The geological study of an oblique and ultra-slow spreading ridge: Using a sidescan sonar analysis; Knipovich Ridge, Arctic Ocean

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The Knipovich Ridge, the survey area of this study, belongs to the ultra-slow spreading mid-ocean ridge system in the Arctic and Northeast Atlantic Oceans. It is the northern part of the Mid-Atlantic Ridge that divides the American and Eurasian plates. The spreading rate and direction are 1.4cm/yr and 307 deg. at 75 deg. N. There is a well-defined axial valley and prominent volcanic axial seamounts, similar to other slow spreading ridges. The axial valley trends approximately N-S, so high obliquity, as well as ultra-slow spreading rates characterize that Knipovich Ridge. However, because of this distinctive setting, the ridge morphology and geology are complex, obstructing investigation of the detailed evolution and present day behavior of the Knipovich Ridge.

Sidescan sonar imagery, the principal data source for this study, was acquired along the center of the axial valley during the 'Knipovich 2000 cruise', Sept.-Oct. 2000. The principal aim of this cruise was to elucidate the spreading mechanism at an ultra-slow spreading ridge. The sonar image covers a 2.5km swath and 400km long of the Knipovich Ridge (almost 80 percents of the ridge length) and it has higher resolution than previous studies of this area.

Detailed mapping of the sidescan sonar images reveals that faults and lava flows are distributed along almost the entire ridge; on the other hand hummocks are irregularly distributed. A detailed geological interpretation map and a numerical analysis of interpreted features made it possible to investigate the geological processes on this ultra-slow spreading Knipovich Ridge.

Interpretation and numerical analysis of geological features shows that there are large differences between the northern and southern Knipovich Ridge. For example, NE trending long faults and large hummocks are found in the northern Knipovich Ridge, and abundant N-S trending short faults and small hummocks are found in the southern Knipovich Ridge. As for volcanic activity, hummocks are superior to the northern Knipovich Ridge while sheet flows are superior to the southern section of the. These results indicate that some kind of difference occurs between northern and southern Knipovich Ridge.

What mechanism brings about such a difference? The difference of topographical features may be controlled by the difference of lava flow condition. Lava flow condition is highly influenced by viscosity (Kushiro et al., 1978), flow rate, pre-volcanic topography, and cooling rate (Gregg et al., 1995). Head et al. (1996) indicates that centralization of activity to several adjacent vents produces chains of hummocky bulbous mounds. Sampled rock analysis indicates there are no large differences within whole of Knipovich Ridge. The interpreted and analysis results suggest that the difference between the northern and southern ridge sections depend on the change of the cooling rate that related to the change of oblique angle between the axial valley trend and spreading direction. This obliquity will influence the tectonic deformation, such as dike width or length, within the axial valley. Therefore, the large difference in obliquity may cause variations in lava flow behavior, eruption rates, and resulting lava flow condition, and hence a difference in the overall morphology of the ridge.