Tectonics of long-offset oceanic transform faults along the Central Indian Ridge

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Oceanic transform faults, conservative plate boundaries in light of plate tectonics, are one of the first-order features of global seafloor. It connects offsets of mid-ocean ridge system up to 400km in length, controlling thermal structure, mantle flow, magmatism and hydrothermalism at mid-ocean ridges. Transform fault is also a good recorder of past and present plate motion and the fault wall is a tectonic window for investigating deep crust / upper mantle lithology. Although the recent numerical studies show that contribution of seawater infiltration along oceanic transform faults is not negligible in global water flux, the degree and spatial extent of serpentinization around the faults system remain poorly constrained. Oceanic transform faults (OTF), especially long-offset transforms where two extremely different age plates are juxtaposing, are thus interesting research target, however the previous field observations are very limited. We mapped the Marie Celeste OTF of 215 km offset as a part of Central Indian Ridge magmatism and hydrothermal activity studies in 2006 and discovered several characteristic features within and around the OTF. Then, we revisited the area January, 2016 and conducted detailed surveys along and across the Marie Celeste and other three OTFs in order to investigate the tectonics, evolution and fluid influence.

Among four transform faults we surveyed, three OTFs (OTF1, 2, and 3) are associated with prominent median ridges near ridge-transform intersections.Median ridges have been reported along both fast- and slow-slipping oceanic transform faults. But the origin of this shallow topography is still enigmatic. Previous studies have proposed along-transform volcanism, intrusion or diapirism of serpentinite, and transpression or localized compression resulting from change of plate boundary geometry. We collected basalt, dolerite, gabbro samples along the middle to upper slope of median ridge of OTF1. The median ridge is sheared and current principal transform deformation zone seems to extend north of the median ridge. Preliminary zircon U-Pb age dating from a recovered sample [Orihashi, personal comm.] shows 13.25+-0.24 [Ma], that is almost same age as the northern wall (=~12 Ma). These observations may suggest that the median ridge is a portion of the northern transform wall which was detached along the present deformation zone.

Previous studies have shown that slow-slipping transform faults are characterized by more positive RMBA (residual mantle gravity anomalies) than their adjacent ridge segment, due to thinning of crustal thickness towards segment ends. We calculated RMBA in our study area, assuming 6-km thick crust and three-dimensional mantle flow. OTF2, where the relative plate velocity is 38 mm/yr., is associated with RMBA of ~0 mGal that is almost same level as the adjacent ridge segment. This result is consistent with spreading rate dependence of gravity anomalies along OTFs by Gregg et al. [2007]. OTF1 (Marie Celeste) shows more negative anomaly than the adjacent ridge segment. A negative RMBA suggests mass deficit along OTF1, which could indicate serpentinization of mantle materials, increase of rock porosity, and/or relatively thick crust. It may suggest the effect of increased rock porosity and serpentinization enhanced by long-offset transform fault, that is usually hidden by effect of crustal thinning. Another possibility is more fast-spreading like crustal structure, that is suggested by off-axis large volcanoes and sheet lava flow within the axial valley at the ridge segment south of OTF1.

Keywords: oceanic transform fault, fracture zone, median ridge, gravity anomaly, Central Indian Ridge, serpentinization

