A re-examination of the subsurface fault structure in the vicinity of the 1989 Loma Prieta Mw 6.9 earthquake, central California, from analysis of steep reflections, earthquakes, and potential-field data

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Abstract

We reinterpet the causative structure of the 1989 Mw 6.9 Loma Prieta earthquake, in central California, using reflection, earthquake, and potential-field data, prompted by recent interpretations of a two-part dip of the San Andreas fault (SAF) accompanied by a flower structure in Coachella Valley, in southern California. Initially, the prevailing interpretation of fault structure at Loma Prieta was that the mainshock did not rupture the SAF, but rather a secondary fault, because no well-defined trace of the SAF was identified on the seismic section E-E' and S-S'. Subsequent double-difference (DD) relocation of Loma Prieta aftershocks clarified the structure at Loma Prieta, supporting a flower structure and possible connection of deep faults in the upper crust to the more moderately south-dipping mainshock rupture in the middle crust. Examination of steep-reflection data, extracted from a 1991 seismic-reflection profile through the Loma Prieta area, indicates a robust fault-like feature, though these agree approximately in shape and location with upper-crustal DD-aftershock clusters. Subsurface shape of the San Andreas, Sargent, and Berndt faults are interpretable from these reflections and aforesaid clusters, and the San Andreas and Sargent faults appear to dip initially northeastward in the uppermost crust. A reinterpretation of the causative fault of the 1989 Loma Prieta earthquake is prompted by recent interpretations of a two-part dip of the San Andreas fault (SAF) which dips moderately to steeply SW, is the SAF, like the geometry seen on profile S-S', and (2) the northeastward curvature of the SAF as seen on the SAF as seen on profile E-E'. This unexpected shape is part of an overall steep dip of the SAF in the upper 5 km. In this sense, the subsurface shape of the SAF resembles the shape of the SAF in the Coachella Valley (Fuis et al., 2017; see below).

Analysis of steep reflections

Prior modeling of potential field data

These two potential-field profiles influence our interpretation that (1) the Loma Prieta mainshock rupture, which dips moderately to steeply SW, is the SAF, like the geometry seen on profile S-S', and (2) the northeastward curvature of the SAF as seen on profile E-E'. This unexpected shape is part of an overall steep dip of the SAF in the upper 5 km. In this sense, the subsurface shape of the SAF resembles the shape of the SAF in the Coachella Valley (Fuis et al., 2017; see below).

Fault interpretation based on steep reflections, potential field, and double-difference relocated earthquakes

Figure 1. Comparison of Loma Prieta fault structure interpreted from reflections with fault structure inferred from Coachella Valley (DD Line 4). SAF faults are reversed.