3-D Geometry of Active Deformation East of the San Andreas Fault Near Parkfield, California

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The thrust-and-fold belt east of the San Andreas fault that extends from the Diablo Range to the Temblor Range has been studied in detail mostly at its toe, where a large amount of data is available from oil exploration. We focus more on the part of the belt closer to the San Andreas fault (SAF). We use earthquake data for the period 1980-2006 coupled with surface geology to examine the 3-D geometry of faults in the southernmost Diablo Range, in particular the SAF from just north of Parkfield to the end of the creeping section, and the faults immediately to the east of the SAF. We then combine the results of our study with existing detailed studies and recent earthquake data of the eastern part of the belt to produce a consistent structural model all the way to the San Joaquin basin. We identify from earthquake data an active reverse fault just east of the SAF that abuts the SAF near the bottom of the seismogenic crust (~15 km depth). This fault strikes parallel to the mountain ridge above it, diverges from the SAF from north to south just like the ridge does, and it steepens close to the surface in its southern half. It also matches a major mapped fault trace at the surface. The presence of this fault would explain why this particular ridge has significantly higher structural relief than the surrounding areas, with the Franciscan brought to the surface. At the western margin of the San Joaquin basin, earthquakes indicate the presence of faulting to at least 18 km depth, deeper than can be inferred from oil data alone. The 3-D shape of some of these structures is also illuminated by earthquakes. For example, the aftershocks associated with the 1985 Kettleman Hills earthquake delineate a ramp-flat structure that is clearly different and separate from the structure associated with the 1983 Coalinga event. In general, structures east of the SAF near Parkfield are west-rooting, steeply-dipping thrust faults oriented perpendicular to the regional compression. From double-difference relocated earthquakes we recognize joint-like structures forming a "sliced-bread" pattern in the SAF near Parkfield. These structures are at the resolution limit, but their orientation matches exactly the one predicted from the orientation of the stress field in this region and agrees with the early SAFOD results.