CS-11-039

Site Code 457A-2

Revocable Permit and Land Use Agreement for an EarthScope Seismic Station

EarthScope is a National Science Foundation (NSF) project to investigate the structure of the North American continent and the physical processes controlling earthquakes and volcanic eruptions. Incorporated Research Institutions for Seismology (IRIS), a non-profit consortium of over 100 U.S. universities, manages facilities for seismological research and is responsible for the installation, operation and removal of the earthquake monitoring equipment of EarthScope under a cooperative agreement with the National Science Foundation. NSF as a federal agency retains title to all equipment.

The undersigned Nassau County Board of County Commissioners (hereinafter called the PERMITTER) hereby grants, as owner of the property, the

Incorporated Research Institutions for Seismology (IRIS)
1200 New York Ave, NW #800
Washington DC 20005
(202) 682-2220
(800) 504-0357

(hereinafter called IRIS) permission to install, operate, maintain and service a Seismic Recording System as part of the EarthScope project. Such Seismic Recording System measures ground movements caused by earthquakes and other natural sources at the location specified below and in attached images and maps (if required):

On the property located at: T2N R27E sec38

Site within 100 meters of: 30.61982, -81.55623
And as shown in accompanying reconnaissance report.

The permit is given without charge in consideration of the above and the following:

1. This permit is for the period beginning 12 / 1 /2011 and continuing for 60 months. The Permitter may terminate this agreement at any time with or without cause upon 30-day notice in writing to IRIS.
2. IRIS or their agent will notify the Permitter (or Permitter's agent) prior to the day of installation of the equipment. IRIS will notify the Permitter (or Permitter's agent) prior to entry for any maintenance visits if required.
3. IRIS accepts the premises in an "as is" condition and upon completion of the permit, agrees to restore the premises as nearly as possible to the condition at the start of the permit.
4. Permitter will not be held responsible for loss of, or damage to, NSF equipment on the property. IRIS agrees to hold Permitter harmless from claims resulting from the activities of IRIS or IRIS' contractors on Permitter's property, and claims resulting from Permitter's activities on the property to assist IRIS or IRIS contractors.
5. IRIS agrees that the installation and maintenance of the seismic equipment on the lands of the Permitter on which they are installed shall be effected with reasonable diligence to avoid damage to the land.
6. IRIS agrees to reimburse Permitter for electrical power, if such power is used and Permitter requires reimbursement.

Permitter name, title, signature and date:

Walter J. Boatright, Chairman

X Walter J. Boatright

X ______
(if property held jointly)

DATE: 10/10/11

IRIS Designee, title, signature and date:

Robert Busby, IRIS, TA Manager

X [signature]

DATE: September 21, 2011

& BK
10/10/11

earth scope USArray

IRIS

RECEIVED NASSAU COUNTY ENGINEERING SERVICES DEPARTMENT

2011 SEP 14 P 3:01

Robert W. Busby
TA Manager
37 Haynes Avenue
Falmouth MA, 02540
busby@iris.edu
508-801-7628

August 30, 2011

Ted Selby / Scott Herring
Nassau County Commission
96135 Nassau Place, Ste. 1
Yulee, FL 32097

Dear Mrs Selby, and Herring

Thank you very much for your offer to host a USArray Earthquake Monitoring Station on your property. We very much appreciate your interest in our project.

Enclosed are two copies of the Land Use agreement. This agreement allows us access to the property for the purpose of installing a monitoring station. You are free to terminate this agreement and we will remove the equipment any time you no longer desire to host our station. **If you are comfortable with the agreement, please sign both copies. Retain one for yourself and return the other copy to us.** If you have any questions, please contact me.

Also enclosed is a copy of our reconnaissance report that provides more details as to the exact construction planned. Please review this to be sure you know where the site will be constructed, and to ensure that it is on your property. Also, if you have any safety concerns regarding access to the site and the dig location, let me or those performing work on your property know. In particular, if you know of any utilities or septic systems in the planned route and dig location, please make us aware of that information.

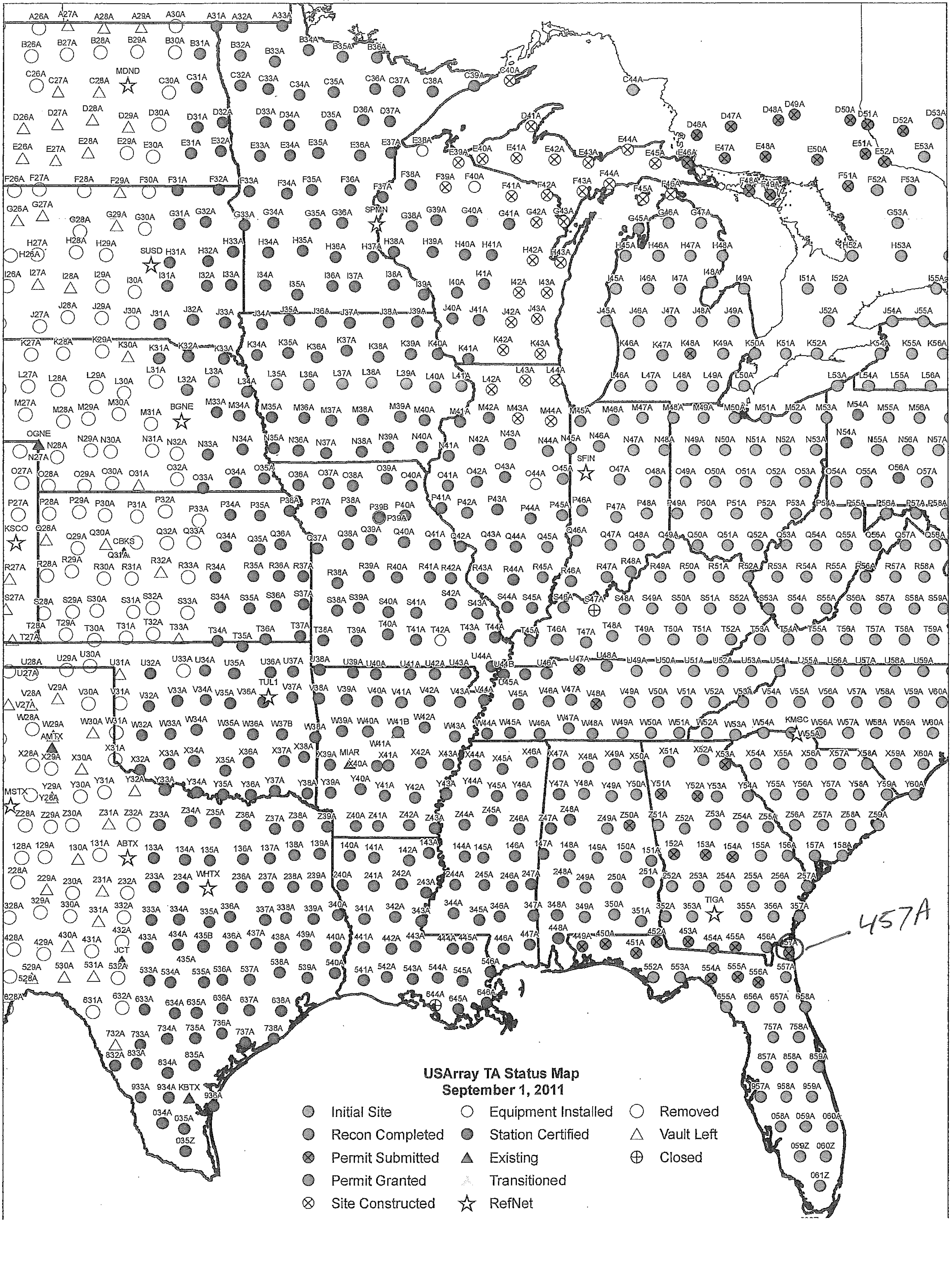
We plan to send a construction crew in November 2011, or at an alternate time you suggest. A construction crew member will contact you a week in advance to schedule the exact dates of construction. We will bring a backhoe and small cement mixer in order to construct a hole for our tank and to cement the tank in place. We will install the actual monitoring equipment after the cement hardens, approximately three to four weeks later.

You will be able to see details of the monitoring system on your land on a web site. It will also display earthquake recordings for recent events from this station. See http://usarray.seis.sc.edu/ and enter station code 457A.

Again, thank you for your help. If you decide against hosting our station, please indicate that on the permit and return it to us. We remain grateful in either case.

Sincerely,

Robert W. Busby


USArray TA Status Map
September 1, 2011
Initial Site
Recon Completed
Permit Submitted
Permit Granted
Site Constructed
Equipment Installed
Station Certified
Existing
Transitioned
RefNet
Removed
Vault Left
Closed
457A

Reconnaissance Report

USArray Transportable Array

Site: 457A-2
Reported by: Guri Zeigerman, Marko Steiger
Visitors: Guri Zeigerman, Marko Steiger
Date of Initial Recon: July 12, 2011
Revised: DL110824
Verified: LJ110823

Coordinates: 30.61982, -81.55623
Elevation: 9 meters
Time Zone: Eastern
Construction: January 2012

Landowner:

Name: Nassau County
MAIL Address: Board of Commissioners
PO BOX 1010
Fernandina Beach, FL 32035-1010

Phone: (904) 491-7380

SITE Address: T2N R27E Section 38 at GPS Coordinates

Contact:

Name: Ted Selby (County Manager)
Address: 96135 Nassau Place
Suite 1
Yulee, FL 32097

Phone: (904) 491-7380
Email: tselby@nassaucountyfl.com

Point of Contact:

Name: J. Scott Herring, PE, Public Works Director
Address: 96161 Nassau Place
Yulee, FL

Phone 904 491-7330
Toll free: 877 588-6860
Email: www.nassaucountyfl.com

Recheck:	DL110824
Access:	Two Wheel Drive, unless wet
Comm Type:	Verizon Digital Service
Fencing:	Required, standard
Eng. Approval:	DRL110824
Template Ver.	2011_01_19

Driving Directions:

From exit 373 on I-95 near Yulee, FL, take State Road 200/A1A 7.84 miles east till you reach License Road. (30.62709, -81.55665)
Make a right onto License road and go 0.08 miles to the first gate. (30.62343, -81.55724)
Continue going straight through the gate and go 0.25 miles to the second gate. (30.62020, -81.55699)
Go through the second gate and continue ~75 feet, site is to the left(East) ~ 250 feet. (30.61982, -81.55623)

Land Use:

Site area used to be a landfill. Site is no longer being used.

Proximity to Initial Location:

457A-2 is 17.4 km, 216.1° from initial site

Noise:

Noisy, very close to the ocean, urban area, model airplanes on Saturday.
Site is 1.31 Km from SR200
Site is 0.35 Km from nearest building.
Site is 1 Km from a local road.
Site is 2.2 Km from a railroad.

Issues:

- Landowner required to be notified prior to construction/installation. All personnel must notify contact for permission to enter site area for any work in the future.
- Earthscope/USArray, at end of occupying site, will remove equipment and the area will be returned to the same condition it was found.
- There are two locked gates to the property. The first can be opened by the animal control personnel on your left as you turn onto License Rd. The second can be opened by Joe Nordeng, Sr.: Cell: (904) 753-3009
- **CREW NOTE: All crews will be escorted onto property and to the site location**
- Location of owner's residence: Ted Selby's Office Address Above
- Water is not available on site.
- Drive-up access to site: 4WD
- Fencing: Required around solar mast.
- Soil type: Sandy
- Tractor-trailer can unload at the residence.
- Site is secure on private property.
- No bedrock within 7 feet.
- Water table below 4 feet.
- Lodging/restaurants available in: Yulee, FL
- Building materials available in: Home Depot in Yulee, FL

Feasibility:

Comms: Verizon Digital Service

	RSSI in dB	Channel	Network	Internet Access?
Verizon	-88	550	Verizon	YES
AT&T			310410	NO

Verizon Screenshot:

Network IP	166.143.156.116
Network State	Network Ready
Channel	550
RSSI (dBm)	-88

AT&T Screenshot: N/A

Power: 1 solar panel, 2 batteries expected.
Landowner: Very helpful

Initial Construction Plan:

Tank Vault Design A. The station consists of a 42-inch diameter plastic pipe vertically embedded into the ground to a depth of 7 feet (the "vault"), with a concrete base (1.0 cu yd) poured into the bottom. Within 23 feet of the vault, an 8-foot tall mast is installed on which is mounted solar panels, a GPS antenna and a cellular antenna. The vault encloses the seismic sensor, electronics, three atmospheric pressure sensors, and batteries. The vault is completely covered with a mound of dirt for thermal protection and to protect from wind noise. A few feet from the vault mound is a chicken wire bag of gravel that contains the port to the atmospheric pressure sensors.

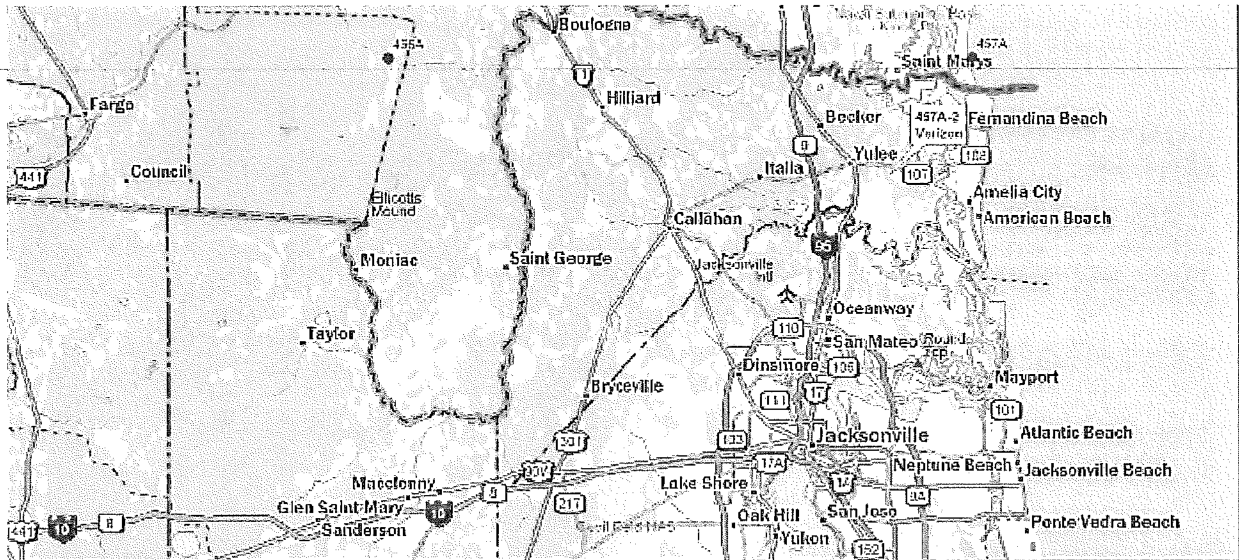
The location for the site should be away from road traffic (1 km), vehicle parking (200 m), irrigation pumps (1-3 km) or windy hilltops. We try to locate the station so that it bottoms onto competent rock so we often select hillsides or ridge saddles. In agricultural land, irrigation pumps are the main concern.

There are no hazardous materials used in the station on in construction. The environmental impacts are limited to a day or two of dust caused by digging the hole, and some increased noise during construction. If clearance is needed for threatened/endangered species or cultural artifacts we hire specialists to perform this work. Either the complete site or just the solar panel mast can be fenced to protect livestock and the equipment.

It usually takes one day to dig the hole, install the vault and lid, and backfill around the vault so there is no unattended open hole. The installation of the sensors and communication equipment occurs on a separate day, usually within 3-6 weeks following construction.

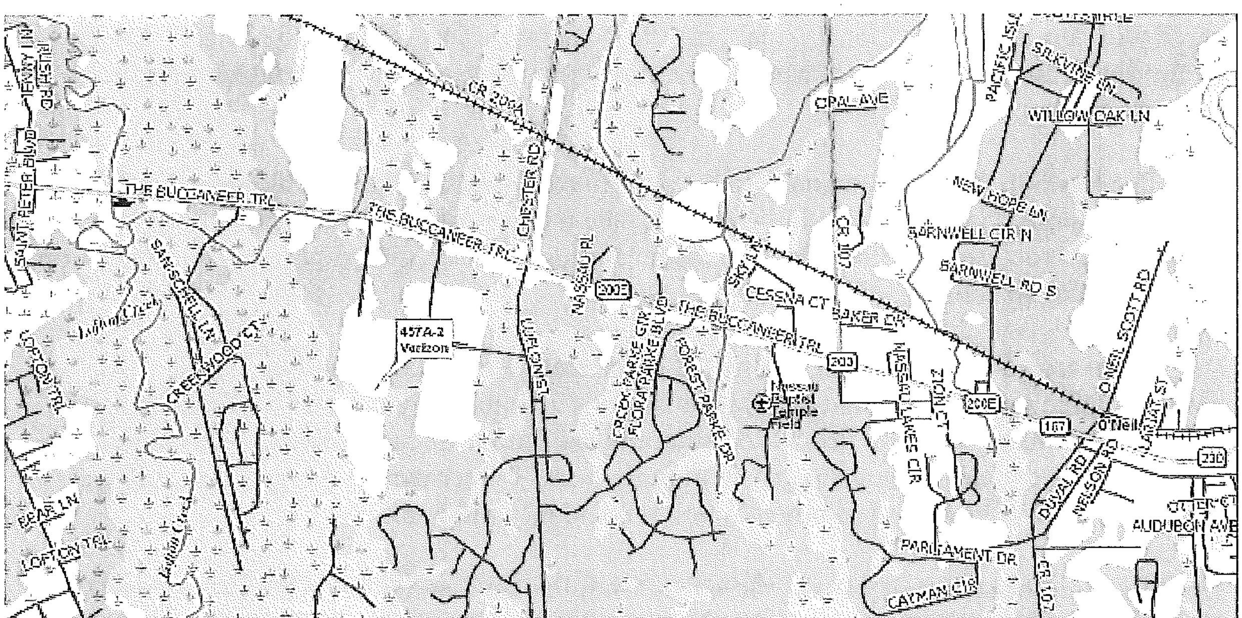
The communication equipment is to be located on the solar panel mast and consists of a Verizon, AT&T, or Alltel cellular transmitter.

MAPS:



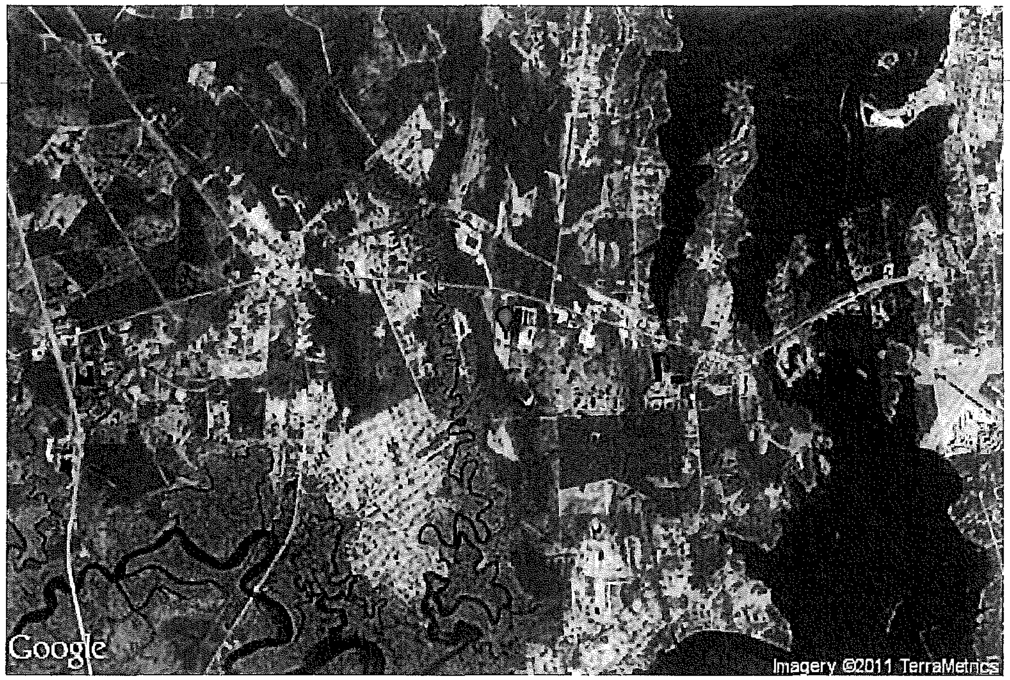
Data use subject to license.
© DeLorme. Topo North America™ 9.
www.delorme.com

Scale 1 : 800,000
1 cm = 8.00 km Data Zoom 8-0

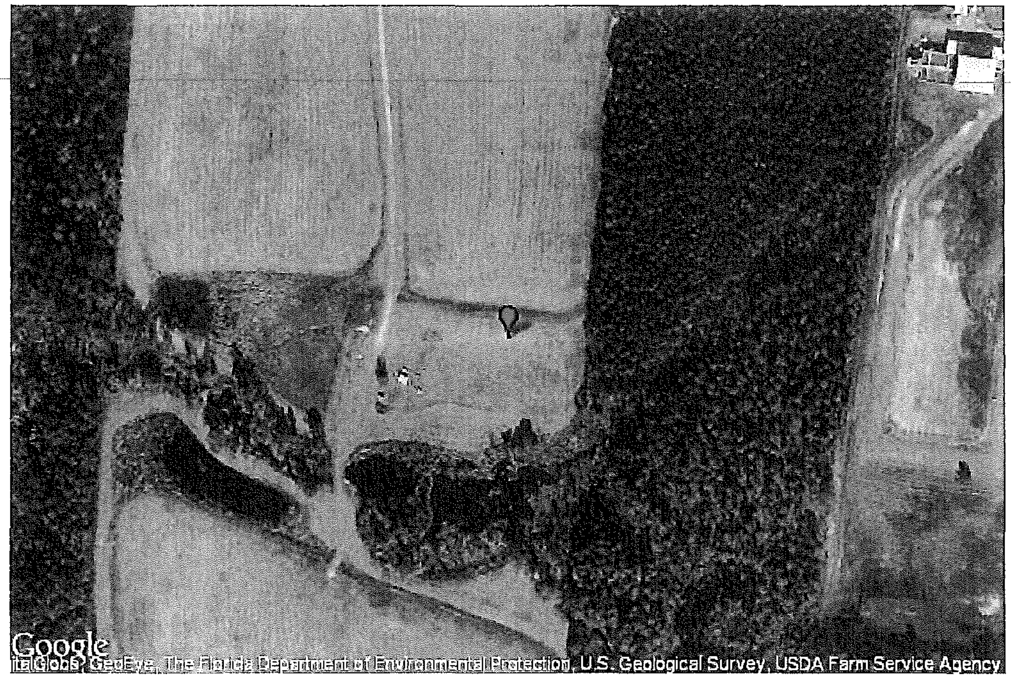


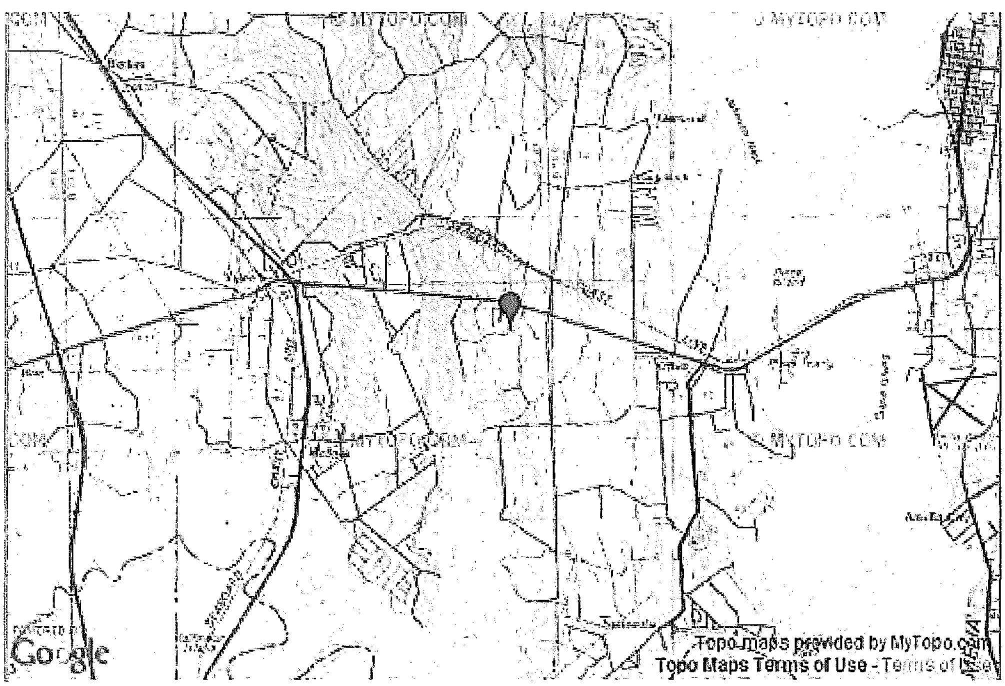
Data use subject to license.
© DeLorme. Topo North America™ 9.
www.delorme.com

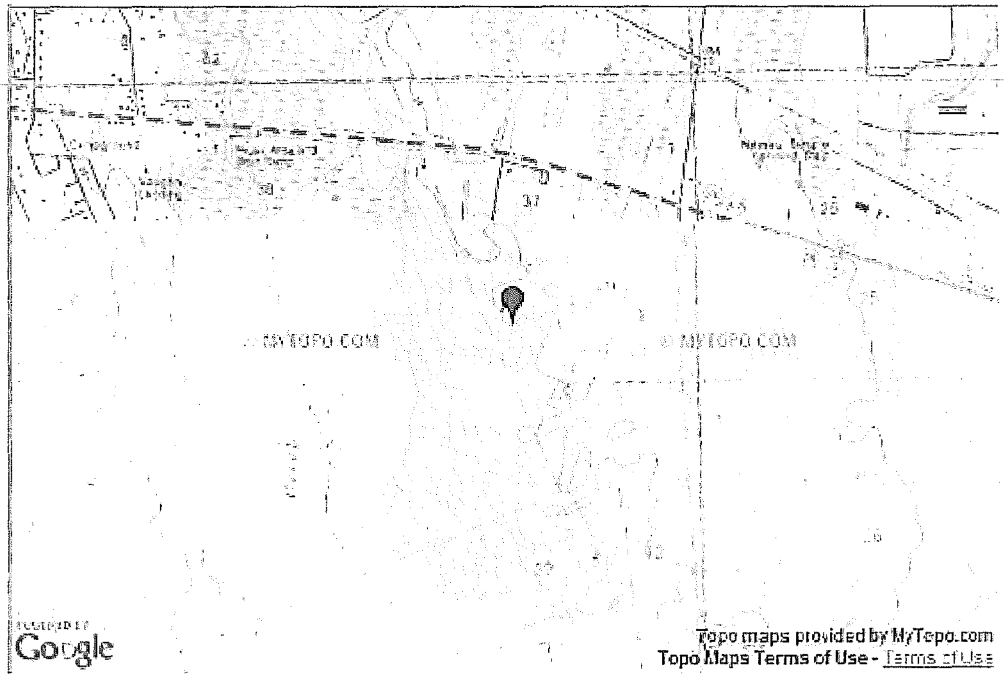
Scale 1 : 37,500
1 cm = 375.0 m Data Zoom 12-4

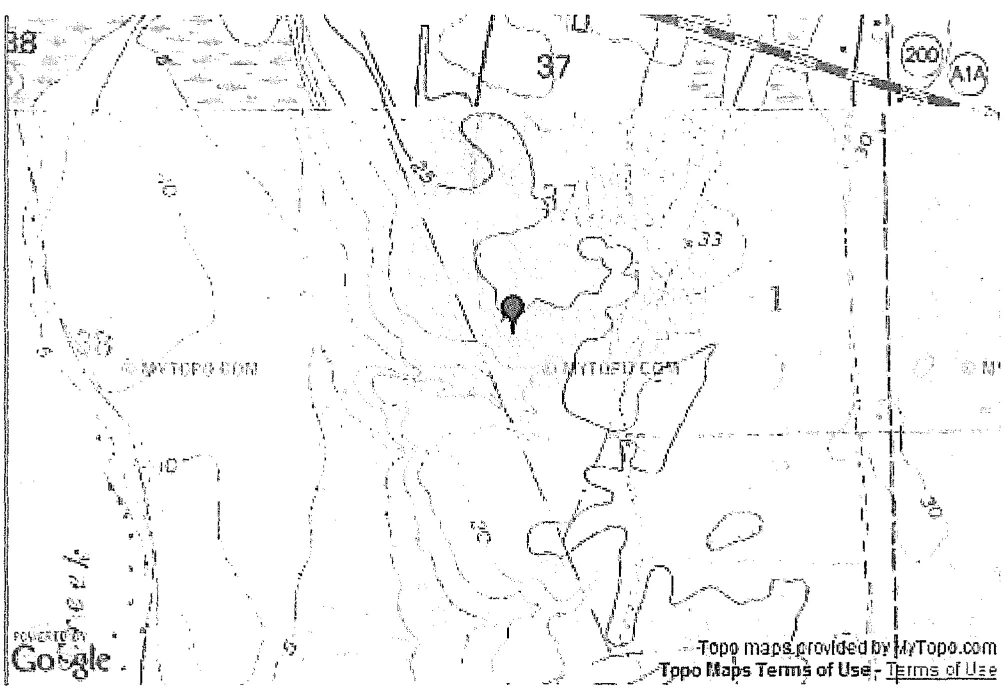

Google
Imagery ©2011 TerraMetrics


Google


Google
The Florida Department of Environmental Protection, U.S. Geological Survey, USDA Farm Service Agency


MYTOPO.COM
Google
Topo maps provided by MyTopo.com
Topo Maps Terms of Use - Terms of Use


© MYTOPO.COM
© MYTOPO.COM
Google
Topo maps provided by MyTopo.com
Topo Maps Terms of Use - Terms of Use


37
200
A1A
© MYTOPO.COM
© MYTOPO.COM
Google
Topo maps provided by MyTopo.com
Topo Maps Terms of Use - Terms of Use

DIRECTIONAL PHOTOS:

Looking North

Looking East

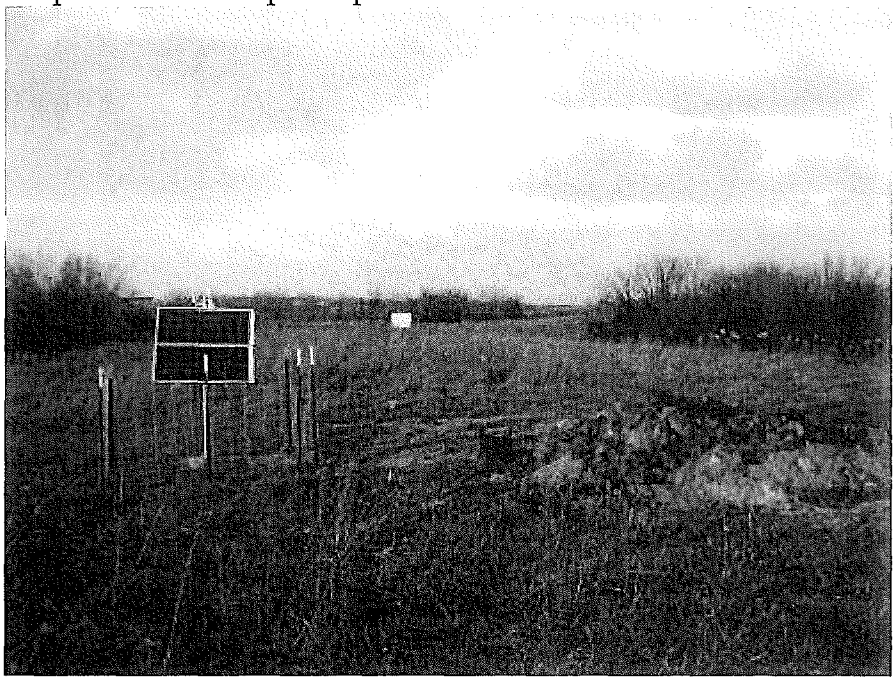

Looking South


Looking West

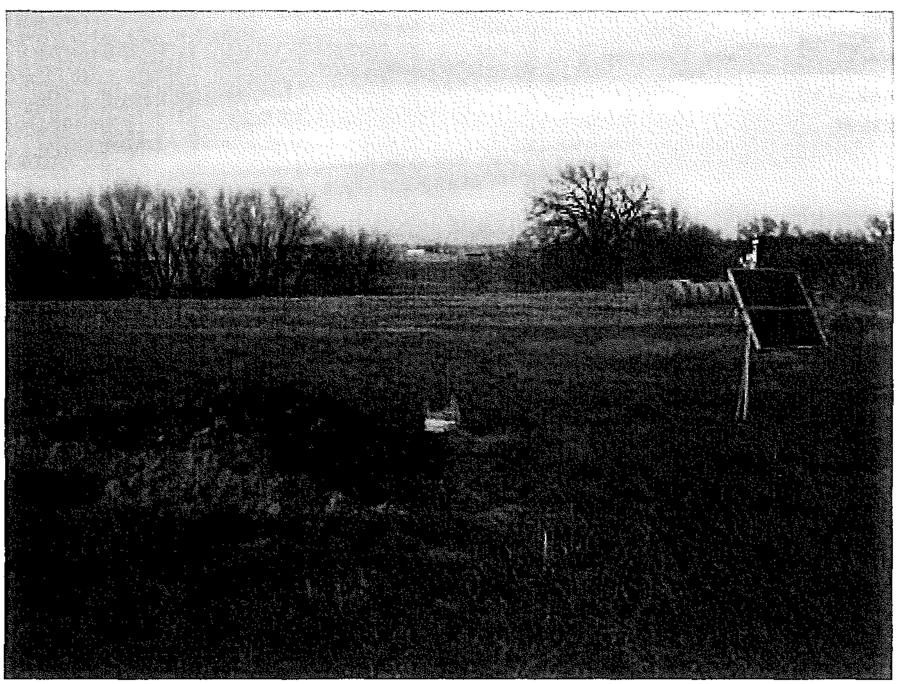
ADDITIONAL PHOTOS:

Typical USArray Site

After instruments are installed, the vault is covered with excess dirt for thermal protection and to protect from wind noise. Note: A few feet from the vault mound is a bag of gravel that contains the port to the atmospheric pressure sensors.



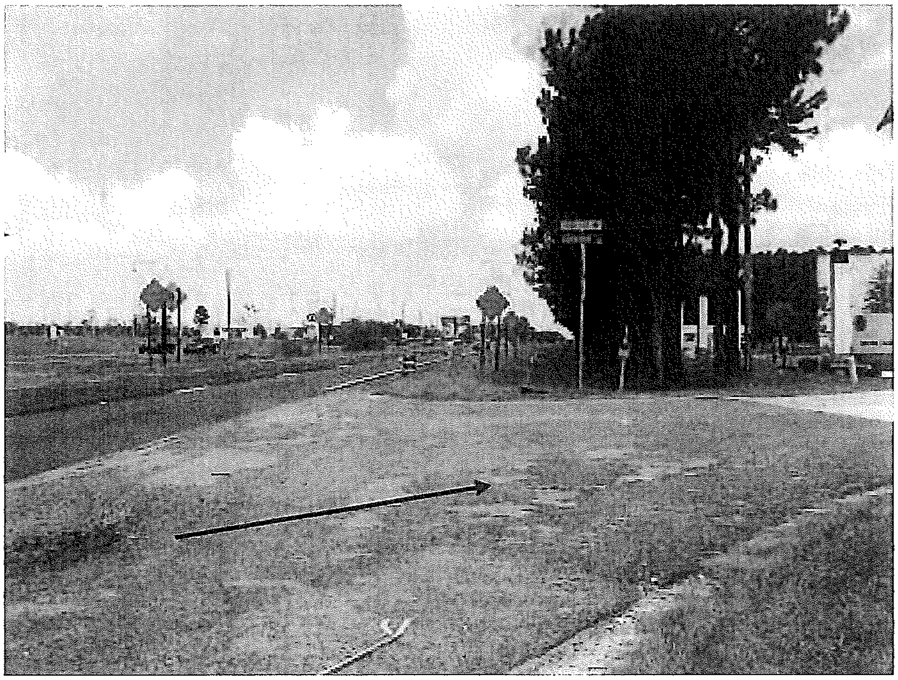
Typical site with "standard fencing."



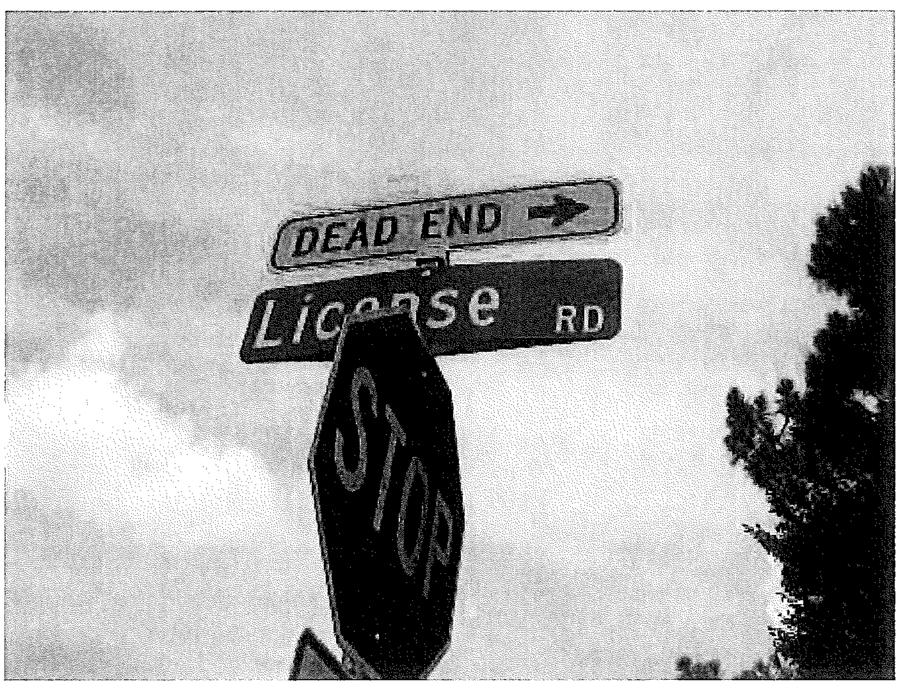
Typical site without "standard fencing."

DIRECTIONS:

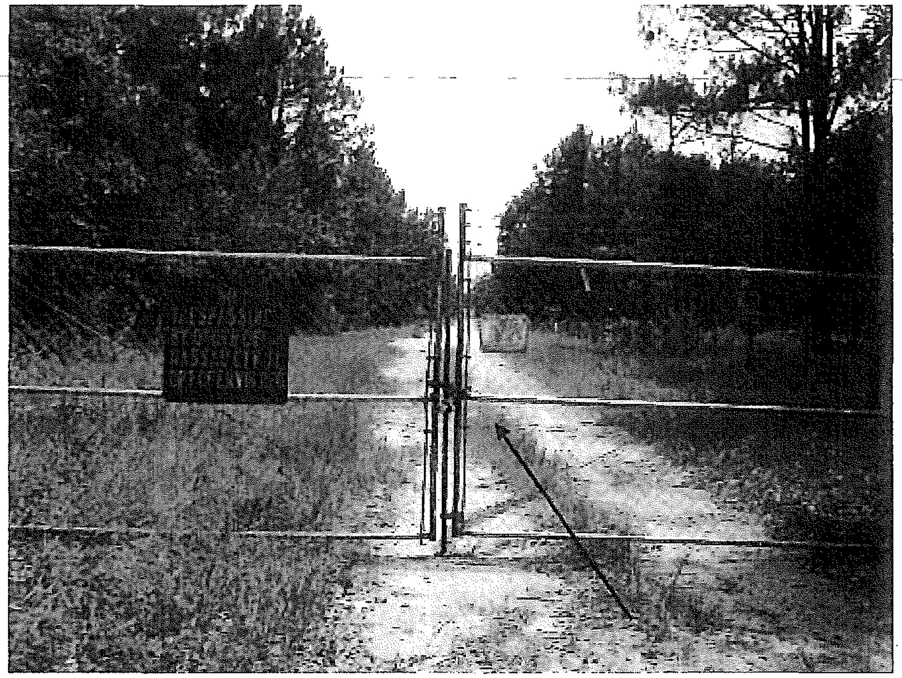
From exit 373 on I-95 near Yulee, FL, take State Road 200/A1A
7.84 miles east until you reach License Road.



(30.62827, -81.55656) Make a right onto License road and go 0.08 miles to the first gate.



Sign Detail



(30.62709, -81.55665) Continue going straight through the gate and go 0.25 miles to the second gate.

Go through the second gate and continue ~75 feet, site is to the left(East) ~ 250 feet. (30.61982, -81.55623)

Transportable Seismic Network:

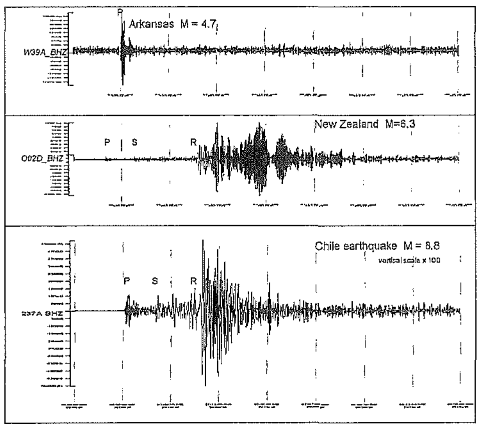
earthscope

www.earthscope.org

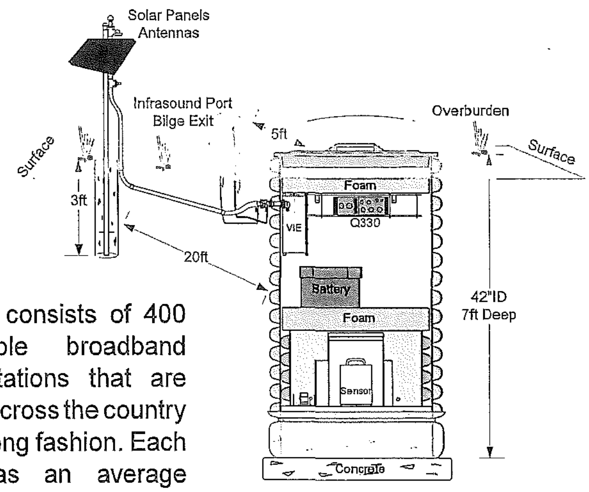
Imaging the Earth's Interior

v0411

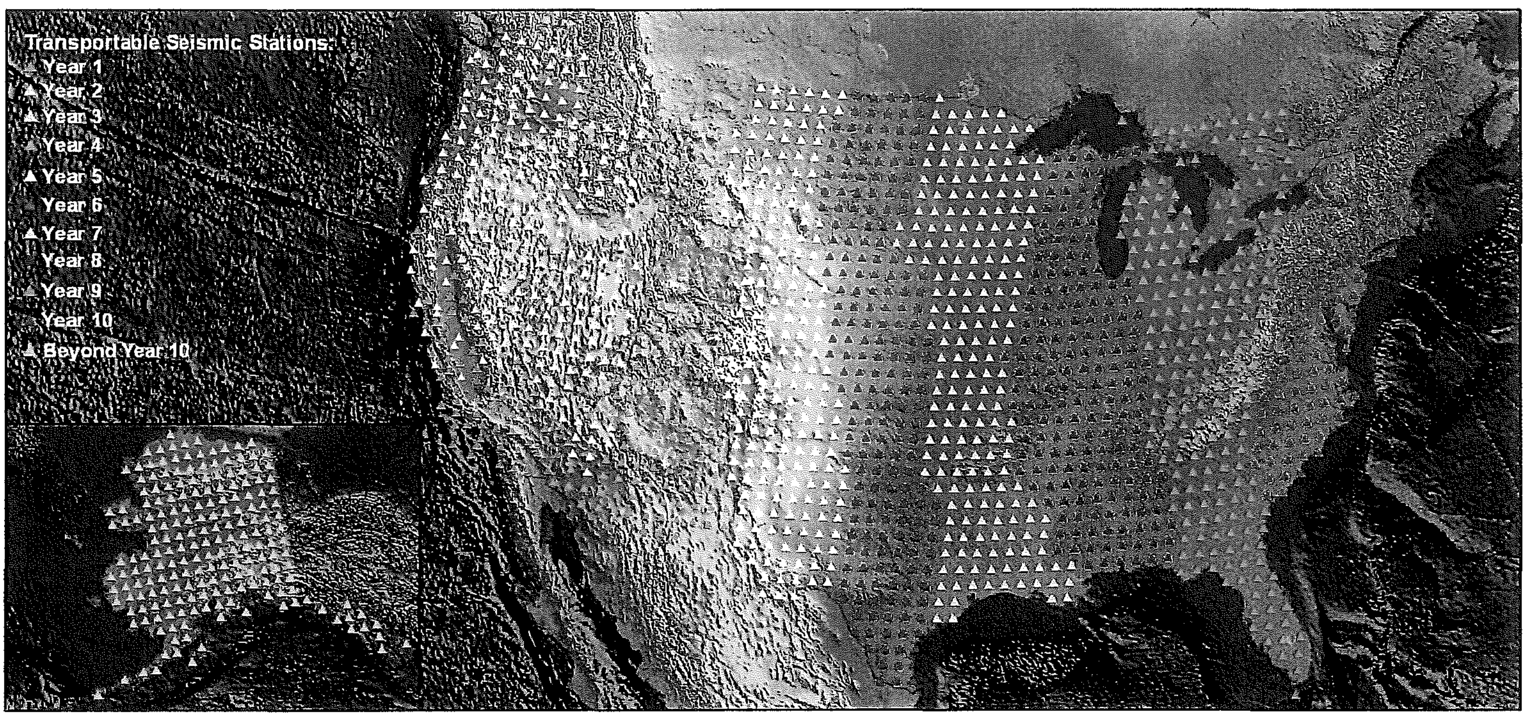
EarthScope is installing a dense array of seismometers across the continental United States, southern Canada, and Alaska. The seismometers record earthquakes that occur locally, regionally, and throughout the world to produce high-resolution images of the Earth's interior and to study the origin and characteristics of earthquakes and earthquake faults. EarthScope scientists integrate these images with other types of geological data to address unresolved issues of the continental structure, evolution, and dynamics.

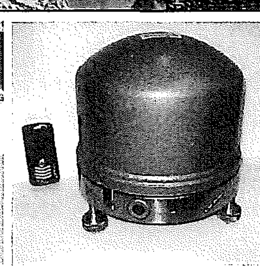


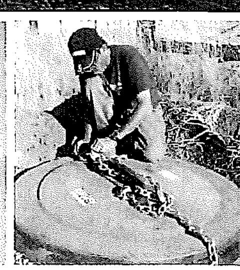
From your USArray station, you will be able to see earthquakes of different magnitudes and earthquakes that occur locally, regionally, and throughout the world.

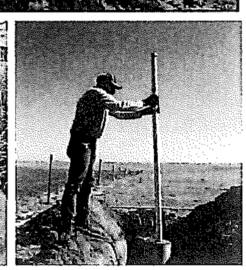


The array consists of 400 transportable broadband seismic stations that are deployed across the country in a roll-along fashion. Each station has an average residence time of 18-24 months, after which it is moved to a new location. Operational since 2005, EarthScope will occupy over 2000 locations and take 15 years to complete, from start to finish. With a station spacing of ~70km (42 miles), the array enables scientists to gain new insights into the earthquake process and to generate 3-D images of the Earth from the crust to the core.









For more information, contact usarray@iris.edu • 1-800-504-0357 (tel/fax)

Participating in EarthScope:

Hosting a Transportable Seismic Station

earth scope

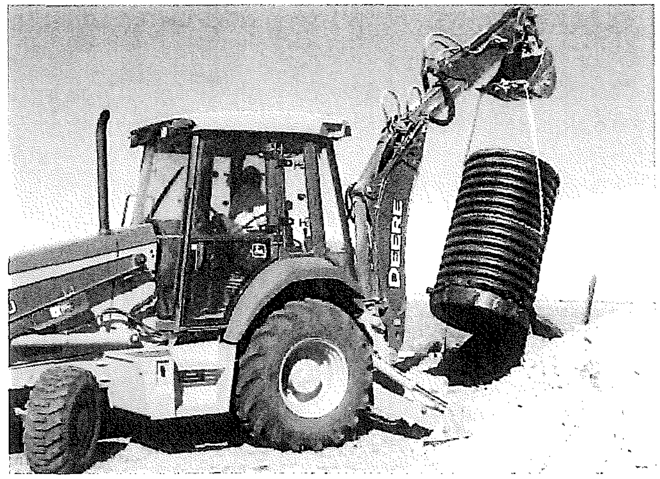
www.earthscope.org

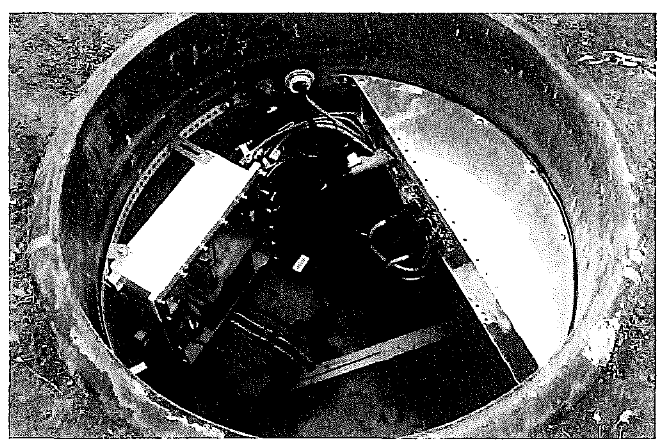
IRIS NSF

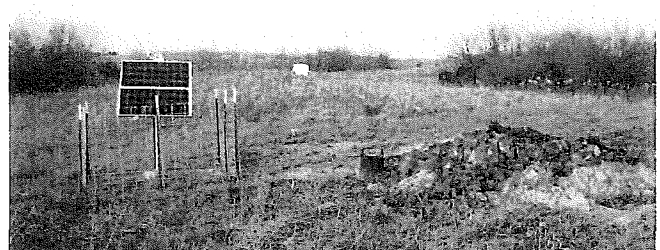
EarthScope earthquake monitoring stations are constructed, operated, and maintained by the Incorporated Research Institutions for Seismology (IRIS) with funds from the National Science Foundation.

v0411

EarthScope is installing transportable seismic stations to record earthquakes occurring locally, nationally, and worldwide. The data are used to produce images of the Earth's interior and provide new insights into the earthquake process. Planned for over 2000 sites across North America, EarthScope is seeking participation from local landowners and schools to accomplish this university-based research experiment.







EarthScope will:

- Respect the property and privacy of landowners throughout the experiment, notifying the landowner whenever access is required.
- Be responsible for the security and operation of the station.
- Assume liability if the equipment is damaged or stolen, remain responsible for any damage done to the landowner's property, and hold the landowner harmless for any loss or injury.
- Remove the equipment completely after the experiment.
- Provide the landowner with updates about the project and sample recordings from their station.

Seismic Station Specifications

Transportable seismic stations have a low profile – there is no noise or motion associated with the equipment. To reduce interference from surface vibrations and to protect the equipment, the seismometer and associated electronics are buried 6 feet below the ground inside a 42-inch diameter tank. Power is supplied by two solar panels mounted on a pole about 20 feet from the tank, with the cables buried inside a conduit. Data are transmitted to the EarthScope data processing center via cellular, broadband, or satellite communication systems. When satellite systems are used, the 3-foot dish and an enclosure with electronics are located near a source of AC power linked by radio to the seismic station. The AC power required for the satellite dish is 25 watts or 220 kWh each year (about $40 per year). In areas with livestock, a fence can be erected for protection. The equipment can also be painted to blend in with the surroundings.

Installation, Maintenance, and Removal

Installation of an EarthScope transportable seismic station usually takes 3 days. On the first day, a backhoe digs a hole 4 feet wide and 7 feet deep. A plastic tank is placed in the hole and cement is poured into the bottom to make a sealed container for the equipment. On a second day a few weeks later, the seismograph electronics, sensor, and communications equipment are installed. An extra day is occasionally required for testing and reconditioning the landscape. The buried equipment is heavily insulated and the tank is often completely covered with soil or rocks to keep the temperature stable.

The seismic stations are temporary, remaining in place for about two years, and are then reused at another site. The equipment operates continuously and routine maintenance is performed remotely. If the equipment malfunctions, it is detected at the data processing center and a service trip may be necessary to correct the problem.

Disassembling the seismic station takes one day. EarthScope removes all the equipment, cuts the plastic tank at the level of concrete (usually 6 feet below grade), removes the tube, and fills in the hole. If requested, the entire tank and concrete can be removed.

For more information, contact usarray@iris.edu • 1-800-504-0357 (tel/fax)

EarthScope Is...

- A community of scientists conducting multidisciplinary research on geological processes affecting North America.
- Scientists and educators bringing the excitement of cutting-edge research into classrooms, museums, and parks.
- Thousands of instruments measuring motions of Earth's surface, seismic waves, and rock properties at depths where earthquakes occur.

www.earthscope.org

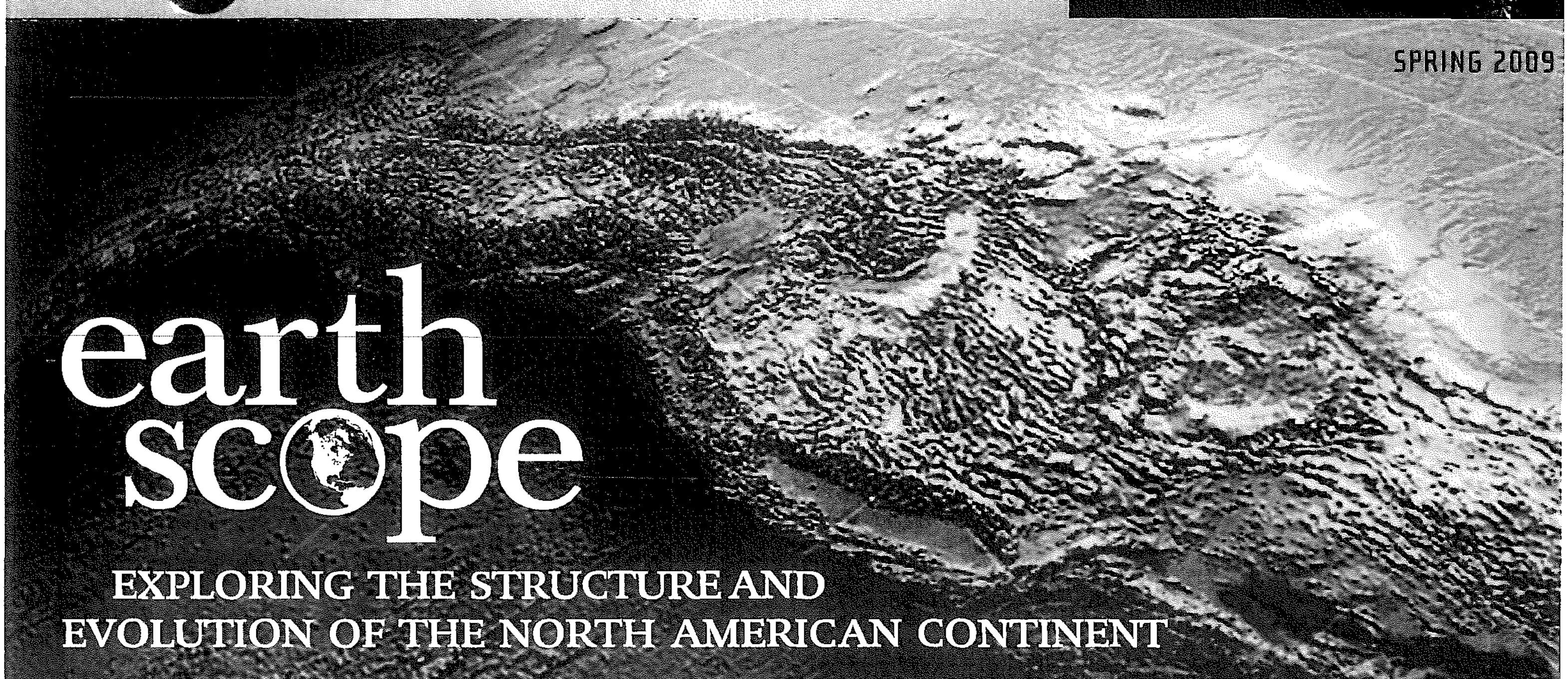
EarthScope National Office (ESNO)
COAS, Oregon State University
104 COAS Administration Building
Corvallis, OR 97331-5503
earthscope@coas.oregonstate.edu

earth scope NATIONAL OFFICE

Free Resources!

All EarthScope data and educational resources are available without restriction or cost to the scientific community, students, teachers, and the public. Visit www.earthscope.org.

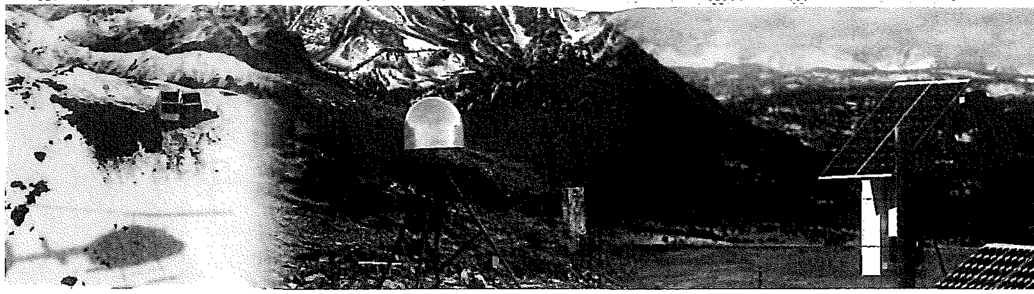
EarthScope is funded by the National Science Foundation



SPRING 2009

earth scope

EXPLORING THE STRUCTURE AND EVOLUTION OF THE NORTH AMERICAN CONTINENT



earth scope

Examples of EarthScope Science

www.earthscope.org/brochure

EarthScope: A National Program of Unprecedented Scale and Scientific Ambition

EarthScope takes a comprehensive approach to understanding the structure and evolution of the North American continent at many scales—from individual faults and volcanoes to the deforming plate boundary and the dynamics of Earth's mantle and core.

EarthScope Observatories

provide data for scientists, students, and the public to study earthquakes, volcanoes, and the structure of the continent.

USArray:

A network of seismometers deployed across the U.S. to record earthquakes and provide high-resolution images of the continent's structure and the Earth's deep interior.

Plate Boundary Observatory (PBO):

An array of GPS instruments positioned throughout the western U.S. to record motions of tectonic plates and deformation of the continent.

San Andreas Fault Observatory at Depth (SAFOD):

A 3 kilometer (2 mile) drillhole through California's famous fault to collect rock samples and to record the physical and chemical properties of an active earthquake zone.

EarthScope Science and Educational Activities

demonstrate that geological forces shape North America's landscape and contribute to the public's understanding of our dynamic Earth. EarthScope research helps us appreciate how the shape, size, and structure of North America change in ways that affect our lives. Teachers, park rangers and museum directors work with scientists to bring EarthScope discoveries to students and the public.

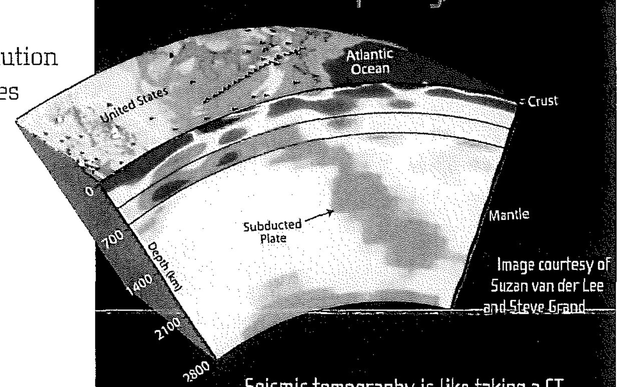
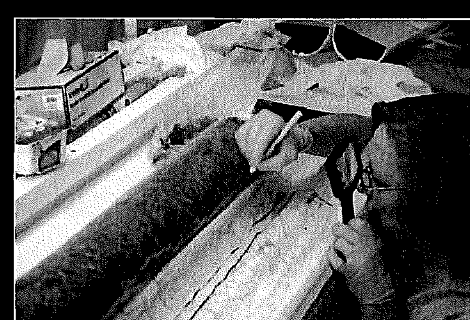


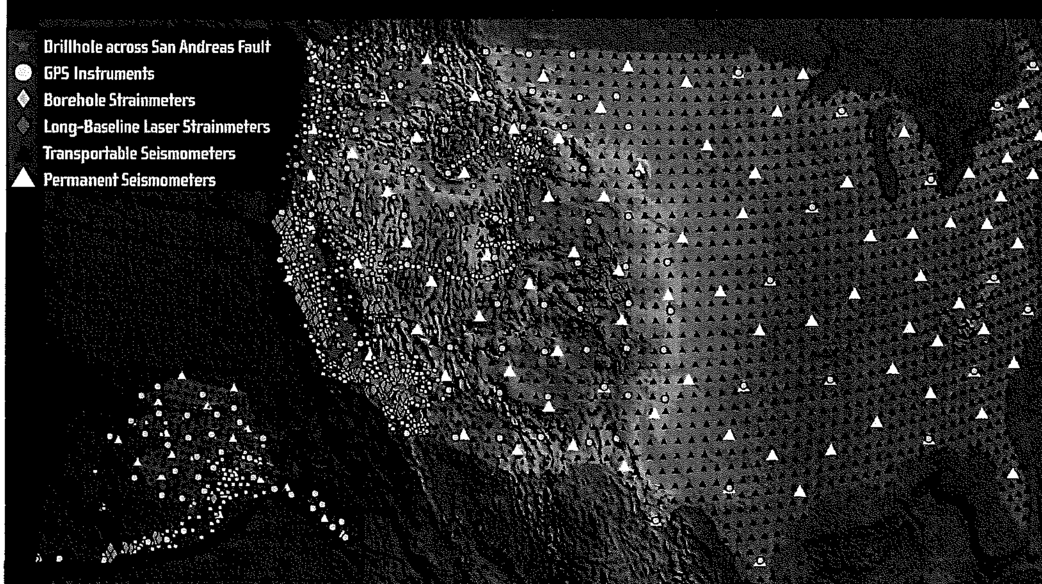
Image courtesy of Suzan van der Lee and Steve Grand

Seismic tomography is like taking a CT scan of the Earth. This image shows an ancient tectonic plate (green region) beneath North America. Data from **USArray stations** will sharpen this image.

PBO GPS stations reveal how the surface of the North American continent is deforming. The red arrows, which represent motion relative to the stable part of North America, show that western Washington and Oregon are rotating and colliding with Canada at a rate of up to 20 millimeters per year!



SAFOD is the first drillhole across an active plate boundary designed to recover intact rock samples from the depths where earthquakes originate. Laboratory analyses of these rocks reveal how fault zones work and lead to a better understanding of earthquakes and their hazards.



Locations of past, present, and future EarthScope instruments.

Down to work. Seismologists are continually transplanting their subterranean seismometers to paint a seismic image of the deep Earth.

GEOPHYSICS

Scoping Out Unseen Forces Shaping North America

As it sweeps across America, the USArray network of seismometers is revealing an impressive but often befuddling subsurface menagerie of slabs, drips, and plumes

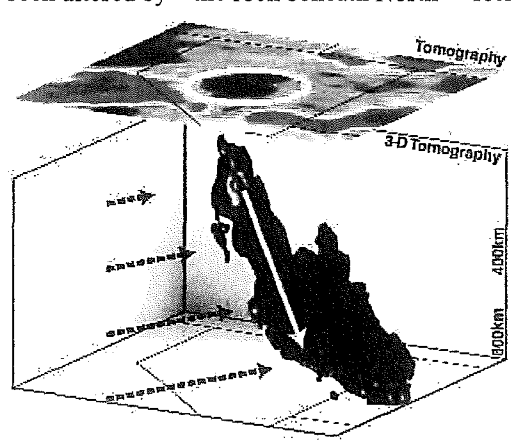
Unlike geologists, who can reach only a few kilometers below Earth's surface, geophysicists routinely probe thousands of kilometers down in search of the ultimate forces that created and still shape the ground we tread. But so far, geophysicists' picture of Earth's interior has been maddeningly fuzzy. To sharpen it, they are scanning the deep subsurface as never before, pushing a fly's-eye-like network of seismometers across the lower 48 U.S. states. Researchers "are jumping up and down" with all the new data, says seismologist Edward Garnero of Arizona State University (ASU), Tempe. "We're pretty ecstatic."

And sometimes they're pretty bewildered. "There are so many [imaged] structures under the western U.S.," says seismologist Eugene Humphreys of the University of Oregon, Eugene. It's like "we just wandered into a dark room and someone turned on the lights. We're struggling to make sense of it." Clearly, the great blobs and chunks of rock rising, sinking, or just floating beneath the surface bear some relation to overlying mountains, basins, and volcanic outpourings, but even the avalanche of new data can't always resolve exactly what the imaged features are or how they are shaping the surface.

A creepy-crawler camera

The data surge comes courtesy of the U.S. National Science Foundation's (NSF's) $25-million-a-year EarthScope program, now early in its second 5-year run. EarthScope's three-pronged approach is creating an evolving three-dimensional picture of the North American continent. In one component, researchers drilled through the San Andreas fault (*Science*, 12 October 2007, p. 183). In the second, they are gauging the changing strain on the crust as it is deformed by deep stirrings and jostling tectonic plates.

EarthScope's third component—the $13.6-million-a-year USArray program—looks much deeper. The USArray system records seismic waves from distant earthquakes after they've passed through—and been altered by—the rock beneath North America. USArray involves three kinds of seismic networks: a Reference Network of 100 seismometers permanently installed 300 kilometers apart in a loose grid across the lower 48 states; a Flexible Array of 446 seismometers that are typically placed 10 kilometers or so apart for a few months or years to study a feature of particular interest; and the novel Transportable Array, an 800-kilometer-wide net of 400 advanced seismometers 70 kilometers apart.



What a drip! Seismic waves that are slower or faster than normal (blues or reds, *top*) can create a 3D image (blue, bottom) of a sinking "drip" tilted by "blowing" mantle rock (dashed arrows).

The novelty of the Transportable Array is its combination of broad coverage, relatively dense instrument spacing, and mobility. The array started out hard against the West Coast in 2004 and has been steadily creeping eastward. Today its net spreads 2000 kilometers along the Rocky Mountains from the Canadian border to the Mexican border. Each month, about 18 instruments on the west side of the array that have collected a couple of years' worth of data are removed from their 2-meter-deep vaults and reinstalled on the east side. Reusing the equipment keeps the project affordable. Over the course of 10 or 12 years, the Transportable Array will occupy 1600 locations from coast to coast. Since 2004, all of USArray has generated 14.3 terabytes of data, nearly as much as the Global Seismographic Network has produced since 1988.

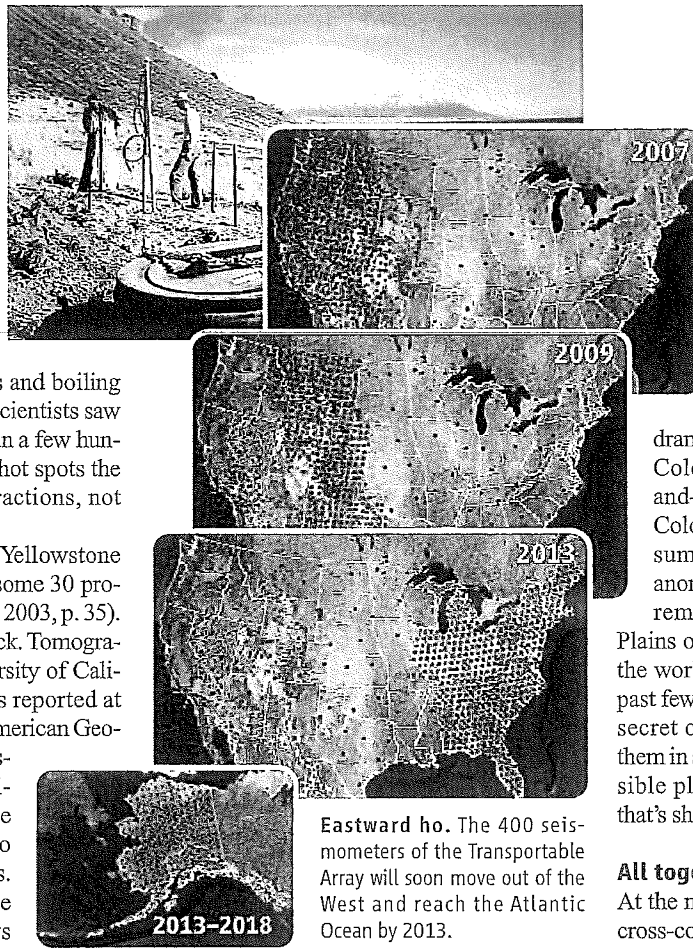
The more data collected and the more closely spaced the instruments, the sharper the pictures of the interior. The most heavily used seismic imaging technique—seismic tomography—works like a computed tomography (CT) scan of the human body. In a CT scan, different body parts absorb x-rays to different extents; in seismic tomography, it is rock's varying effect on the velocity of seismic waves that paints the picture. Waves pass through colder rock faster, for example—yielding a patch of blue in tomographic images—and through hotter rock more slowly, rendered as red.

A deep zoo

For the first time, seismic tomographers are incorporating substantial amounts of USArray data into images of the deep western United States. Already, the new images have added fuel to a long-running debate over the existence of mantle plumes (*Science*, 22 September 2006, p. 1726). One contingent of researchers studying tomographic images had seen these

CREDITS (TOP TO BOTTOM): COURTESY OF THE IRIS CONSORTIUM; FIGURE ELEMENTS FROM J. D. WEST ET AL., NATURE GEOSCIENCE 2, 439-444 (24 MAY 2009), REPRINTED BY PERMISSION FROM MACMILLAN PUBLISHERS LTD.

Published by AAAS



tall columns of hot rock rising thousands of kilometers from deep in the lower mantle like smoke from a stack. Where plumes reach the surface, those researchers say, the rising hot rock melts and feeds hot spots like the volcanoes of Hawaii or Iceland or the geysers and boiling pools of Yellowstone. But other scientists saw hot rock extending no deeper than a few hundred kilometers and considered hot spots the products of tectonic plate interactions, not heat from the deep interior.

The putative plume beneath Yellowstone was among the most suspect of some 30 proposed plumes (*Science*, 3 January 2003, p. 35). But with USArray it's coming back. Tomographer Richard Allen of the University of California, Berkeley, and colleagues reported at last December's meeting of the American Geophysical Union (AGU) that Transportable Array data add to evidence of a seismically slow zone beneath Yellowstone extending to a depth of at least 1000 kilometers.

"The whole history of mantle plumes makes you hesitate," says Allen. Still, he says, "I feel pretty confident about a plume to lower mantle depths." Unlike the bolt-upright columns geoscientists imagined when they first conceived of plumes in the 1970s, Allen says, his group's Yellowstone plume slants to the northwest through the upper mantle and balloons into a much broader slow zone below 660 kilometers in the lower mantle. It even seems to have torn the cold slab of oceanic plate sinking eastward through the upper mantle under the continent.

Other researchers, however, see different pictures. Seismologist Matthew Fouch of ASU Tempe agrees that there's "no clear evidence of a simple mantle plume" beneath Yellowstone. Rather than a contorted columnar plume, Fouch and colleagues say, their processed seismic data show a bent, thin "hot sheet" extending between shallow and deep blobs of hot rock. But when seismologist Rob van der Hilst of the Massachusetts Institute of Technology in Cambridge looks at his and others' tomographic images, he finds that "it's hard to say if [the hot feature] is continuous." Whether there's a single tall plume or a random series of unconnected blobs "is still up in the air," he says.

Some other creatures in the tomographic zoo are proving easier to interpret. Recognized decades ago, the Isabella Anomaly is a blob of rock lying 70 kilometers to 250 kilometers beneath the western edge of the Sierra Nevada mountains of central California. Seismic waves pass through it unusually fast, prompting speculation that it is denser due to the composition of its rock. That higher density might have made it fall away (or drip away, as geophysicists say) from the base of the Sierra Nevada. Relieved of that burden, the less dense crust could have floated up to form high mountains.

In part to test the Sierra Nevada drip idea, seismologists led by George Zandt of the University of Arizona, Tucson, superimposed the Flexible Array on the Transportable Array as it was passing over the Isabella Anomaly. The sharpened view showed a narrower anomaly than before, which allowed the group to calculate a density for the anomaly's rock. It turns out to be so dense that it must contain just the kind of rock hypothesized to have dripped away from the base of the Sierra Nevada, Zandt, William Levandowski of the University of Colorado (CU), Boulder, and the rest of the group reported at the AGU meeting. The group concludes that the drip could have triggered the Sierra Nevada's uplift.

Other seismic anomalies both fast and slow are now getting close looks in USArray data. In the June issue of *Nature Geoscience*, seismologist John West of ASU Tempe, Fouch, and colleagues reported that they had discovered a 500-kilometer-tall drip beneath south-central Nevada, tilted to the northeast by slowly flowing mantle rock "blowing" in that direction. The flow of the Great Basin Drip tugging on the crust would explain a mysterious patch of crust under compression amid the Great Basin's pervasive crustal extension, the group says, although others see mantle flowing around a slab fragment rather than a drip.

The Aspen Anomaly, a stretch of rock that slows seismic waves dramatically, sits directly beneath 80% of Colorado's 14,000-foot-(5100-meter)-and-higher peaks as well as the ore-rich Colorado Mineral Belt. Researchers presume there's a connection between the anomaly and the mineralized uplift, but it remains unproven. And the High Lava Plains of southeastern and central Oregon—the world's largest volcanic province of the past few million years—must be guarding the secret of their origins somewhere beneath them in a mix of sinking slab fragments, a possible plume tail, and flowing mantle rock that's showing up in the latest data.

Eastward ho. The 400 seismometers of the Transportable Array will soon move out of the West and reach the Atlantic Ocean by 2013.

CREDITS: COURTESY OF THE IRIS CONSORTIUM

All together now

At the midpoint of the Transportable Array's cross-country march, researchers wish USArray were yielding more insights and prompting less squabbling. "We're getting a clearer vision in the West," says van der Hilst, but "when you look at the details, people do see different things. The [tomographic] models allow for different interpretations." Fouch notes that with each group's different processing of the same data, "you can let tomography become a Rorschach test."

Researchers say they'll soon find better ways to interpret USArray observations. "It's such an unwieldy mass of data," says geophysicist Craig Jones of CU Boulder. "Playing with it is a different game than we're used to. I have a feeling we'll be seeing in the next 5 years analyses far more imaginative than what we've done so far." Some innovative new techniques are already on the horizon. For one, seismologists are starting to use background seismic noise generated by ocean waves—so-called ambient noise—to form tomographic images.

And then there are the geologists. EarthScope was originally supposed to bring geophysicists and geologists together (*Science*, 26 November 1999, p. 1655). Funding shortfalls early in EarthScope frustrated the marriage, but now NSF is managing to fund more geological work in and out of EarthScope. Relating geological traces at the surface to underlying seismic anomalies could help explain why there's such a weird assortment of still-active deep processes shaping the surface of the American West. **–RICHARD A. KERR**

Published by AAAS