A HIGH-RESOLUTION FINITE ELEMENT MODEL OF THE HAYWARD FAULT

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RESEARCH OBJECTIVES

We are using a numerical model to investigate the effects of 3D variation in rock properties and 3D fault geometry on the behavior of the Hayward fault. We will explore (a) how rock properties and 3D geometry affect the stresses on the fault; (b) whether the observed seismicity and fault creep can be explained by rock properties and 3D geometry; and (c) whether it is possible to deduce the locations of locked patches and fault segment boundaries from geologic models.

APPROACH

New studies reveal the three-dimensional structure of the Hayward fault in considerable detail (Ponce et. al.). They include a 3D geologic model of the Hayward fault (Graymer et al); a 3D geologic model of the Bay Area (Jachens et al); a velocity model that assigns elastic properties to the rock units in the geologic models (Brocher et al); and an independent velocity model derived from seismic wave travel times (Thurber et al).

We have constructed a finite element model of the Hayward fault, with cells small enough to resolve the details of the geologic and velocity models. It includes surface topography, 3D fault geometry, and 3D variation of rock properties based on geologic models. We have begun to explore the effect of locked patches on the fault surface, detachment layers at depth, etc. Model results include stress concentrations on the fault, with consequent warping of the fault surface, and displacements at the Earth's surface. Results will be compared to observational data including seismicity (Waldhauser and Ellsworth), surface creep (Lienkaemper et. al.), geodetic, and InSAR data.

ACCOMPLISHMENTS

We devised a new technique for separating the effects of material properties from the effects of 3D fault geometry. The entire geologic model is "morphed" to convert the curved fault surface into a plane. Preliminary results indicate that on-fault stresses generated by rock properties are controlled by rock units close to the fault, and are largely independent of how the model is driven.

Beginning in late 2006, we used our FaultMod finite element software to run several variants of the model: (a) with different sets of material properties; (b) with a "morphed" planar fault, or with actual 3D fault geometry; (c) with or without a horizontal detachment layer below the fault; (d) with or without locked patches; and (e) with "shear distortion" or "sliding block" boundary conditions. The figure below shows one typical example.

Separately, we also created a catalog of idealized models, to develop intuition on how rock units near a fault may generate stresses on the fault.

In 2007, the model will be extended to perform dynamic rupture calculations, in an effort to determine if rheology and geometry create natural segment boundaries. There are also plans to add fault friction, and to extend the model southward toward the Calaveras fault.

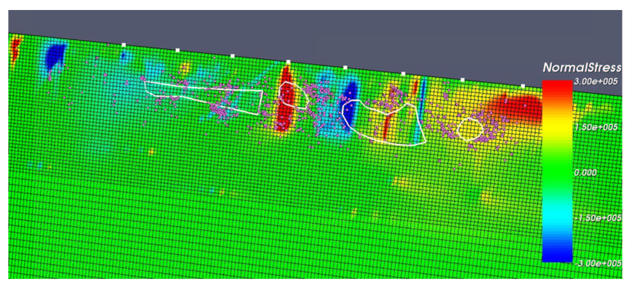

Figure 1. Calculated normal stress on the Hayward fault, viewed from the west. Red denotes tension (unclamping) and blue denotes compression (clamping). White marks at the top of the fault are at intervals of 10 km, with the northernmost (leftmost) mark at Point Pinole. Purple dots are relocated seismicity, and white curves are proposed locked patches (Waldhauser and Ellsworth). Rheology is from the Bay Area Velocity Model (Brocher et. al.). The model is "morphed" to reveal the effects of rheology alone, without 3D fault geometry. The model is driven by applying a shear distortion to the boundary. The calculated normal stressing rate is about 700 to 2000 Pascal/year.

For more information see: **www.FaultMod.com**.