Geophysical Research Abstracts
Vol. 12, EGU2010-7143, 2010
EGU General Assembly 2010

Structure-forming deformations on Knipovich ridge (physical modeling)

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Knipovich ridge is a strongly oblique ultra-slow spreading ridge which extends on more than 500 km along Svalbard continental margin. It gives a unique opportunity to study influence of spreading obliquity on ultra-slow spreading system, its relations with structures of continental margin. Moreover, this region is very young. It formed as a result of regional plate motion changes during chron 13 (36-38 My ago). Transtension setting in the area of ancient Spitsbergen transform zone changed on transpressive setting. An unstable system of transform-like ridge formed as a result. Its development is continuing till nowadays.

Knipovich ridge consists of short magmatic segments perpendicular to the spreading direction linked by long amagmatic segments sub parallel to the spreading direction. Average trend of the ridge varies from 345° in the south to 5° in the north. Regional direction of plate divergence is 307°. Spreading velocity varies from 16 to 14 mm/year. Ridge obliquity varies from 35 to 60°. Magmatic segments are morphologically expressed by rises with volcanic constructions. They rise above surrounding rift valley on 500-1200 m reaching depths of 3000-2500 m. They have vividly expressed trails in off-axis morphology. Amagmatic segments are expressed by sedimentary basins with rhomb-like shape in a plan view. They have flat surface with small areas of volcanic swells relief trending north-east. Seafloor of this basins lies on depths from 3500 to 3100 m. Profile of the ridge is highly asymmetric. Its eastern edge is strongly sedimented because of the large inflow of sediments from Svalbard continental shelf. Flank rises of the eastern edge are covered by sediments and only the largest rises are observed on the surface. The western edge is characterized by rift mountains rising to depths of 1500-1800 m. Thus, Knipovich ridge is characterized by two trends of structures: trending north-west structures responsible for realization of strike-slip movements and trending north-east structures and lineaments responsible for extension movements. It results in diversity of relief and structural pattern of the ridge which is complicated by proximity of continental margin and straight non-transform junction with Mohns ridge.

In order to distinguish the most important geodynamical factors of structure-forming on Knipovich ridge we conducted a series of experiments. The experimental setting was following. Three weak zones were emplaced. Their trends confirmed modern trends of Gakkel, Mohns ridge and Sptitzbergen fault zone together with Knipovich ridge. The following parameters varied: crustal thicknesses, widths of weak zones, orientation of “Knipovich” weak zone to the extension trend. Segmentation of fractures in the area of “Knipovich” weak zone included short suborthogonal to the extension direction segments connected by long subparallel to the extension direction slip segments with unstable relation of slip and extension components of spreading. In some experiments we received very long clear strike-slip transform segments connected by short pull-apart segments. Increase of the angle between trend of “Knipovich” weak zone and extension direction resulted in gradual decrease of length of strike-slip segments. It reached its minimum under the angle of 50°. Under all the experiments the system of structures was extremely unstable and undergone rebuilds with cease of some segments. But the overall structure pattern with two elements was inherited and defined the structural pattern. Thus, experimental pattern showed good confirmation with natural structural plan of Knipovich ridge. The basical role of extreme obliquity of the ridge and unstable relation between spreading components is confirmed by experiments. Knipovich ridge is forming as unstable transform system consisting of two elements with two trends responsible for realization of two types of stresses: extensive and strike-slip.