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A deep crustal fluid channel into the San Andreas Fault system near Parkfield, California

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SUMMARY

Magnetotelluric (MT) data from 66 sites along a 45-km-long profile across the San Andreas Fault (SAF) were inverted to obtain the 2-D electrical resistivity structure of the crust near the San Andreas Fault Observatory at Depth (SAFOD). The most intriguing feature of the resistivity model is a steeply dipping upper crustal high-conductivity zone flanking the seismically defined SAF to the NE, that widens into the lower crust and appears to be connected to a broad conductivity anomaly in the upper mantle. Hypothesis tests of the inversion model suggest that upper and lower crustal and upper-mantle anomalies may be interconnected. We speculate that the high conductivities are caused by fluids and may represent a deep-rooted channel for crustal and/or mantle fluid ascent. Based on the chemical analysis of well waters, it was previously suggested that fluids can enter the brittle regime of the SAF system from the lower crust and mantle. At high pressures, these fluids can contribute to fault-weakening at seismogenic depths. These geochemical studies predicted the existence of a deep fluid source and a permeable pathway through the crust. Our resistivity model images a conductive pathway, which penetrates the entire crust, in agreement with the geochemical interpretation. However, the resistivity model also shows that the upper crustal branch of the high-conductivity zone is located NE of the seismically defined SAF, suggesting that the SAF does not itself act as a major fluid pathway. This interpretation is supported by both, the location of the upper crustal high-conductivity zone and recent studies within the SAFOD main hole, which indicate that pore pressures within the core of the SAF zone are not anomalously high, that mantle-derived fluids are minor constituents to the fault-zone fluid composition and that both the volume of mantle fluids and the fluid pressure increase to the NE of the SAF. We further infer from the MT model that the resistive Salinian block basement to the SW of the SAFOD represents an isolated body, being 5–8 km wide and reaching to depths >7 km, in agreement with aeromagnetic data. This body is separated from a massive block of Salinian crust farther to the SW. The NE terminus of resistive Salinian crust has a spatial relationship with a near-vertical zone of increased seismic reflectivity ∼15 km SW of the SAF and likely represents a deep-reaching fault zone.

Key words: Magnetotelluric; Transform faults; Crustal structure.

1 INTRODUCTION

Fluids are ultimately linked to many fault-related processes at transform plate boundaries. Fault zone fluids at high pressures can lower the effective normal stress on a fault and decrease its shear strength at seismogenic depths (Hardebeck & Hauksson 1999). Overpressured fluids within the core of the San Andreas Fault (SAF) were considered a likely explanation for its weakness (Zoback 2000) between Parkfield and Hollister, CA, where the SAF exhibits a combination of aseismic creep and repeating micro-earthquakes. Directly accessing fluids and understanding their role and the *in situ* physical and chemical conditions within the core of the SAF is one of the major goals of the San Andreas Fault Observatory at Depth (SAFOD) (Hickman *et al.* 2004).

From the chemical analysis of well waters, Kennedy *et al.* (1997) proposed that fluids can enter the brittle regime of the SAF system from the lower crust and mantle and may contribute directly to fault-weakening high fluid pressures at seismogenic depths. In this