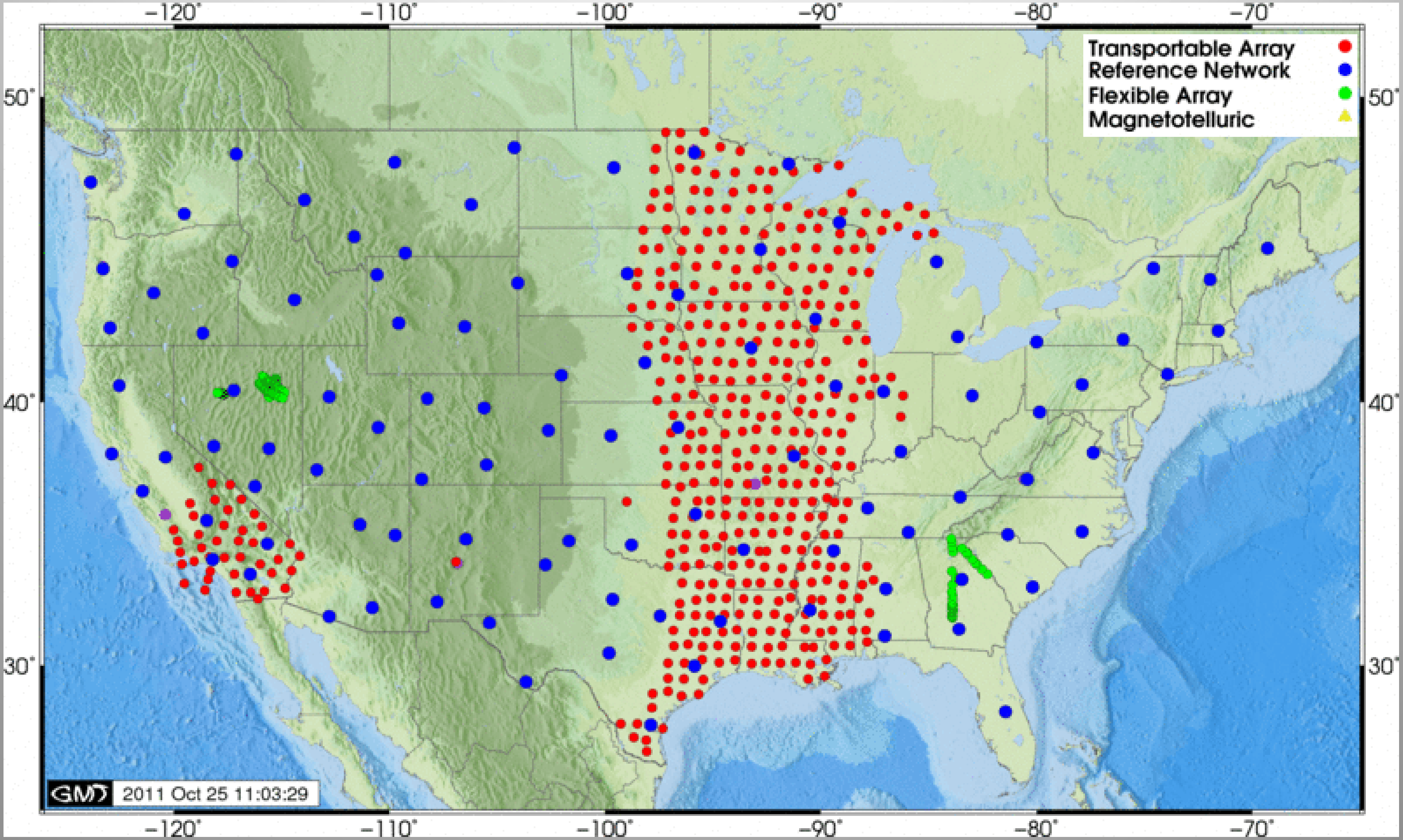


Science Questions outlined through a number of workshops culminating in new science plan

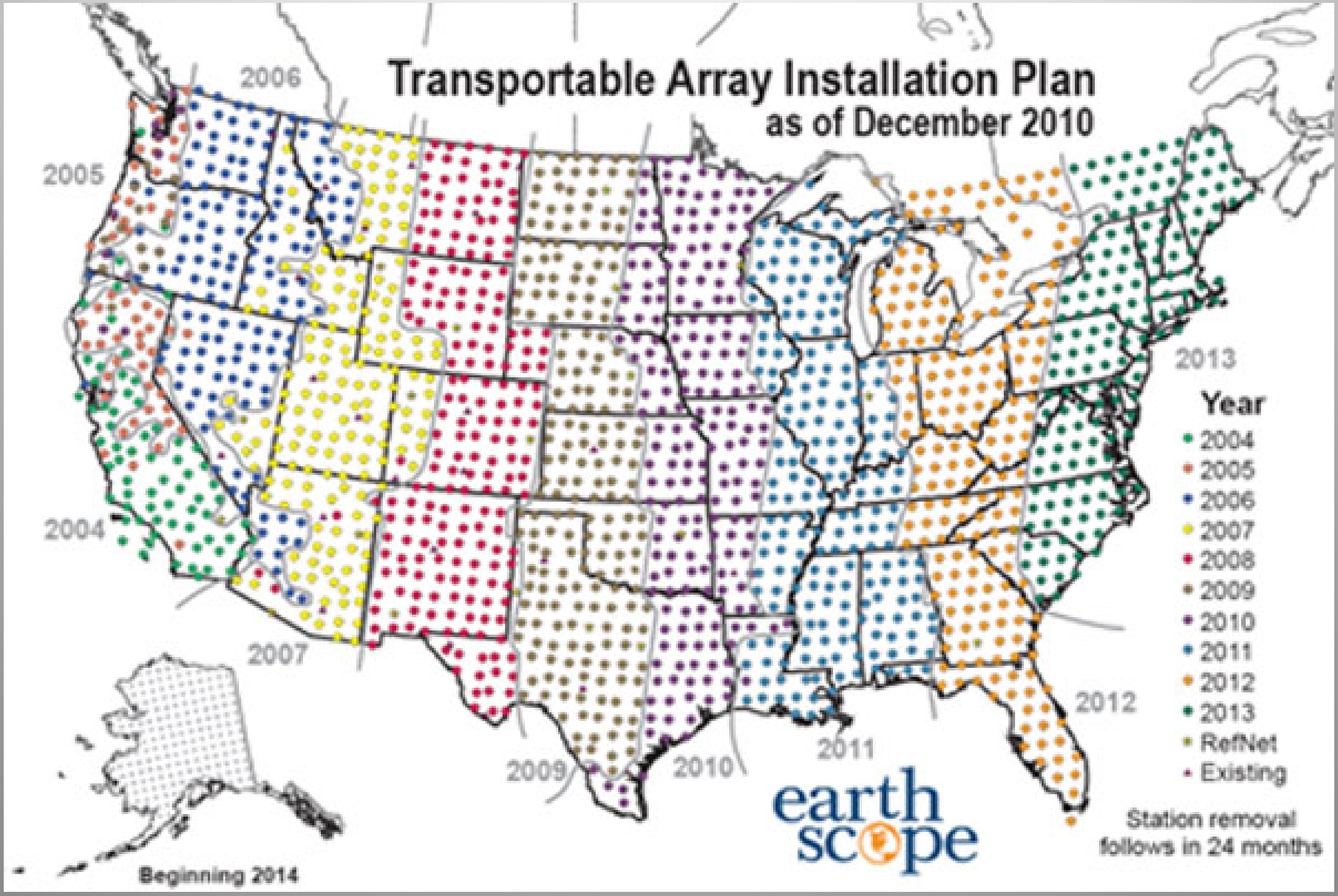
1. Imaging the Crust and Lithosphere beneath North America
2. Examine Active Deformation of the North American Continent
3. Continental Evolution through Time
4. Deep Earth Structure and Dynamics
5. Earthquakes, Faults and Rheology of the Lithosphere
6. Magma and Volatiles in the Crust and Mantle
7. Topography and Tectonics
8. EarthScope and the Hydrosphere, Cryosphere and Atmosphere

Williams, Fisher, Freymueller, Tikoff, and Trehu

Current USArray Status



TA coming to ENAM soon…



How to talk EarthScope (US Array)

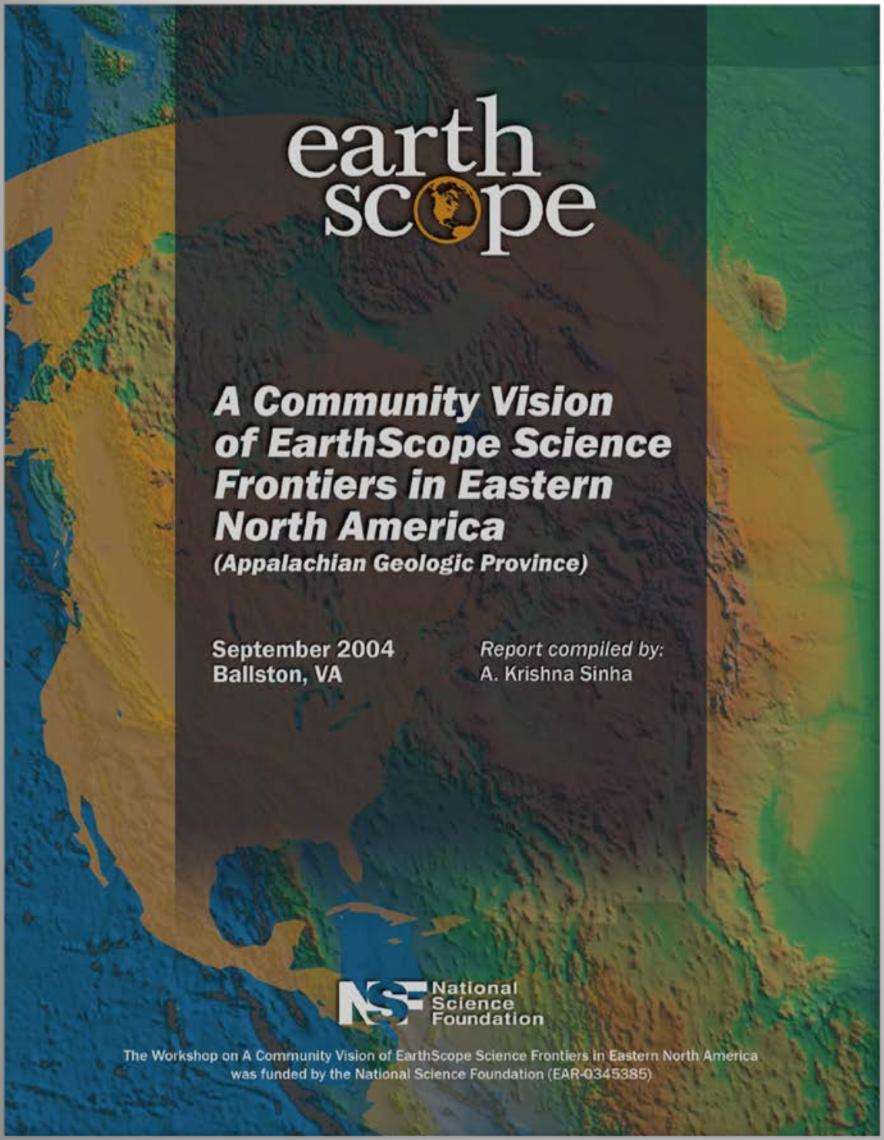
- TA – Transportable Array
  - These are the seismometers that move in a swath across the US (except Hawaii)

  Note to geologists: The 70 km spacing of the TA will not allow resolution of crustal features, save Moho depth

- FA – Flexible Array
  - These are the ~400 broadband and intermediate seismometers (passive) and ~1700 Texans (active). The FA broadband seismometers are chronically overbooked (booked ~2 years in advance). The Texans sit idly some of the time.

Previous EarthScope workshops worth knowing about

- 2007: EarthScope/Margins workshop prior to 2007 Biannual EarthScope meeting in Monterey. Focused on areas of areas of mutual interest to the two programs. This resulted in joint EarthScope/Margins funding for a Salton Trough project (SSIP).
- 2010: Cascadia Initiative in Portland (Joint EarthScope/Margins funding for facility)
- 2004: Appalachian Geology



http://www.earthscope.org/es_doc/workshops/WS-communityvision.pdf

I. Tectonics and magmatism during assembly of a late Middle Proterozoic supercontinent controlled timing, geometry and nature of the following subsequent cycle of supercontinent breakup and reassembly in eastern North America.

II. Lateral transitions in the structure and composition of mantle lithosphere from craton to margin (Archean craton through Mesozoic rifted margin) reflect fundamental changes in the geochemical and geophysical evolution of the earth.

III. Deep subcontinental flow under the eastern U.S., driven by the descending Farallon plate, influences modern tectonics in the eastern U.S.

V. Landscape Evolution of Eastern North America

APPALACHIAN GEOLOGY:
KEY QUESTIONS FOR EARTHSCOPE

Jim Hibbard

with input/ideas from: S. Barr, F. Cook, A. Dennis, P. Karabinos, B. Miller, J.B. Murphy, D. Rankin, M. Steltenpohl, K. Stewart, W. Thomas, C. van Staal

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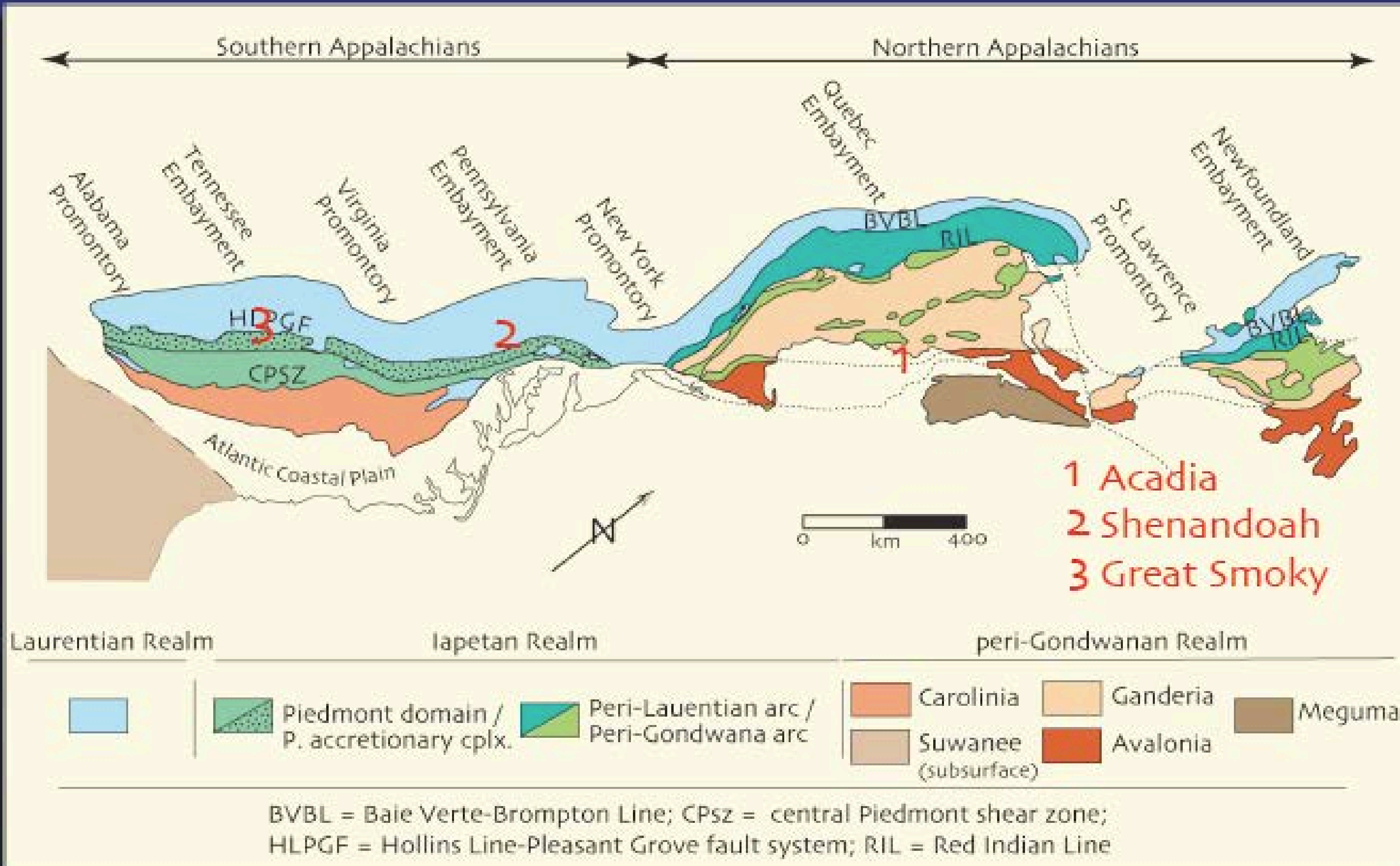


Major lithotectonic elements of the Appalachian Orogen

Continental Structure, Deformation, & Evolution (Hibbard et al.)

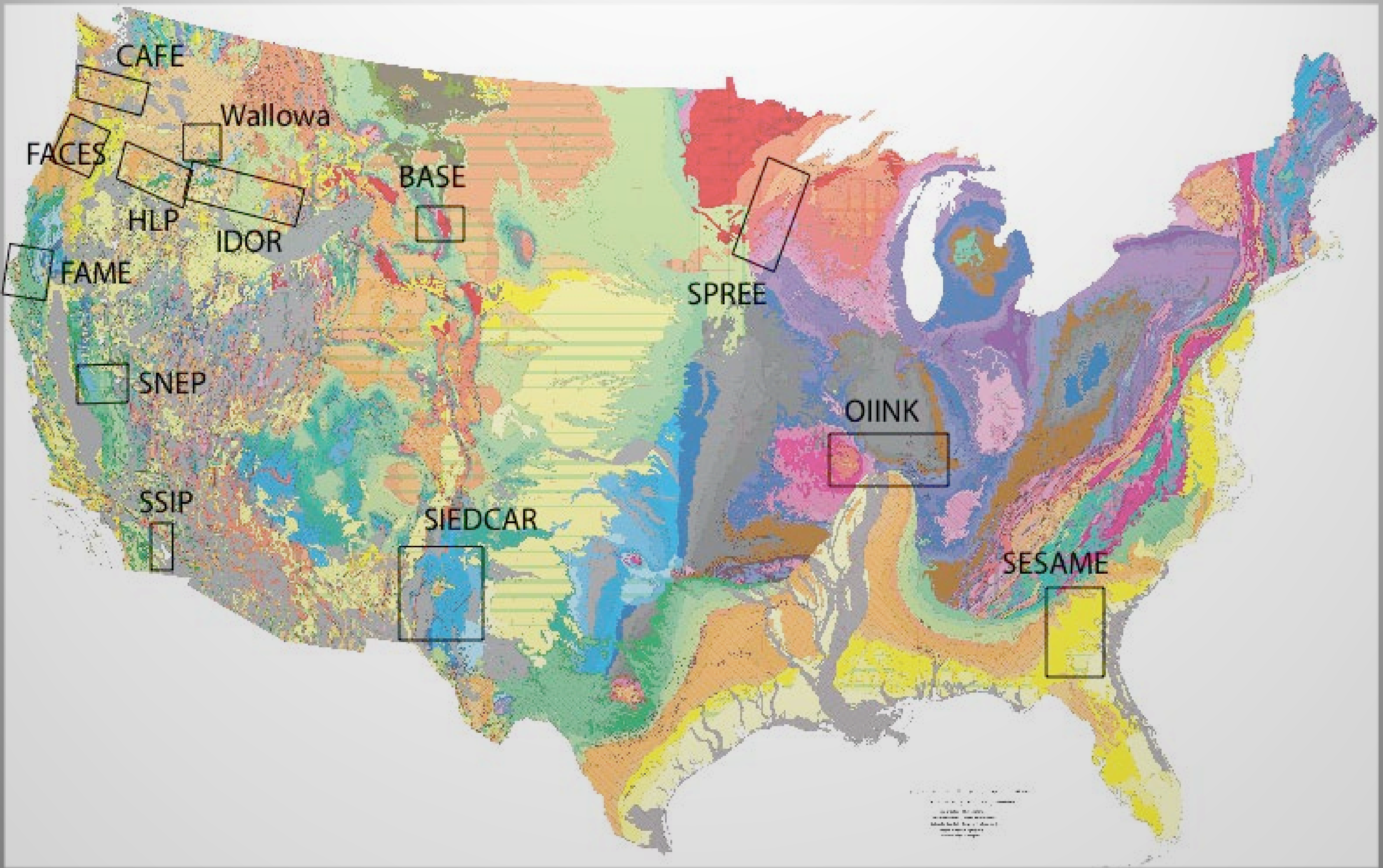
- What is the response of the subcrustal lithosphere to the youngest events: Alleghanian shorteing (continent-continent collision) & Mesozoic extension?
- Do remnants of older lithospheric scale events (e.g., suturing Carolinia) yet lurk in the lower crust to mantle (e.g., NY-AL lineament, Paleozoic delamination/slab breakoff events)
- Upper crustal geology records simple progressive outward growth of the continent – is there any record of this growth pattern in the lower crust and/or mantle? If not, what pattern of growth is recorded there?

Crustal strain and deformation(Hibbard et al.)

What is the rheological persistence of Iapetan ridge-transform geometry and interaction of oceanic fractures with the continent. If the Moho and mantle are rejuvenated in the late Paleozoic-Mesozoic, does the crust preserve memory of this ridge-transform template?

Important point of all EarthScope activity: It is often best at seeing large-scale patterns!

Approximate position and extent of funded EarthScope experiments



What has gotten funded for FA projects?

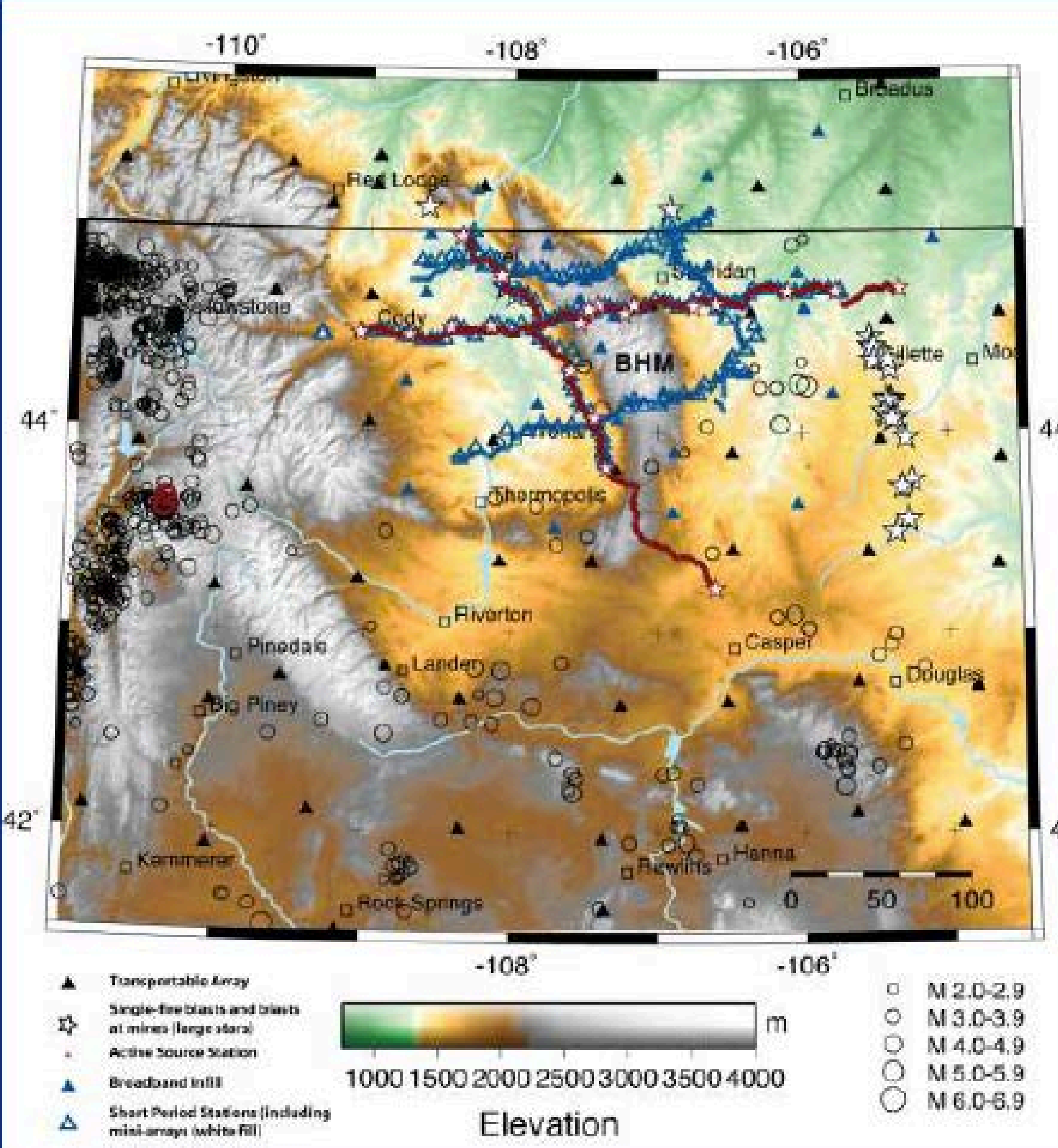
- Small groups (typically 2-3 seismology PIs, typically 4-5 for integrated projects)
- Most groups contain a passive source seismologist. Some contain only passive source seismologists. A few contain active source seismologist (SSIP, Bighorn, IDOR).
- There are multiple examples of 2-3 geophysicists and 2-3 geologists doing integrated science.

Formation of Basement-Involved Foreland Arches: New Results from the EarthScope Bighorn Project

Eric Erslev* and Karen Aydinian, University of Wyoming; Anne F. Sheehan, William L. Yeck, Zhaohui Yang, Colin O'Rourke, and Joshua C. Stachnik, University of Colorado; Kate C. Miller and Lindsay L. Worthington, Texas A&M University; Megan L. Anderson and Christine S. Siddoway, Colorado College and Steve H. Harder, University of Texas at El Paso
* Speaker, P.I.s highlighted in yellow

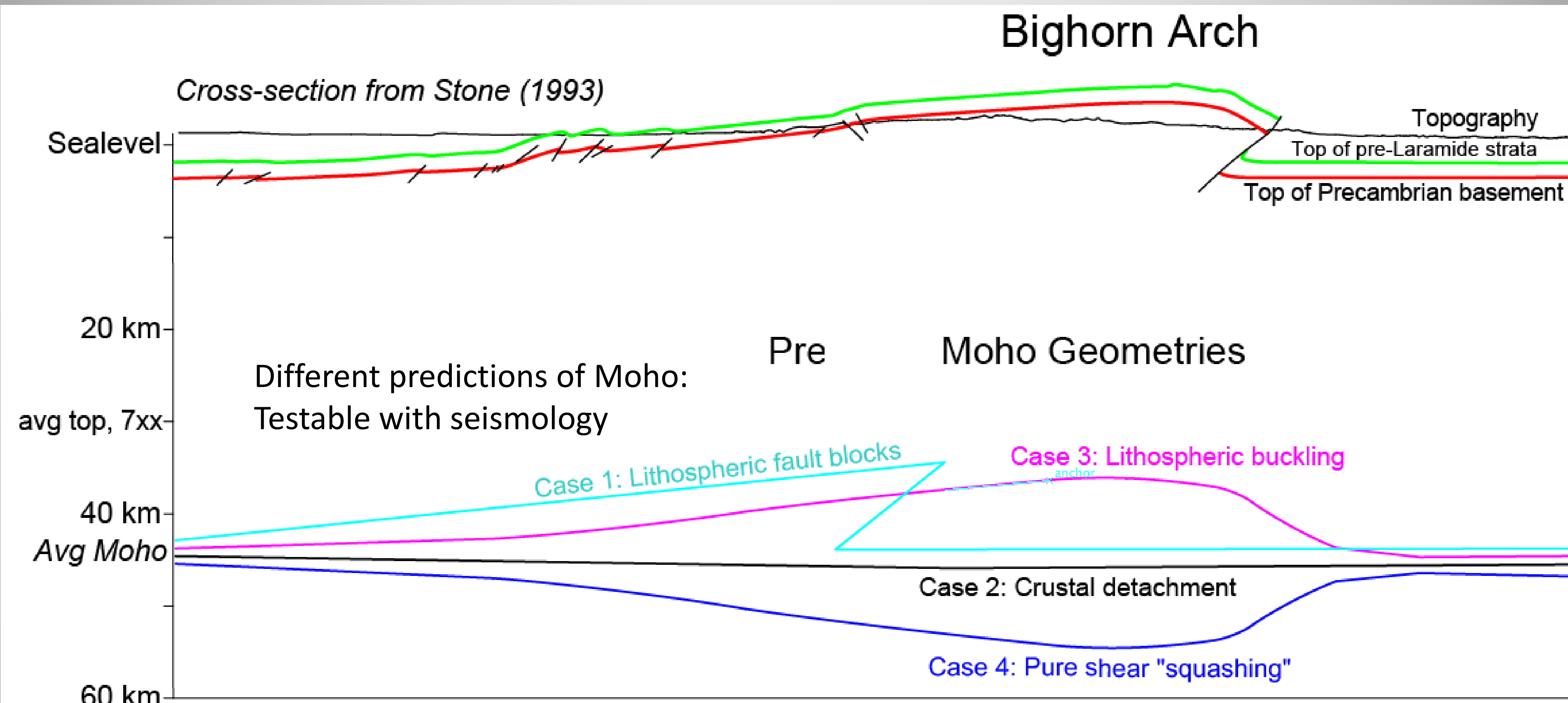
BASE: 5 Passive and Active Seismic Experiments

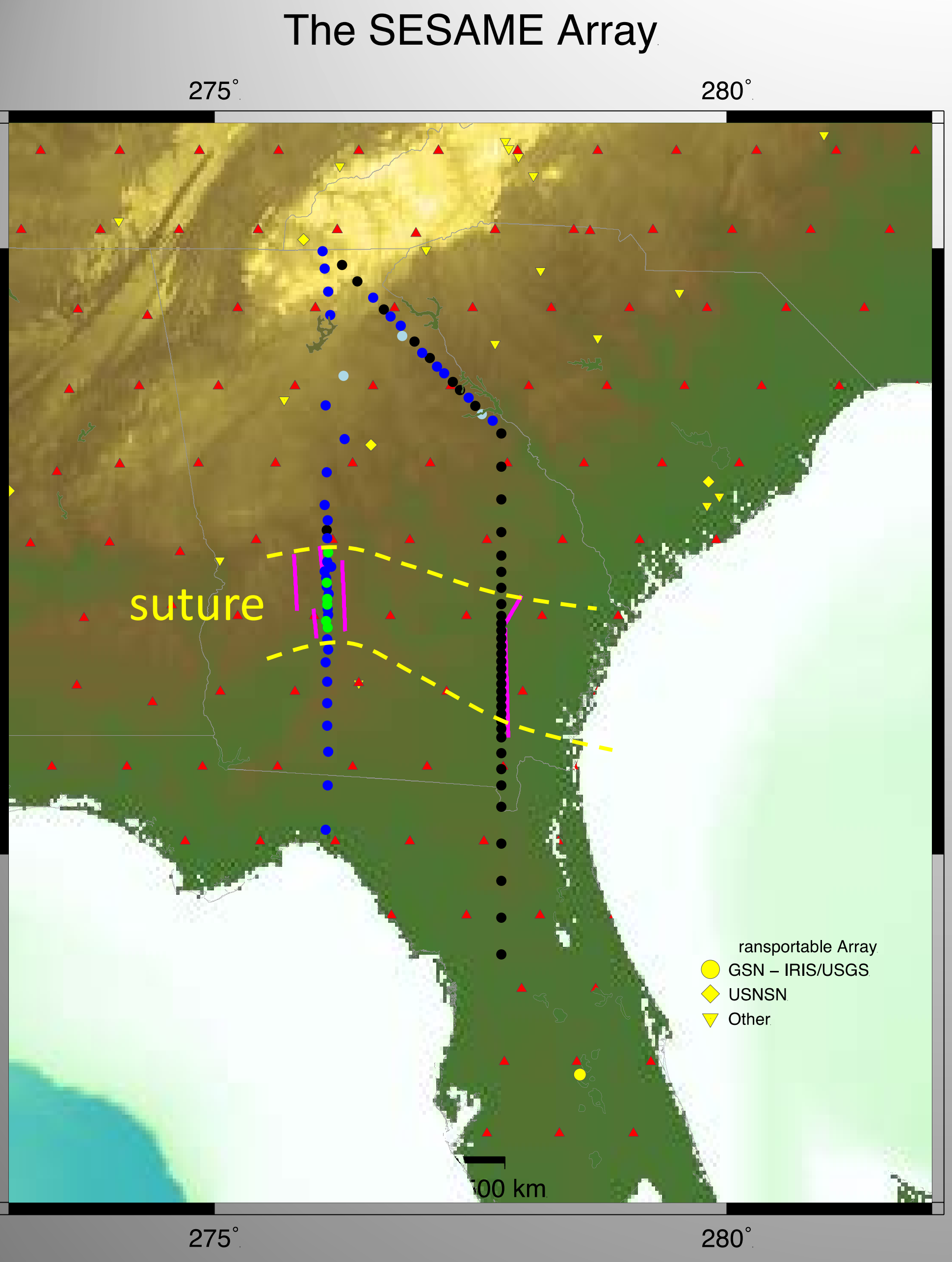
- 39 (27) broadband stations – 1 year, 35 km spacing
- 170 short period stations – 6 months, 5-10 km spacing
- Active source experiment – 1800 Texan seismographs, 24 shots 0.1 – 1 km
- Passive Texan deployment, 850 Texan seismographs, 12 days, 1 km spacing
- three 5-element regional arrays, one w/ co-located infrasound, 6 months



Character of Laramide faulting in the crystalline core of the Bighorn arch

Christine Siddoway // Colorado College

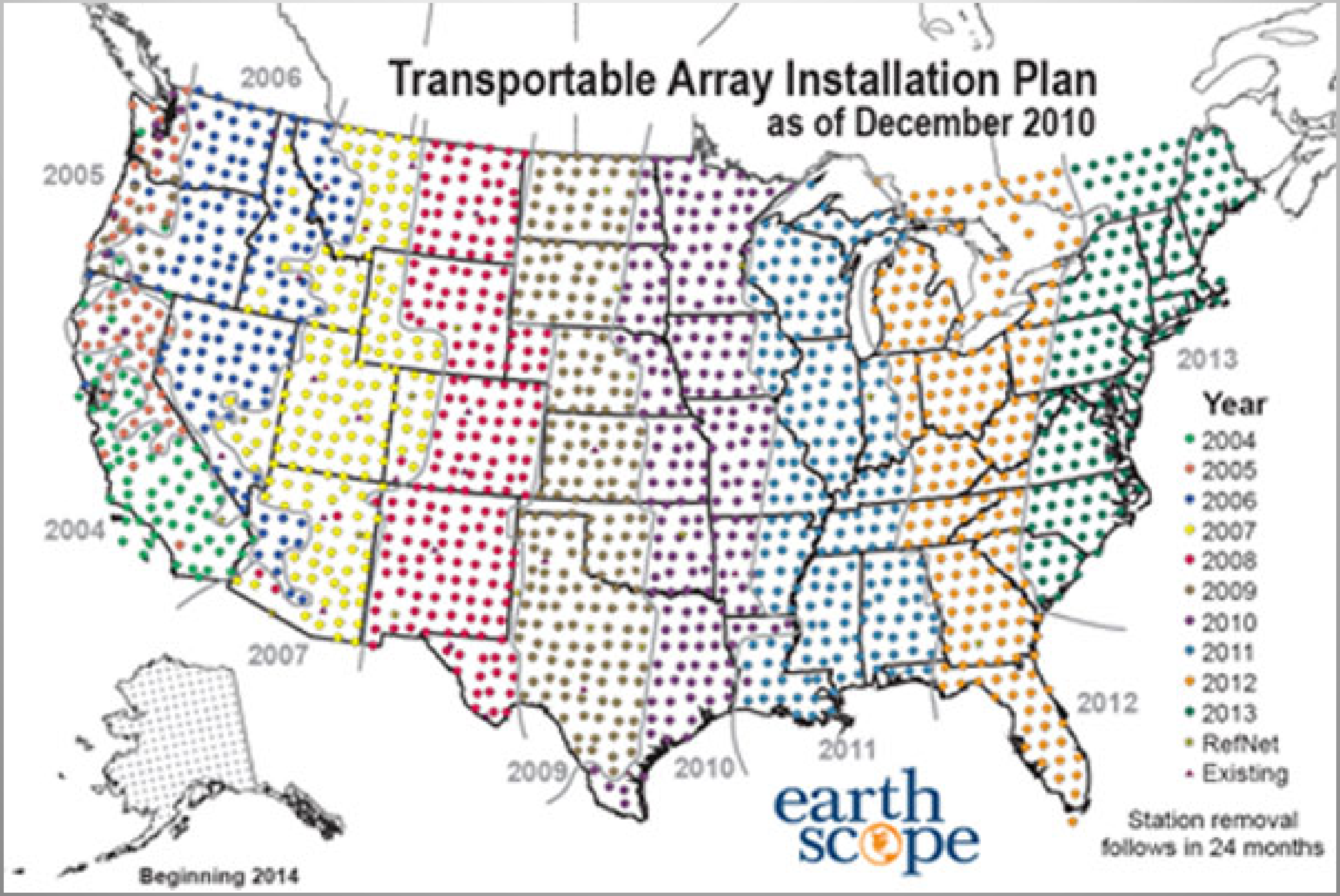




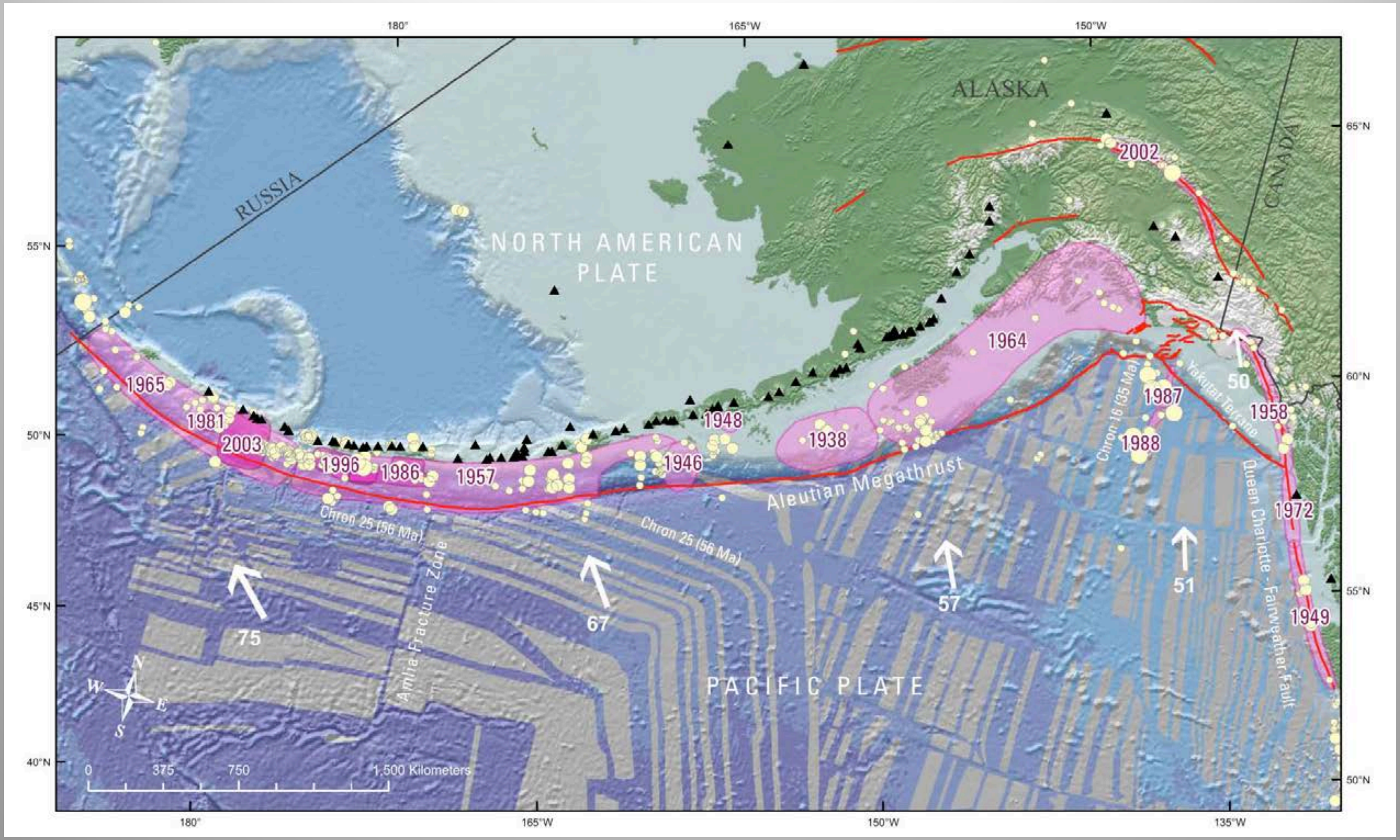
SESAME: Imaging the lithospheric suture between Laurentia and Gondwana and subsequent rifting processes

- Funded by NSF/EarthScope
- 85 BB USArray/FA seismometers
- PIs:
    - Karen Fischer, Brown University
    - Rob Hawman, Univ. of Georgia
    - Lara Wagner, UNC, Chapel Hill
    - Don Forsyth, Brown University
- Stations deployed 2010-2012
- In field until 2014 to coincide with TA
- Will image crust and mantle structure

What happens after 2015?

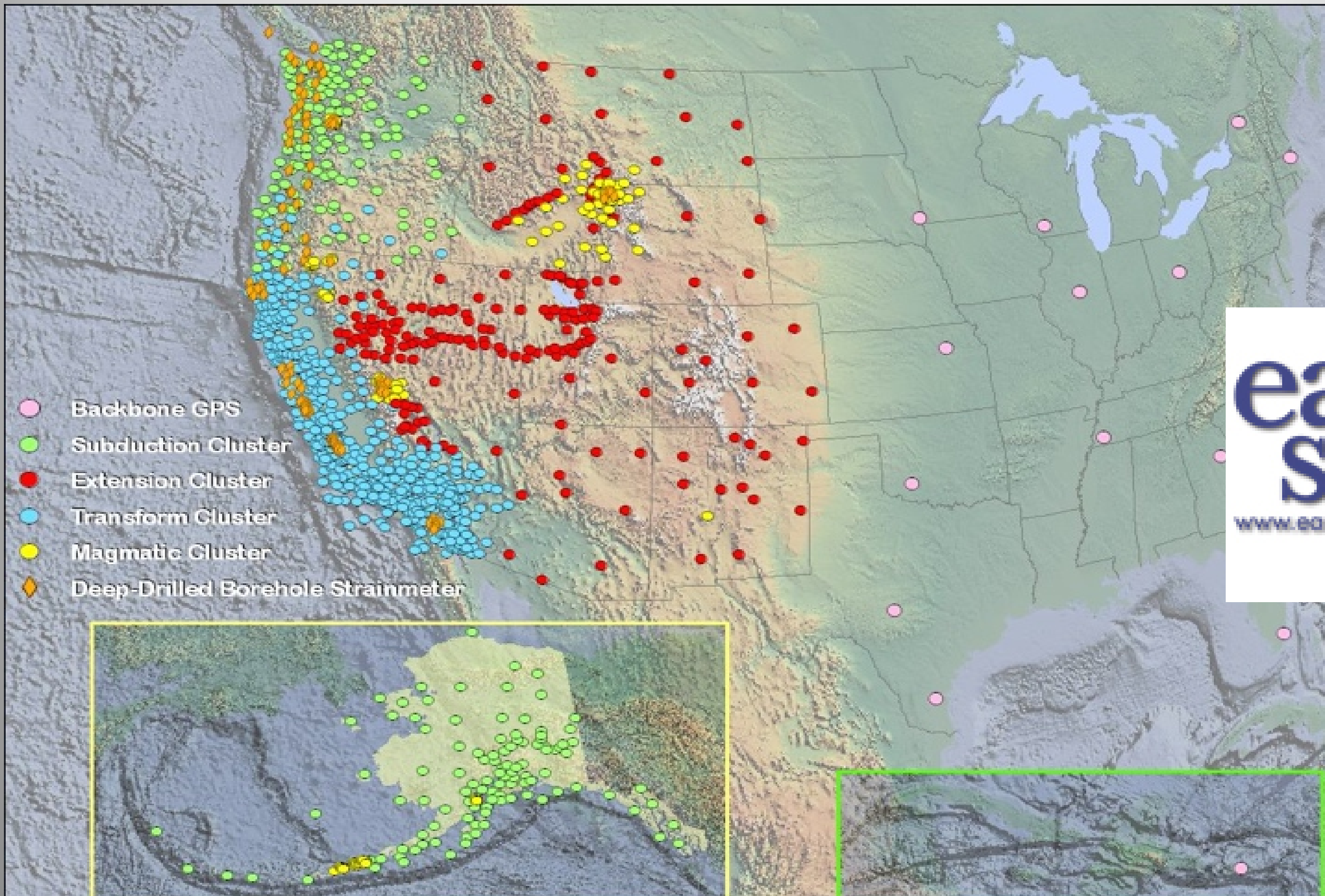


Alaska!



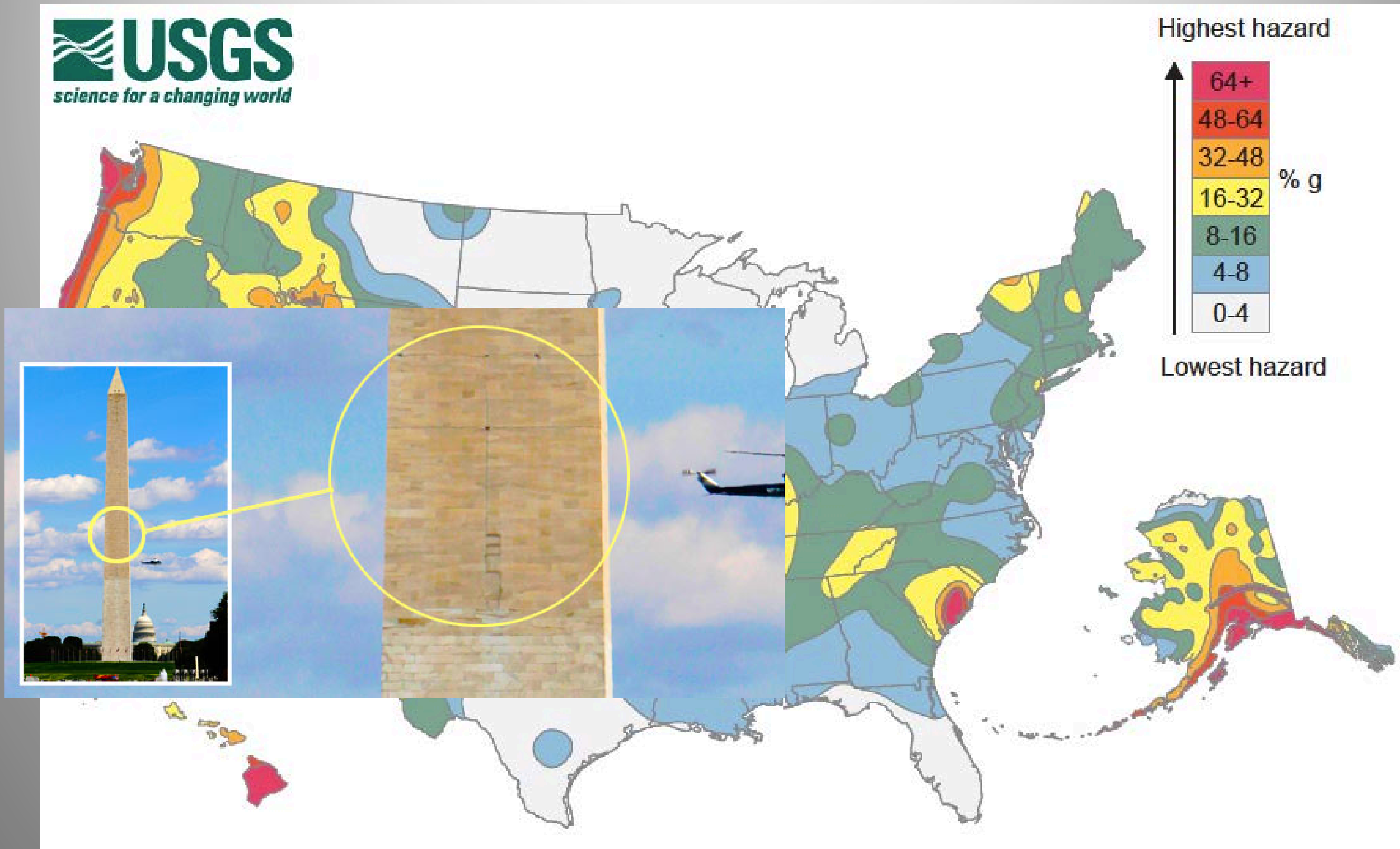
But, as it turns out, the Alaska array will not use all of the USArray Transportable Array, which leads many people to think many things about what to do with, say, a bunch of extra broadband seismometers…

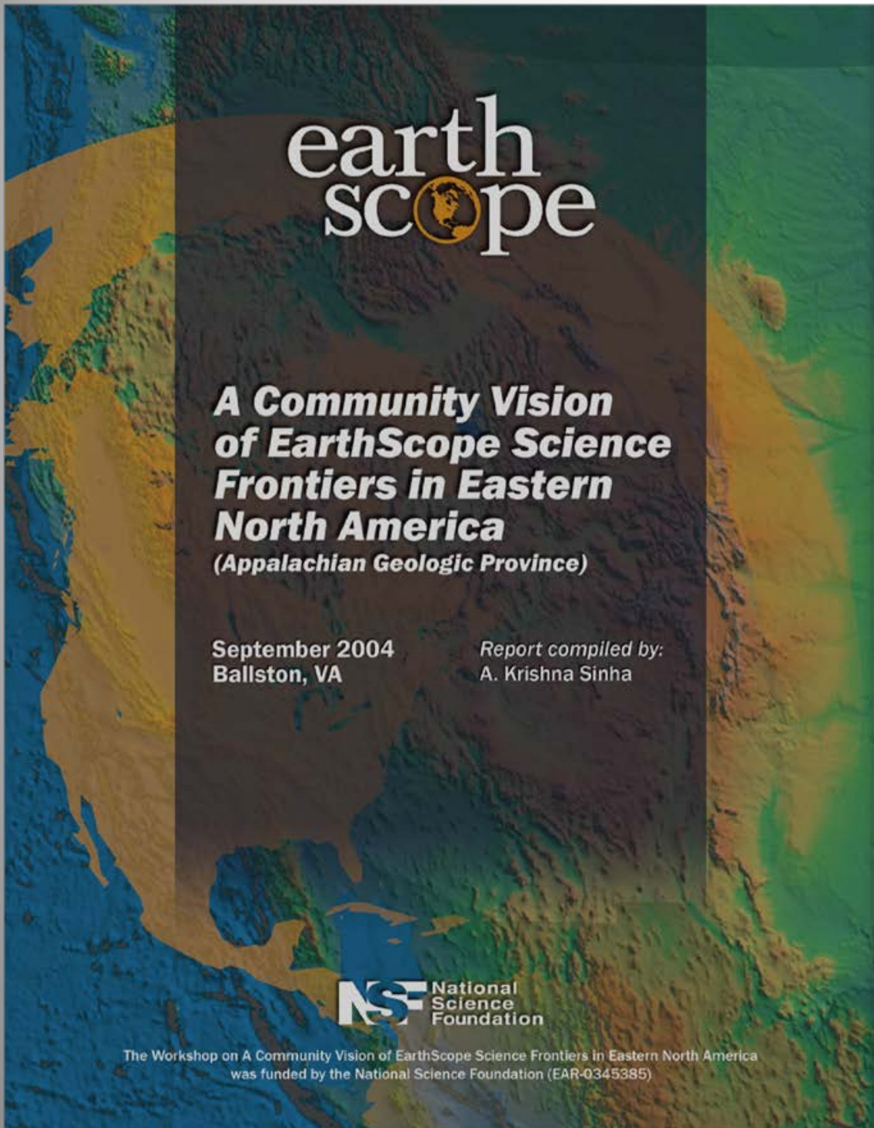
Plate Boundary Observatory (PBO)



1100 permanent Global Positioning System (GPS) stations, 78 Borehole Seismometers, 74 Borehole Strainmeters (BSM), 26 Tiltmeters and 6 Laser Strainmeters (LSM) are currently deployed in the integrated PBO network and are collecting data on a real-time to near-real-time basis.

Passive-Aggressive Margin Observatory (PAMO)





IV. Spatial Variations in Lithospheric Thickness and Structure and Temperature
Distribution Influence the Occurrences, Spatial Distributions, and Stress Directions of Modern Earthquakes, and Neotectonic Deformations in the Intraplate Eastern North America

-Tectonic Strain Accumulation in Eastern North America

-Seismic Hazard Delineation by Regional and Focused Local Earthquake Monitoring

-Intraplate Earthquakes and Lithospheric Structure in Eastern North America

http://www.earthscope.org/es_doc/workshops/WS-communityvision.pdf

How are EarthScope and GeoPrisms going to interact?

earthscope
www.earthscope.org

GeoPRISMS Geodynamic Processes at Rifting and Subducting Margins

What are their differences?
What are their similarities?
Where are the areas of overlap for mutual benefit?

Alignment of EarthScope and GeoPRISMS science objectives

RIE questions -> EarthScope targets | V	Continental Rift Initiation	Evolution of rifting processes	Control of architecture of rifted margins	Mechanisms and consequences of fluid and volatile exchanges with earth, oceans, atmosphere	Cross the shoreline?
Imaging crust and lithosphere	X	X	X		Y
Active deformation of the continent	X	X			Y
Continental evolution	X	X	X		Y
Deep earth structure and dynamics	X				Y
EQs, faults, and rheology of the lithosphere	X	X	X		Y
Magmas and volatiles in the crust and lithosphere				X	Y
Topography and tectonics		X	X	X	Y
Connections to Hydrosphere, crysophere, atmosphere				X	Y

Summary

earth scope
www.earthscope.org

GeoPRISMS
Geodynamic Processes at Rifting and Subducting Margins

- Both programs have community driven science, but the approaches are a bit different
- In particular, EarthScope has only supported PI driven science, without the explicit designation of research areas (unless you count the continental US as the research area)
- This workshop is designed to outline the common research objectives