Magmatic crustal accretion at the ultraslow spreading Southwest Indian Ridge segment at 50º28'E

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The oceanic crust is formed by a combination of magmatic and tectonic processes at mid-ocean ridges. Under ultraslow spreading environment, however, observations of thin crust and mantle rocks on the seafloor suggest that a large portion of crust is formed mainly by tectonic processes, with little magmatism. Although the thermodynamic models predict a largely reduced melt supply at ultraslow ridges, the strong along-axis variations of gravity and bathymetry indicate that melt focusing should exist to form large volcanic centers. In order to understand the role of magmatism in crustal accretion at ultraslow ridges, I study a magmatically robust segment of the Southwest Indian Ridge at 50º28'E (segment 27) with ocean bottom seismometer data.

A three-dimensional (3-D) travel time tomography at the shallow segment 27 reveals a round-shaped (diameter of ~7 km) low velocity anomaly (LVA) in the lower crust beneath the segment center, accompanied by an unusually thick crust (~9.5 km), indicating an extremely magmatic accretion. The resolution of the LVA is further improved by a 2-D full waveform inversion of an across-axis profile running over the segment center, which shows a strong velocity contrast at the top boundary of the LVA, suggesting the correspondence to an axial magma chamber (AMC) and the accumulation of melt at the roof. I also perform a 2-D travel time tomography of an along-axis profile that extends from segment 27 to a non-transform discontinuity (NTD) and segment 28 on the west side. The result shows a significant along-axis variation in the crustal thickness from ~9.5 km at the center of segment 27 to less than 4 km beneath the neighboring NTD, within a 30-50 km distance, requiring a highly-focused melt delivery from the mantle. While the NTD crust exhibits a typical structure composed of a thin, intensely fractured volcanic crust overlying a partially serpentinized mantle, it may have been fed by the AMC at segment 27 through shallow processes, such as lateral dyke propagation. The evidence of such processes is found in the 3-D tomography results as a small low-velocity anomaly at the mid-crustal depth on the west side of the central AMC.

I conclude that the extremely magmatic accretion at segment 27 is due to a focused melt flow towards the large volcanic center, which has been enhanced by the significant large-scale variation in the lithospheric thickness along the ultraslow spreading ridge. The focused melt from the mantle forms the localized AMC and thick lower crust at the large volcanic center, whereas the lateral redistribution of melt from the crustal AMC through shallow processes forms the relatively uniform upper crust along a long stretch of the ridge axis. However, due to the wide spacing of large volcanic centers and the oblique spreading at NTDs impeding dyke propagations, amagamtic extensions with little magma emplacements at any depth are also observed. The wide spectrum of melt supply leads to a complex interaction between magma emplacement, tectonic and hydrothermal processes, which creates a diversity of seafloor morphology and extremely heterogeneous crust at ultraslow spreading ridges.

Biography

I got my bachelor degree in geophysics from Peking University in China in 2010. In 2016 I got my PhD degree in marine geophysics from a joint program between Peking University, China, and Institute de Physique du Globe de Paris, France. My dissertation focused on the study in ultraslow spreading ridges by analyzing ocean bottom seismometer data with advanced inversion methods. In 2017, I did a 10-month postdoc in France to analyze multi-channel seismic data acquired from the equatorial Mid-Atlantic Ridge. Then I work in Dalhousie with Mladen as an OFI postdoc since March 2018. For the second year of my postdoc contract, I will work in Woods Hole Oceanography Institution.