UCSB
EARTH SCIENCE

SPEAKERS CLUB

WEBB 1100 • THURSDAY MAY 18th. • 2:00 PM

In Situ observations of site response during and after nonlinear soil behavior

Kenneth Hudson
Department of Earth Science
UC Santa Barbara

Instrumented geotechnical field sites are designed to capture the infrequent but critically important in situ case histories of ground response, deformation, and liquefaction during significant earthquakes that generate high intensity ground shaking and large strains. The University of California at Santa Barbara has been monitoring densely instrumented geotechnical array field sites for almost three decades, with continuous recording now for more than a decade. When seismic waves travel into soil with sufficiently large ground motions, the soil behaves nonlinearly meaning the shear modulus of the material decreases from the linear value observed during weak ground motions. The degraded shear modulus can continue to affect a site for a period of time by changing the soil response during smaller ground motions after the large event. Decreased shear modulus is inferred when a decrease of shear wave velocity between two sensors in a vertical downhole array is observed. This velocity is calculated by measuring the difference in shear wave arrival times between the sensors using normalized cross correlation. The trend of decreasing shear wave velocity with increasing peak ground acceleration is observed at multiple geotechnical array field sites. The length of time the decreased velocity remains following stronger shaking is analyzed using more than 450 events over more than a decade at the Wildlife Liquefaction Array (WLA). Using both monthly and yearly velocity averages between sensors, there is evidence that suggests the shear wave velocity remains low over a period of months following larger significant shaking events at the site. In addition, at WLA there is evidence that the decrease in shear wave velocity can be detected at ground motion levels as low as 20 cm/s2.

Timing and Mechanisms of REE Mineralization at Central City, CO

Carina Edelman
Department of Earth Science
UC Santa Barbara

There is currently renewed interest in understanding petrogenesis of rare earth element (REE) mineralization in the U.S. because of an increasing demand for green technologies such as solar panels and electric vehicles. One such deposit occurs in migmatite gneiss at Central City, Colorado USA, but little data are available on the formation mechanisms of these rare earth phases with respect to the host rock. This study presents new petrologic and geochronologic data to constrain the timing and formation mechanisms of ore-grade concentrations (30.4% rare earth oxide) of REE-bearing phases, monazite, (REE)PO4, and xenotime, (Y,REE)PO4 that occur in in these high-grade metamorphic and igneous rocks. Pods and veins consisting of monazite, xenotime, magnetite, and biotite cut through a felsic granitic matrix of quartz, potassium feldspar, and mica (mostly biotite). Textural analysis of ore-phases indicates igneous crystallization of monazite and xenotime, with a younger recrystallization event preserved in the rims.

In-situ paired geochemical and U-Pb geochronologic analyses of monazite and xenotime from migmatite gneiss samples yield ages of ~1650 and ~1450 Ma. Zircon U-Pb geochronologic analyses from these migmatite gneiss samples indicate igneous crystallization at ~1800 and 1700 Ma, with a metamorphic recrystallization event at ~1650 Ma. Zircon U-Pb geochronologic analyses from sampled local batholiths indicate regional magmatism at ~1750 and ~1485 Ma. This study aims to link primary igneous crystallization of monazite, xenotime, and zircon in migmatite gneiss at Central City, CO to regional volcanism and plutonism occurring throughout Colorado and southwestern USA during the Proterozoic.

Nearby garnet-bearing biotite sillimanite gneiss was used to calculate pressure-temperature estimates. Measurements from garnet, biotite, and plagioclase were made to calculate an intersection of the GARB thermometer with the GASP barometer. A P-T-time estimate of 596 ± 43 °C and 2.14 ± 0.31 kbar is reported at ~1700 Ma from accessory monazite in-situ U-Pb geochronologic data. This supports previous work characterizing this region by high-T low-P metamorphism. Y-in-monazite thermometry of monazite in mineralized gneiss report hotter temperatures ranging from 560-840 °C calculated at 2.5 kbar.

Two mechanisms for REE mineralization are proposed. Multiple periods of partial melting and fractional crystallization of crustal rocks might have occurred during the formation of the Colorado Province. The potential incorporation of REE placer deposits during these crustal re-working events might have led to a highly REE-enriched melt. This is supported by igneous textures of accessory phases, and inherited-age zircon cores. Alternatively, pegmatite formation might have occurred during the final stages of fractional crystallization. This could have led to the formation of immiscible liquids that separated a phosphate and REE-concentrated melt from a silicate melt. Cooling and crystallization formed a granitic coarse-grained rock with preserved melt pods of this REE-bearing phosphate melt from which ore-grade monazite and xenotime crystallized. This is supported by whole rock geochemical data and observed petrographic textures. This study aims to contribute to the ongoing global effort of ore-grade REE deposit characterization.