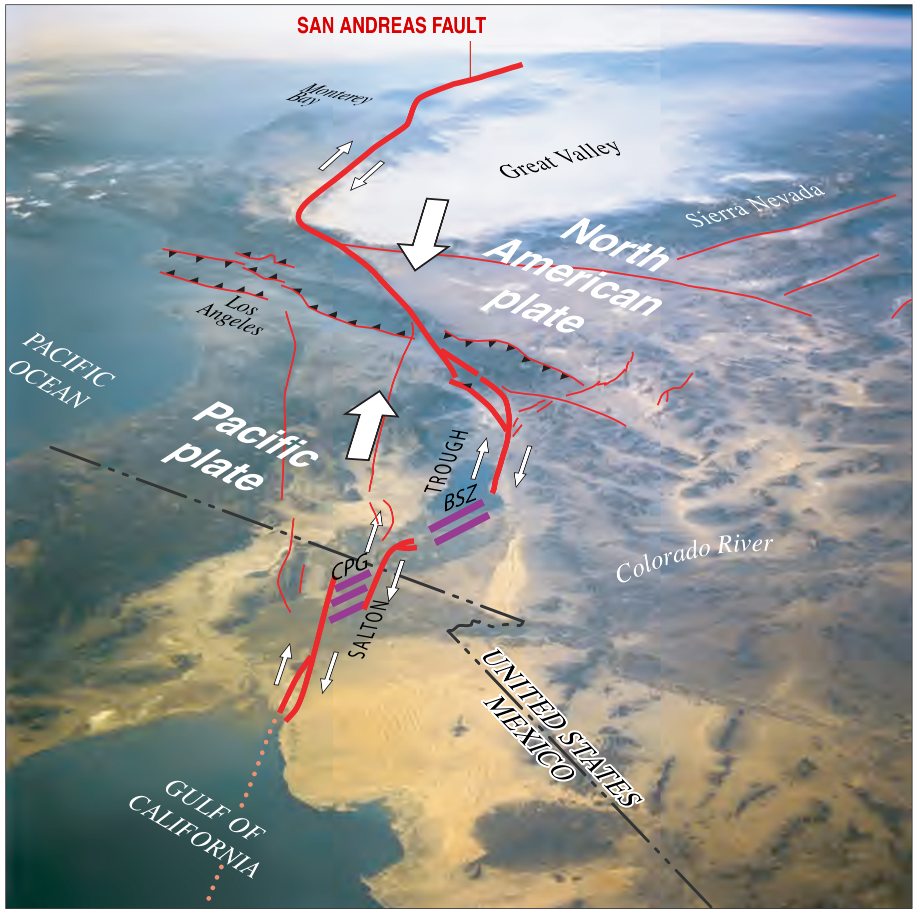
The Salton Seismic Imaging Project—Studying Earthquake Hazards and Rifting Processes in the Imperial and Coachella Valleys



Southern California consists of two of Earth's plates (the Pacific and North American plates) moving past each other. The boundary between the two plates is quite crooked. Heavy red lines indicate the San Andreas and related faults. As the two plates move past each other along these faults (in the directions of the small white arrows), earthquakes occur. The purple lines indicate locations between these faults where the Earth is being pulled apart, creating a deep valley or even new ocean. Volcanoes and underground magma in these areas create geothermal energy and hot springs (CPG is Cerro Prieto Geothermal area; BSZ is Brawley Seismic Zone and geothermal area).

The Imperial and Coachella Valleys are forming by active plate tectonic processes. From the Imperial Valley southward into the Gulf of California, plate motions are rifting the continent apart. In the Coachella Valley, the plates are sliding past one another along the San Andreas and related faults. These processes build the stunning landscapes of the region, but also produce damaging earthquakes.

Rupture of the southern section of the San Andreas Fault, from the Coachella Valley to the Mojave Desert, is believed to be the greatest natural hazard that California will face in the near future. With an estimated magnitude between 7.2 and 8.1, such an event would result in violent shaking, loss of life, and disruption of lifelines (freeways, aqueducts, power, petroleum, and communication lines) that will bring much of southern California to a standstill. As part of the nation's efforts to avert a catastrophe of this magnitude, a number of projects are underway to more fully understand and mitigate the effects of such an event. One project, funded jointly by the National Science Foundation (NSF) and the U.S. Geological Survey (USGS), is to understand through "seismic imaging" the structure of the Earth surrounding the San Andreas Fault, including the sedimentary basins on which cities are built.

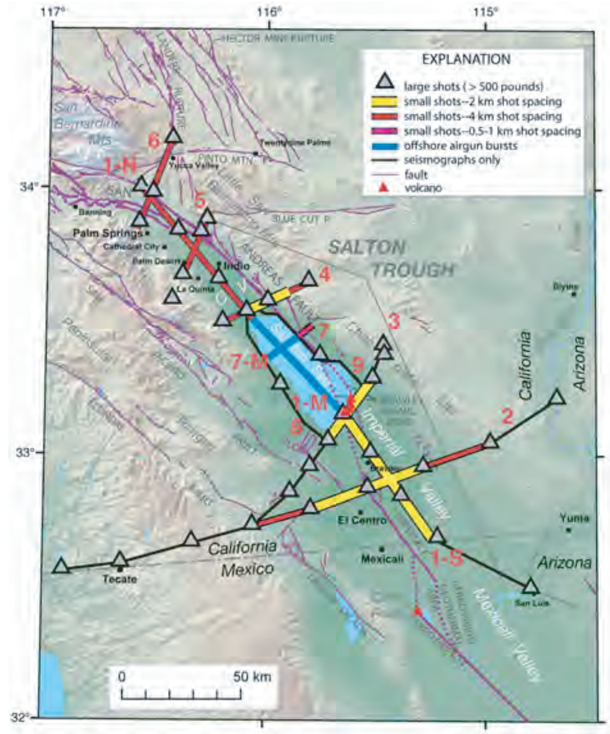
This project, the Salton Seismic Imaging Project (SSIP), will create images of underground stucture and sediments in the Imperial and Coachella Valleys and adjacent mountain ranges to investigate the earthquake hazards they pose to cities in this area. Importantly, the images will determine the underground geometry of the San Andreas Fault, how deep the sediments are, and how fast earthquake energy can travel through the sediments. All of these factors determine how hard the earth will shake during a major earthquake. If we can better understand how and where earthquakes and strong shaking will occur, then buildings can be better designed or retrofitted to resist damage and collapse, and emergency plans can be better prepared.

"Seismic imaging" is a collection of techniques, similar to ultrasound and CAT scan techniques in the medical industry, that enable scientists to obtain a picture of what is underground. The petroleum industry routinely uses these techniques for exploration for oil and gas, but SSIP needs to be able to see as much as 20 miles into the earth's crust. This project will generate and record seismic waves, similar to sound waves, that move downward into the Earth and are bent (refracted) or echoed (reflected) back to the surface.

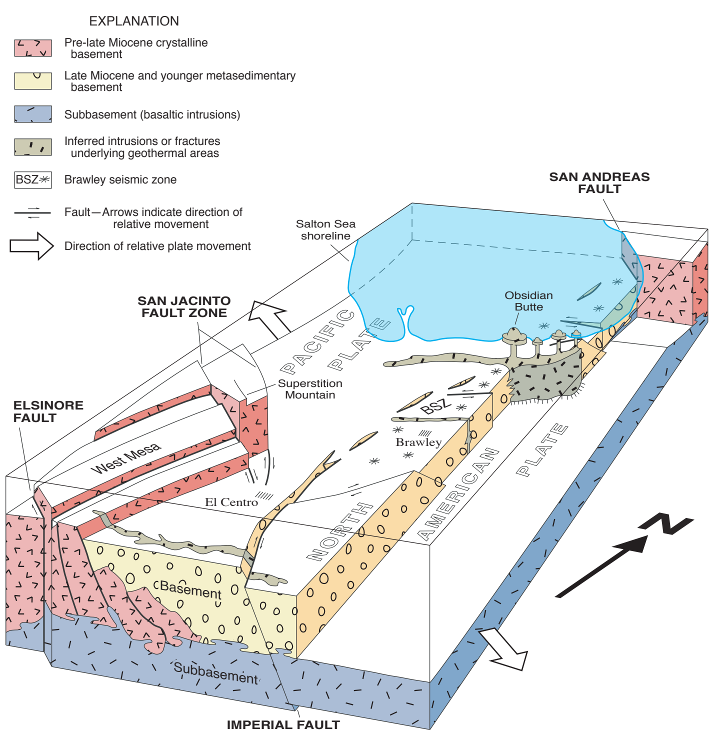
SSIP will acquire data in a series of intersecting lines that cover key areas of the Salton Trough. The sources of sound waves will be detonations (shots) in deep boreholes, designed to create energy equivalent to magnitude 1–2 earthquakes. The study region routinely experiences earthquakes of this magnitude, but earthquakes are not located in such a way as to permit us to create the detailed images we need for earthquake hazard assessment. Temporary deployments of small, portable seismometers will record the energy from our borehole shots.

SSIP is similar to the LARSE surveys of 1994 and 1999 across the Los Angeles region (http://pubs.usgs.gov/fs/1999/fs110-99/). The LARSE surveys demonstrated that the USGS and collaborators can safely and effectively conduct seismic imaging surveys in urban and non-urban areas, on lands with many different owners or managers. Information was produced that could not have been obtained any other way and that has changed key ideas on earthquake hazards in the Los Angeles region. These surveys produced no significant environmental impact or damage to structures, and they did not trigger earthquakes.

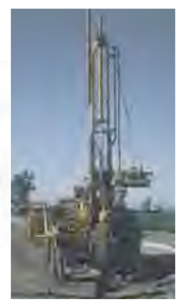
Layout of Salton Seismic Imaging Project (SSIP). Gray triangles are larger shots. Smaller shots are located at 1.2- to 2.5-mi spacing along the red and yellow lines, and seismographs are located at 325- to 650-ft spacing along red, yellow, and black lines. CV, Coachella Valley.

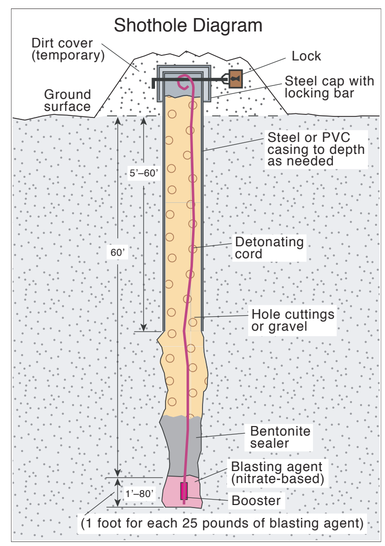


The ShakeOut Earthquake Scenario, of November 13, 2008 (http://pubs.usgs.gov/circ/1324/), was a coordinated inter-agency exercise to communicate earthquake hazards to the public and to practice community disaster plans. In this scenario, an M 7.8 earthquake was simulated, where the Earth ruptured from the east side of the Salton Sea through the Coachella Valley and northwestward into the Mojave Desert.



In 1979, the USGS conducted a seismic-imaging survey in the Imperial Valley. This survey was quite modest by today's standards, but nevertheless made some surprising discoveries, including the observation that the central part of the Imperial Valley contains no old rocks (pink), only new crust consisting of young sediment from the Colorado River (yellow where metamorphosed) and a large body of solidified intrusive basaltic rocks below that (gray). SSIP will significantly improve images of these features and related faults, and extend the images northward into the Coachella Valley, which has not previously been investigated.





Seismic charges will be detonated at the bottom of a cased drill hole (identical to a water well). The upper part of the drill hole is filled with gravel and expanding clay to contain the energy and prevent damage at the surface. Shot holes will be placed at a safe distance from structures on previously disturbed land. Drill hole sites will be returned to their original condition. The shot engergy will be recorded on small portable seismometers, the size of a soda can, buried just below the surface.

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Project web site: http://earthquake.usgs.gov/regional/nca/research/salton/