Modeling strains associated with fluid extraction

Andrew J. Barbour[1], Duncan C. Agnew, and Frank K. Wyatt

[1] abarbour@ucsd.edu

EarthScope National Meeting
13–15 May 2013
Raleigh, North Carolina

A class of strain signals found in data from a few borehole strainmeters in the Plate Boundary Observatory network is believed to be associated with pumping of nearby water wells. To test the connection between fluid extraction and strain signals, we have constructed a multi-year record of the pump activity at two actively-pumped wells near the pair of strainmeters at the Pathfinder Ranch, which is located near the San Jacinto fault in southern California. These data indicate a strong correlation between times of fluid extraction and the onset of significant strain changes. We have modeled spatiotemporal strain and pore-fluid pressure fields associated with these episodes of fluid extraction in a layered, radially extensive poroelastic medium. The simplest model which fits the observed strains is a two layer model where rigid bedrock of relatively high diffusivity is overlain by roughly 100 meters of alluvium having slightly higher diffusivity, and behaving as an unconfined aquifer system. The lack of a strong diffusivity contrast suggests the bedrock material has a relatively high density of hydraulically conductive fractures, which logging data for the instruments corroborate. The requirement that both layers have high conductivity may also explain the relatively low-amplitude response of the aquifer system to quasistatic strains from earth tides and teleseismic surface waves.

Education and Outreach

The Pathfinder Ranch operates annually as an independent, non-profit, youth summer camp and outdoor educational school. We have presented their education coordinator with a scientific poster which outlines the concepts of stress and strain in the context of earthquakes and crustal faulting. The poster also explains the purpose of the strainmeters, and presents data associated with pumping activity. We hope this presentation will both show our gratitude for the administrative staff's assistance, and supplement any geology or physics classes given by helping students understand the motivation for using strainmeters.

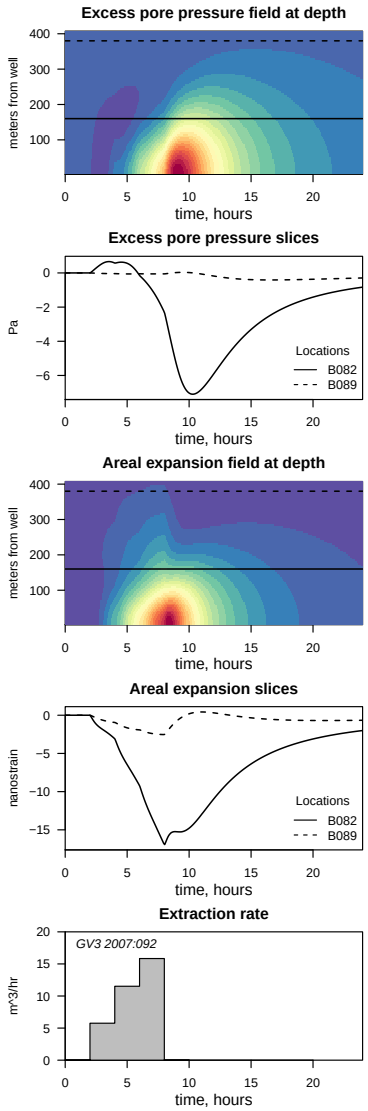

Figure 1: Simulated spatiotemporal fluid-pressure and areal strain in a two-layer poroelastic material, observed at strainmeter depths. The time history of extraction (bottom) is based on a real pumping test performed at a well near the strainmeters (GV3).