Text

Borehole Geophysics and Rock Mechanics

- The initiation and propagation of earthquake ruptures depend upon the mechanical behavior of fault rocks and fluids at depths of several kilometers or more. Using borehole geophysical measurements in conjunction with laboratory studies, USGS scientists determine the temperature, stress, and fluid-pressure conditions at the depths where earthquakes occur and characterize the mechanical behavior of fault-zone materials at realistic in-situ conditions.
- **This knowledge is combined with surface-based geophysical observations, measurements of tectonic strain accumulation, and other information to yield improved models of the earthquake cycle.**

Earthquake Geology & Paleoseismology

- Earthquake geology in the broad sense is the study of the history, effects, and mechanics of earthquakes within and on the Earth's crust. Most often, earthquake geology is synonymous with active tectonics, a term used to describe the study of tectonic movements that are expected to occur within a future time span of concern to society. Such definitions overlap considerably with other research topics on this site, such as Crustal Deformation, Seismology and Earth Structure, and Strong Motion and Site Response. Important aspects of earthquake geology include the study of tectonic landforms on the Earth's surface and folds and faults within its crust produced by many earthquakes over thousands to millions of years.
- **Paleoseismology is the study of the timing, location, and size of prehistoric earthquakes. Key to assessing the likelihood of such an earthquake is knowing how often they have occurred in the past, and when and how large the last one was. These questions underly the science of paleoseismology.**
- **Paleoseismologists, geologists who trench across faults, document evidence of paleoearthquakes, prehistoric earthquakes large enough to rupture the fault at the ground surface. By exhuming the top few meters of an active fault, paleoseismologists may find disturbed ancient soil layers or other traces left by past earthquakes. Exploratory trenches provide a valuable means to precisely locate and establish the recency of movement of particular fault traces. When dates of the past earthquakes can be estimated through the use of radiocarbon and other dating techniques, they provide a basis for estimating the probability of the next earthquake.**

Regional & Whole-Earth Structure

- Seismology is the study of earthquakes and the Earth using seismic waves. From recordings of earthquake-generated waves, information about the earthquake source may be derived, including its magnitude, location, time of occurrence, depth, and its orientation and movement on the fault. Teleseismic waves (waves coming from distant earthquakes) provide information about the entire Earth structure (crust, mantle and core). Seismic waves generated by a controlled source are used to image the Earth's crustal structure.
- **These images reveal the depth and area of basins, fault networks, and the physical properties of rocks.**
- Seismic imaging techniques have analogs in medical science. Waves transmitted (refracted) directly through the earth produce a "catscan"-type image, while waves reflected back to the surface from layer boundaries or faults produce a "sonogram"-type image. Traveltime observations and variations in amplitude, frequency, and waveform are combined to produce a model of the geologic structure. The model must be consistent with other geophysical and geological data, such as measurements of the strength of gravity, measurements of the strength of the magnetic and electric fields, and laboratory measurements of the speed of seismic waves in rock samples.

Strong-motion Seismology, Site Response & Ground Motion

- Intense ground shaking during large earthquakes can damage or even cause failure of engineered structures such as buildings, bridges, highways, and dams. Sustained strong shaking can also trigger ground failures, such as rock falls, landslides, earth flows and liquefaction. Strong motion seismology uses special sensors, called accelerometers, to record these large-amplitude ground motions and the response of engineered structures to these motions.Recordings of large-amplitude seismic waves near the earthquake source can be used to investigate the fault motions that produced the earthquake.
- Site response and ground motion studies use standard seismometers and oil-industry standard geophones to measure the local shaking from natural and man-made sources.
- **These measurements help predict differential, site-dependent ground motion resulting from earthquakes.This information is used to upgrade building codes, to design earthquake-resistant structures, and to predict the patterns of strong shaking from**

future large earthquakes. Rapid reporting of shaking levels also helps to focus emergency response efforts in areas where damage is likely to be the greatest.