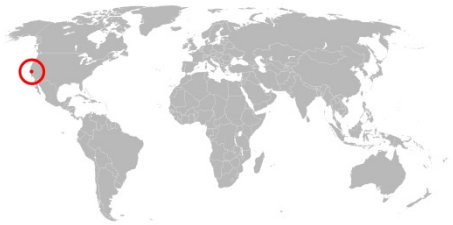
SAFOD

San Andreas Fault
Observatory at Depth
California, USA



Goal & Scientific Objective

SAFOD is driven by the need to answer fundamental questions about the physical and chemical processes controlling faulting and earthquake generation within a major plate-bounding fault zone. The principal goals of SAFOD are to (i) study the structure and composition of the San Andreas Fault at depth, (ii) determine its deformation mechanisms and constitutive properties, (iii) measure directly the state of stress and pore pressure in and near the fault zone, (iv) determine the origin of fault-zone pore fluids, and (v) examine the nature and significance of time-dependent chemical and physical fault zone processes (Zoback et al., 2007).

Operational Achievements

Pilot Hole (SAFOD-PH): vertical, 2168 m depth, complete downhole logs, no core

Main Hole (SAFOD-MH): deviated, 3993 m depth, intersects SAFZ between 3100-3400 m, drill core from 1462-1468 m, 3056-3067 m, 3990-3993 m plus 60 side wall cores, downhole logging by OSG, USGS and service comapnies

SAFOD-III: four side tracks penetrating the SAFZ at depth, side track E contained core from 3141 to 3154 m, side track G contained core from 3191 to 3200 m and from 3300 to 3313 m

Data & Sample Access

Data holdings from the SAFOD Project can be accessed on the ICDP and the Northern California Earthquake Data Center (NCEDC) website. SAFOD physical samples are curated at the Gulf Coast Repository at Texas A&M University, under the supervision of John Firth (firth@iodp.tamu.edu)

Web & Media Resources

www.earthscope.org/science/observatories/safod

http://safod.icdp-online.org

http://earthquake.usgs.gov/research/parkfield

www.youtube.com/watch?v=yJ3zql8SkIY

www.youtube.com/watch?v=pUgxXqwdOlg

Timeline

1996/2004/2005 ICDP Proposal Submissions

2002 Pilot Hole Drilling (SAFOD-PH)

2004 Phase I Main Hole Drilling (SAFOD-MH)

2005 Phase II Maín Hole Drilling (SAFOD-MH)

2007 Side Tracking (SAFOD-III)

Principal Investigators

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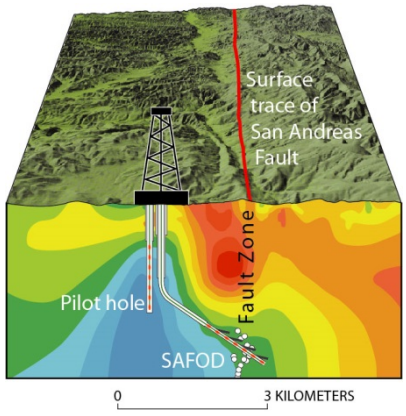

Schematic cross section of the San Andreas Fault Zone showing the SAFOD wells (Source: USGS)

Scientific Findings

At SAFOD, the San Andreas Fault Zone is located between ~3150 to 3420 m depth, containing several discrete 2–3 m wide zones that exhibit very low P- and S-wave velocities and low resistivity

Two of these zones are actively creeping and have progressively deformed the casing at measured depths of 3192 m and 3302 m

The deformation zones are composed of highly foliated, incohesive fault gouge. Fault weakening is mainly driven by talc-bearing serpentine, saponite, and/or nano-coated clay minerals

No evidenced for high pore pressure was observed in the SAFZ which supports fault weakening models by low friction clay minerals. The SAF hydrologically separates Pacific Plate from North American Plate but serves partly as conduit for mantle-derived fluids

Changes in seismic velocity caused by coseismic stress changes were monitored few hours before two earthquakes, suggesting that they may be related to pre-rupture stress induced changes in crack properties

Key Publications

Zoback, M.D., Hickman, S., and Ellsworth, W., 2007. The role of fault zone drilling. In Kanamori, H., and Schubert, G. (Eds.), Earthquake Seismology—Treatise on Geophysics Vol. 4: Amsterdam (Elsevier), 649–674.

Zoback, M.D., Hickman, S., Ellsworth, W., and the SAFOD Science Team (2011): Scientific Drilling Into the San Andreas Fault Zone – An Overview of SAFOD's First Five Years, Sci. Dril., 11, 14-28, doi:10.2204/iodp.sd.11.02.2011.

Niu, F. L., P. G. Silver, T. M. Daley, X. Cheng and E. L. Majer (2008). "Preseismic velocity changes observed from active source monitoring at the Parkfield SAFOD drill site." Nature 454(7201): 204-U244.

Lockner, D. A., C. Morrow, D. Moore and S. Hickman (2011). "Low strength of deep San Andreas fault gouge from SAFOD core." Nature 472(7341): 82-U107.

Schleicher, A. M., B. A. van der Pluijm and L. N. Warr (2010). "Nanocoatings of clay and creep of the San Andreas fault at Parkfield, California." Geology 38(7): 667-670.

Wang, C. Y. (2011). "High pore pressure, or its absence, in the San Andreas Fault." Geology 39(11): 1047-1050.

Serpentine and foliated fault gouge in SAFOD-III drill core extracted at 3194 m depth. Source: Earthscope