論文内容の要旨

Faulting and melt supply at the ultra-slow spreading Southwest Indian ridge 35-40E, based on geophysical mapping and modeling

地球物理観測およびモデリングに基づく南西インド洋海嶺東経 35-40 度の断層活動とメルト供給量に関する研究

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It has been widely accepted for many years that the gross morphology of the mid-ocean ridge spreading centers varies with the spreading rate. Over the last decade, several exceptions to the spreading rate dependency have been reported. For example, oceanic core complexes where lower crust and/or upper mantle rocks are exposed along long-lived detachment faults are discovered along many ultraslow to intermediate spreading ridges. Ridges adjacent to hotspots show fast spreading type axial morphology and anomalous thick crust regardless of spreading rate. These observations suggest that the melt supply controls the morphology and structure of oceanic lithosphere. Another exception can be observed in ultraslow spreading ridge where the full spreading rate under 20 mm/yr, which has remarkable features that have not been observed in other faster mid-ocean ridge. In the off-axis area of Southwest Indian Ridge (SWIR), the “smooth seafloor” with little or no axial volcanism was found and considered to form at minimal melt supply. On the other hand, large explosive volcanoes sometimes fill the axial valley, indicating focused melt supply. Although the magmatic activity is proportional to the spreading rate in general, so these findings suggest that a spreading rate is not only parameter to control the oceanic crustal formation. Numerical modeling can partly explain the variety of ridge process by changing melt supply rate, which is the rate of dike opening specified by the fraction of plate separation rate. However, the quantitative estimation of actual melt supply based on the field data and the investigation of its influence on the structure and tectonics have not been done so much.

The aim of this thesis is to understand how the variation of melt supply affects ridge structure using geophysical observations (bathymetry, geomagnetism and gravimetric). To tackle this theme, ultraslow spreading ridge is a suitable place because it has been suggested that unusual structure is mainly caused by the variation of melt supply under exceptionally slow spreading environment.

The survey area of this study is an about 300 km length ridge portion of SWIR, 35-40°E located between Prince Edward fracture zone and Eric Simpson fracture zone. This segment is fully covered by prominent geoid high anomaly, and the Marion Island, the nearest the hotspot (37◦51'E 46◦52'S) from the ridge, is now located on 28 Ma crust about 250 km south from the SWIR. In addition, low $Na_{8.0}$ along the axis within the geoid high area has been reported. These facts suggest that the survey area might have been under relatively high melt supply environment in spite of its ultraslow spreading rate and that the area is a natural laboratory to observe the temporal and spatial variation of melt supply and their effect on mid-ocean ridge process.

New swath bathymetry, magnetic data and gravimetric data were acquired in 2008 and 2010 by scientists aboard R/V *Hakuho-Maru* (KH07-04, Leg2 and KH09-05, Leg4). Basement dredge, seismic survey and electromagnetic survey were also conducted during these cruises. Several long, flow-line parallel geophysical profiles were also acquired during the transit, so the bathymetry and magnetic data were used to estimate long term history of spreading rates. Based on the analysis of newly obtained geophysical data and the integration with model studies and previous datasets, I draw the following conclusions;

1) The survey area consists of three orthogonal spreading subsegments and two oblique spreading subsegments. Orthogonal spreading subsegments might have received more melt than oblique subsegments. Crustal thickness variation derived from gravity, magnetization intensity and seafloor morphology suggest that the melt supply rate is different in each subsegment and varies with time and space. The focused melt supply process has been occurred at least for 7 Myr.

2) The continuity of morphology and magnetic isochrones from western subsegment to oblique subsegment suggest that oblique spreading geometry is not a stable structure at least in the survey area. The current oblique subsegment could be orthogonal spreading segment around 3-4 Ma. Then the place of focused melt supply started to move westward, followed by the formation of oblique subsegment. The westward movement of focused melt upwelling also causes the V-shaped topographic high in off-axis area. Ridge obliquity could suppress the extracting melt to the surface and this effect may encourage the further melt focusing to the adjacent orthogonal subsegments.

3) Long term variation of spreading rate since 80 Ma is revealed by using transit line. The result suggests that the spreading rate has not been constant and the ultraslow spreading in this area might suddenly start at C6Bn.

4) Several observed seafloor morphology and structures resemble to what could be seen at hotspot affected ridges. Axial crustal thickening and axial morphological transition could be seen. A V-shaped topography pointing away from the hotspot is also recognizable but, the shape is irregular and it does not accompany with the elongation of volcanic subsegment. Petrological studies reported that basaltic rocks recovered from oblique subsegment contain more enriched trace elements than the other subsegment. This indicates high melt supply. but the geochemical signature could not be explained simply by mixing N-MORB and Marion hotspot trace element.

5) It is clear that the magmatic fraction derived from tectonic strains that are calculated from seafloor lineaments are different from what is used in the numerical modeling. The former contains lithospheric rheology but the latter does not. So these magmatic fractions cannot compare directly. In addition, seafloor morphology cannot explain the magmatic fraction alone. It is also clear that the axial lithospheric thickness relates fault spacing, under the condition of fixed magmatic fraction.

Seafloor morphological asymmetry at the segment end may be explained by the asymmetry of thermal structure between IC and OC, because the thermal structure can change the fault spacing and heave. But to confirm this explanation, precise measurement of seafloor lineaments is essential.