

Characterizing the enigmatic resistivity structure of the Gofar Oceanic Transform Fault's rupture barrier zone from marine CSEM data

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SUMMARY

Persistent segments of aseismic creep and microseismicity have been found to globally separate locked patches of oceanic transform faults (OTFs). The westernmost branch of the Gofar OTF at the East Pacific Rise (EPR) exhibits this phenomenon, with a well-documented "barrier zone" that hosts abundant microseismicity located between two rupture asperities that nucleate recurring $M_w \sim 6$ earthquakes. Nucleation of large earthquakes has never been recorded in the "barrier zone," hence its name. To date, most observations of the Gofar barrier zone have involved seismic techniques, which have less sensitivity to pore-bound fluid phases in the crust than do electromagnetic (EM) methods. Additionally, there has yet to be consideration of whether off-fault processes, distinct from the brittle deformation experienced within the fault valley, contribute to generating or maintaining the barrier zone. Here, we present the electrical resistivity structure of the crust and uppermost mantle of the Gofar OTF from controlled-source EM data acquired along three fault-crossing profiles, which bisect the barrier zone. While the resistivity north of the fault is typical for oceanic lithosphere of this age, we identify a vertical conductor offset to the south of the fault valley and prominent subhorizontal conductivity anomalies in the upper and lower crust south of the fault. The vertical conductor can be associated with enhanced porosity due to intensified damage along the OTF. The geometry and location of the subhorizontal conductors are inconsistent with fault-induced damage zones, and their conductivities are too large to be explained by seawater filling pore spaces. We instead suggest that the upper crustal conductor may be related to hydrothermal circulation and/or reactions. We propose that the lower crustal conductor likely indicates a region of brine deposition. Because the lower crustal conductor occurs asymmetrically about the fault, this implies that a differential mechanism driving phase separation (i.e. brine generation) is or was present to the south of the fault. We posit that a reasonable candidate for this mechanism is unextracted mid-ocean ridge melts from the main branch of the EPR located south of Gofar. Such melt would have provided a heat source to drive differential fluid infiltration deep into the crust south of the Gofar OTF, which may alter the rheology of the crust and play a role in barrier zone development at Gofar.

Keywords: oceanic transform fault, aseismic creep, marine controlled-source electromagnetic method
