## **Borehole Observations of Pore Pressure and Ground Motions from the 1999 Hector Mines Earthquake at the Garner Valley Engineering Seismology Test Site.**

Ground motions and pore pressure are monitored at Garner Valley via vertical array instrumentation in the near-surface alluvium, the weathered rock, and down at 0.5 km depth in the crystalline Granite bedrock (Figure 1).

## Shallow Pore pressure Observations from the Liquefaction Array

While the largest motions recorded at GVDA from the Hector Mine earthquake were on the order of only 10% g, still considered in the linear range for dynamic soil behavior, evidence of the onset of nonlinear soil response is seen in the acceleration and pore pressure records of the Garner Valley vertical array in the upper 10-20 meters (Figures 2&3). Dynamic pore pressure oscillations in the near surface alluvium and a steady increase in pore pressure with time correlate with a breakdown in the linear behavior of the stress-strain time histories (Figure 3).

At UC Santa Barbara, we have been developing modeling techniques for dynamic soil behavior at large strain or "strong-motion" levels. Nonlinear modeling including the effects of pore pressure, are used to simulate the ground motions and pore pressure observations in the shallow alluvium. A critical element to the development of any nonlinear model of soil behavior is having control experiments for different soil types, where the input motion below the soil, and the surface motions are recorded. Even better, if we can have a series of observations at different levels within the soil layers, similar to the experiment at the Garner Valley test site. Permanently instrumented field sites to monitor soil behavior at different strain levels and at multiple sites with different soil types are critical to any validation and calibration of state-of-the-art modeling techniques.

We are involved in initiatives to try and increase the number of these types of arrays in the United States. In addition, structural arrays at some of these sites to investigate soil structure interaction and building response would also be extremely useful to the engineering community to improve design methods and public safety.

## Garner Valley Engineering Seismology Test Site Vertical Accelerometer Array



Dual-gain Three-component Accelerometer

Figure 1.



**Garner Valley Test Site, California** Pore Pressure in the Near-surface Alluvium Observed on the Liquefaction Array

