Combining the PASSCAL and EarthScope Texan Instrument Pools for 3D and 3C Imaging of the High Lava Plains, Oregon

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High Lava Plains Project
Geophysical & Geological Investigation

ABSTRACT

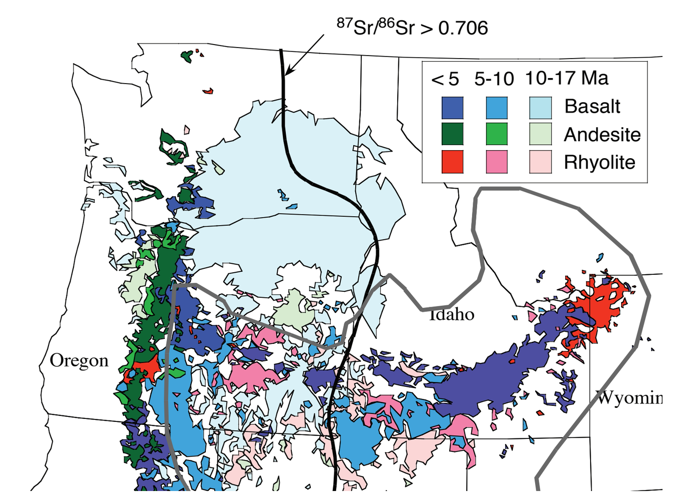
In early September 2008, 67 scientists, students, and volunteers deployed 2612 Texan short-period seismic recorders and 120 RT-130 recorders from the PASSCAL and EarthScope instrument pools, and fired 15 seismic sources spaced across the High Lava Plains (HLP) of eastern Oregon and adjacent parts of Idaho and Nevada. This massive effort is the largest number of instruments deployed in an on-land controlled- source seismic experiment. This army of helpers includes 42 students from 12 different universities, mainly the University of Oklahoma, Oregon State, Arizona State, MIT, Stanford, Miami-Ohio, University of Texas at Dallas, and Rhode Island, ably assisted by 6 staff members from the PASSCAL/EarthScope Instrument Center. This deployment takes advantage of 100 broadband seismometers in the existing HLP array placed during the past three years by Carnegie Institution and Arizona State University. The University of Oregon, Michigan Tech, and the U. S. Geological Survey also deployed an array in the Newberry volcano area to record earthquakes and the seismic source. Together, these efforts will provide a deep and three- dimensional image of the structure of this region. New instrumentation built by PASSCAL allowed us to carry out 3C recording using the Texan facility to study crustal anisotropy. The seismometers were located to provide high-resolution images of the mantle and crust directly beneath the path of volcanism that dotted the High Lava Plains during the past 16 Ma. In addition to the seismic component, the overarching project, funded by the National Science Foundation's Continental Dynamics program, includes field geologists, petrologists, and geodynamicists interested in resolving the origin of the sudden massive outpouring of basalt volcanism 16 million years ago and a puzzling trend of age-progressive rhyolite domes that reaches west toward Newberry volcano, the youngest complex in the trend. URL: http://www.dtm.ciw.edu/research/CEO

INTRODUCTION

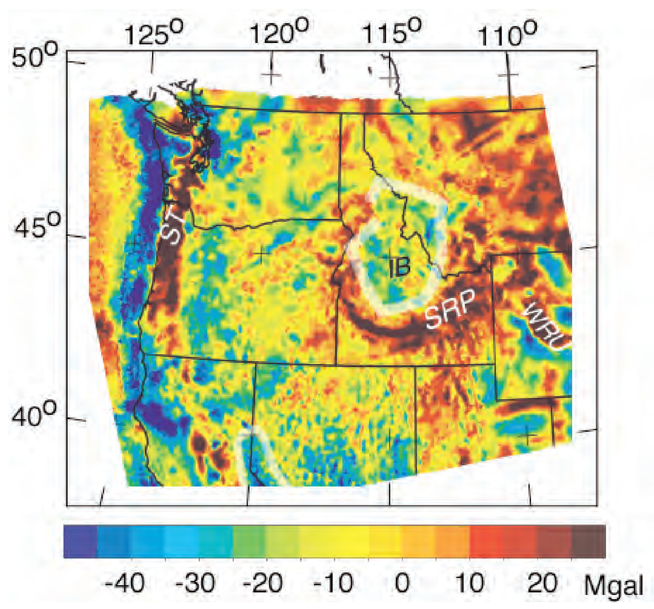
This project is a multidisciplinary effort to understand the causes of continental intraplate magmatism. Our project examines an area that represents one of the most accessible, yet least understood, examples worldwide of voluminous and regionally extensive continental magmatism that is young enough to allow comparison of surface expressions of magmatism with seismically imaged crust and upper mantle structures. By conducting the active source component of this survey, we will determine crustal and upper mantle structure beneath the High Lava Plains of eastern Oregon, interpret the imaged structure with input from geochemical, geochronologic, and petrologic data on the young surface volcanism, and combine these observational datasets with geodynamic modeling to understand why this minimally extended part of the Basin and Range has been the most volcanically active region of North America in the late Cenozoic. We believe that this area holds key insight into to such questions as: 1) Is a plume necessary for large-volume intraplate volcanism? 2) Can shallow-dip subduction establish the conditions that lead to active tectonism and magmatism when the subducting plate eventually steepens? 3) Does flow of mantle around the edges of a subducting plate instigate focused volcanism in the overlying crust? 4) What role does "bottom topography" of the lithosphere play in localizing tectonomagmatism in the overlying crust? 5) Is crustal extension the cause or expression of continental magmatism?

We installed a dense array of broadband seismometers across two transects of the High Lava Plains. One extends from the Cascade front over 400 km southeast to the Proterozoic crust of southern Idaho. The other reaches from nonextended crust composed of accreted terranes north of the High Lava Plains 350 km southward to northern Nevada near the first exposures of pre-Cenozoic basement. Embedded within this passive seismometer deployment will be two seismic refraction lines and accompanying gravity measurements to provide high resolution images of crustal structure across these widely varied terranes. The structural information returned from the geophysical components will be combined with the geologic history derived from volcanology-geochemistry-geochronology-petrology data and compared with geodynamic modeling of mantle flow expected for various models of slab and plume behavior in the "dying" continental convergent margin exemplified by the Pacific Northwest. The objective of this synthesis is to better understand the relative roles of lithospheric structure, tectonics, flat-slab subduction, slab roll-back, and plumes as instigators of aerially extensive magmatism that continues from a plate margin well into the interior of a continent.

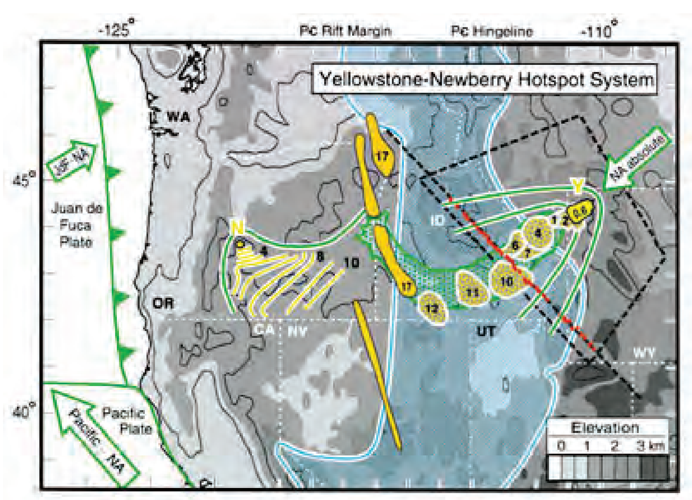
GEOLOGIC SETTING



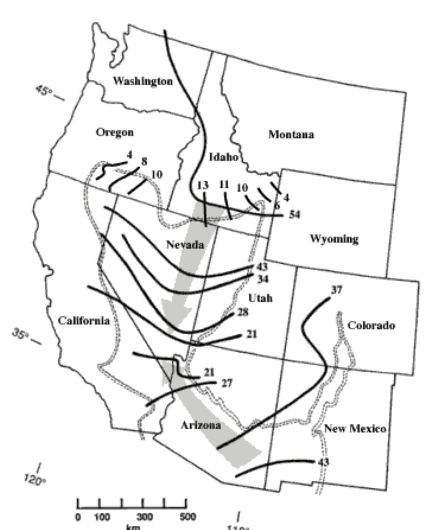
Map of Neogene Volcanism (after Luedke and Smith, 1984). Basin and Range and volcanism does not recognize the Precambrian continental boundary. Volcanism is concentrated at Basin and Range margins, particularly the northern boundary. Largest volume of basalt erupted north of SRP and has no associated silicic volcanism. Bimodal volcanism is characteristic of High Lava Plains, Snake River Plains, and Basin and Range. ~4 Myr hiatus between flood basalts and beginning of rhylolite migrations.



Map of Isostatic Gravity. Eastern Oregon and Washington show no gravity signal of underplated basalt, unlike the Snake River Plains (SRP). Where are the fractionation products of 250,000 km of flood basalt, not to mention the underplating expected with HLP volcanism?

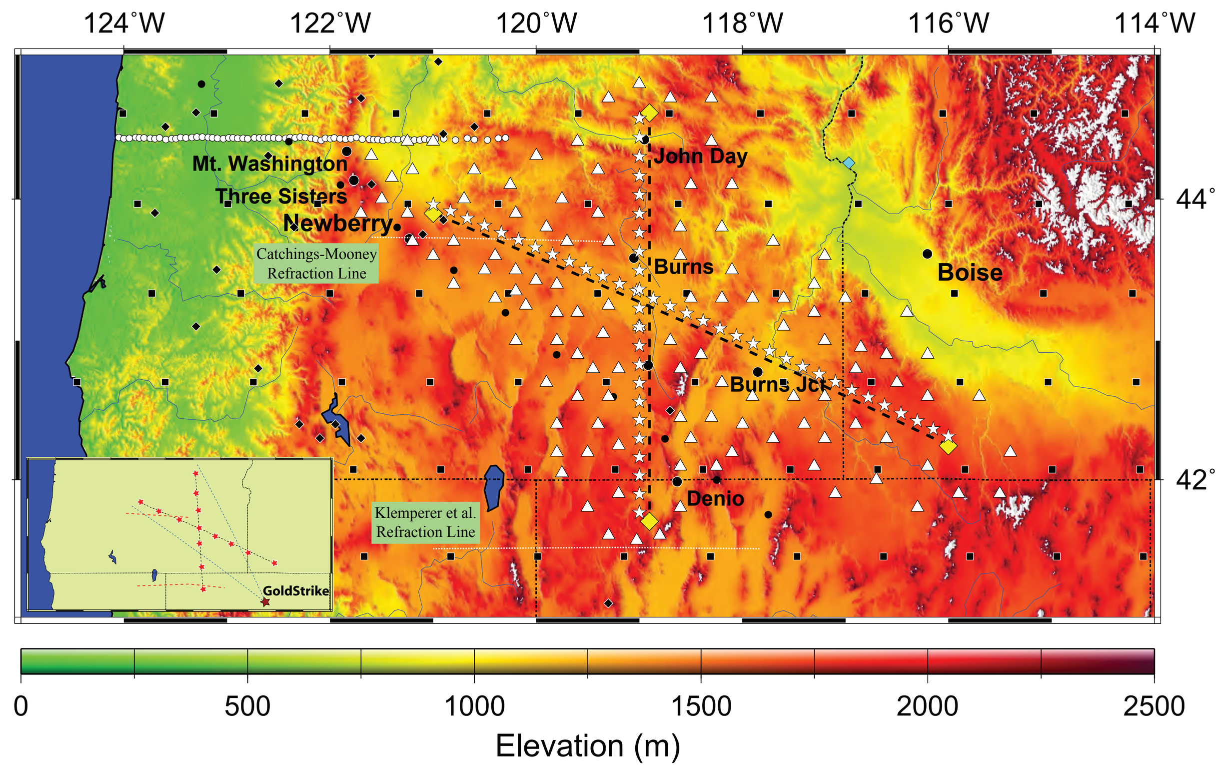


Map of the Yellowstone and Newberry volcanic trends starting from the same area, and then propagating out in opposite directions. Newberry propagates westward into Oregon, while Yellowstone heads east. This is highly suggestive of a common origin for the two trends.

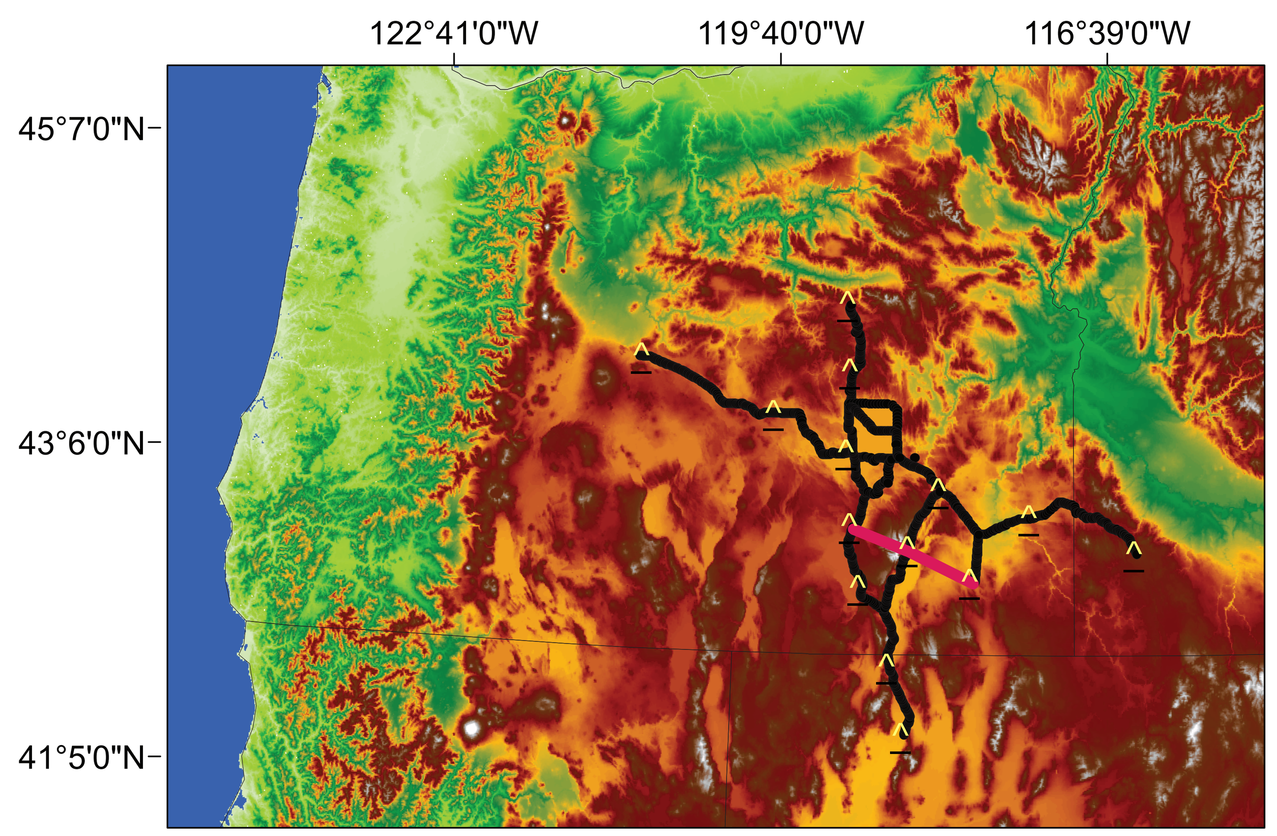


A plot of the major silicic time progressive volcanism (approximate countours of age in Ma) that occurred in the western U.S. during the Cenozoic (original plot from Gene Humphreys).

EXPERIMENT LAYOUT



Proposed layout of High Lava Plains experiment. Stars - Dense Broad Band Deployment. Triangles - Additional Broad Band Deployment. Dashed Line - Refraction / Low-Fold Reflection Lines.



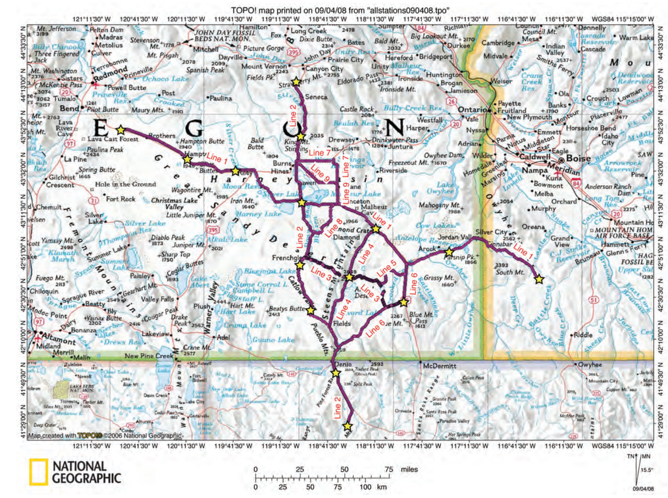
Final layout of the active source portion of the High Lava Plains experiment. Stars - shotpoints. Black lines - TEXAN single component deployment. Pink line - RT130 and 3 component TEXAN deployment.

Drill rig used to drill 12 inch diammeter hole to 80 feet deep.

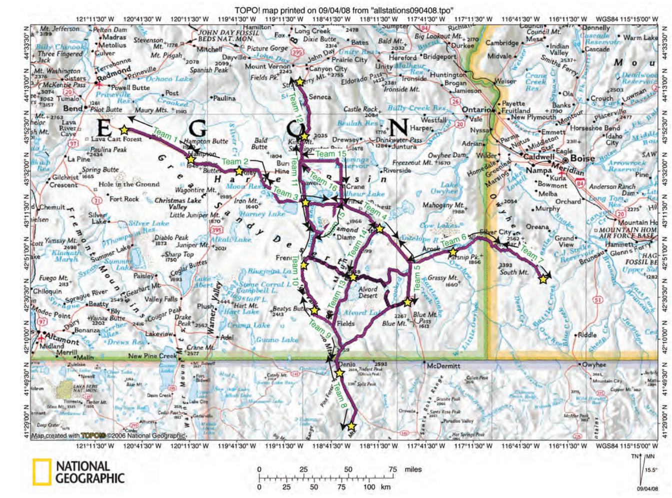
Loading of ammonium nitrate gel explosives.

Shovel crew stemming the upper 60 feet of the hole.

DEPLOYMENT



Deployment map showing breakdown by line. A total of 9 lines.



Deployment map showing breakdown by team. A total of 18 teams.

Over 200 instrument cases.

Loading cases of assigned equipment into team vehicle.

New "Lunch Box" used to take GPS readings in the field during deployment.

Deployment of RT130.

Deploying single component TEXANs by ATV.

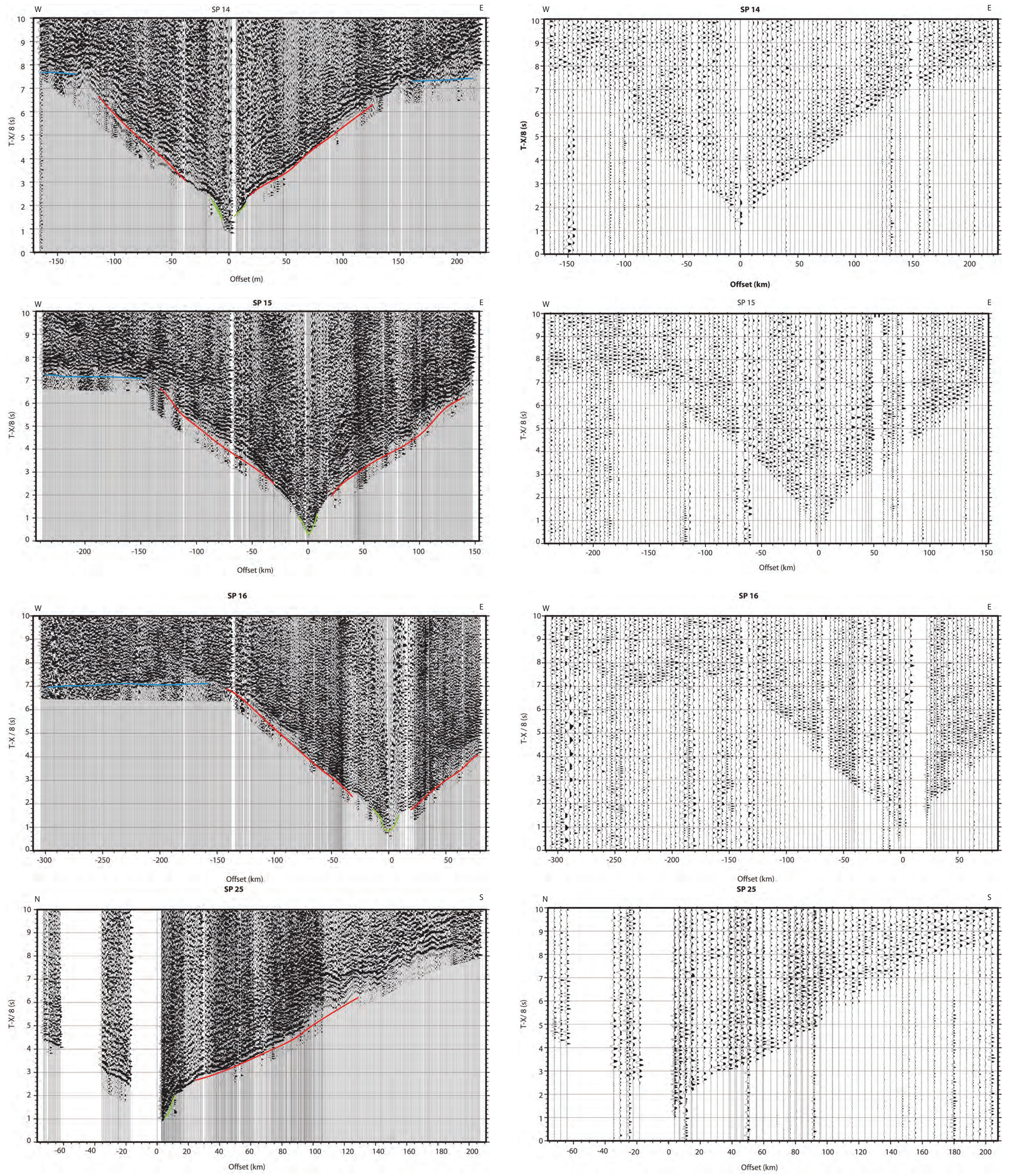
Surface expression after a shot showing minimal damage.

PI Randy Keller filling a blown out crater.

Group photo of deployment teams.

RECORD SECTIONS

Preliminary shotgathers from the High Lava Plains experiment. These were created by using zplot. The shotgathers in the left column are non-decimated and show the following tentatively identified phases: green - the direct wave traveling through sediments and volcanics; red -P g traveling in the upper and middle crust; cyan - Pn. A preliminary interpretation is that the Pn phase become a first arrival at about 150 km which indicates a crustal thickness of ~40 km. The relatively long offset to which the direct wave remains the first arrival indicates a thickness of sediments and volcanics of ~5km. A preliminary conclusion is that the Pg phase indicates an average upper and middle crustal velocity of ~6.2 km/s, which is similar to values in the Basin and Range to the south. Shotpoints 14 and 25 are the same shotpoint at the intersection of lines 1 and 2.



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