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Experimental study of structure-forming deformations in obliquely spreading ultra-slow ridges

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This paper is dedicated to obliquely spreading ultra-slow ridges of North Atlantic and Arctic. The study covers four ridges: Reikjanes, Kolbeynsey, Mohns and Knipovich They are rather young (spreading initiated 58-60 Myr ago) and angles between their trends and spreading direction are from 33 to 85°. All the ridges have peculiarities in structure patterns, kinematics, and morphology and develop in specific geodynamical environments. Kolbeynsey and Reikjanes ridges are developing under influence of Iceland hotspot. Knipovich ridge is developing in ancient slip zone along the heavily sedimented Spitzbergen margin. Spreading at Mohns ridge occurs in conditions of thick lithosphere and extremely narrow heating zone.

In order to study geodynamical features of structure-forming on these ridges we apply experimental modeling The model material used in modeling is a colloidal system composed of mineral oils, solid hydrocarbon and surface-active substances. It has elastic-viscous-plastic properties, under temperature and strain rate, it is capable of failure like a brittle body.

Reikjanes (ridge obliquity 60-65°) and Kolbeynsey (80-85°) ridges show changes of morphology with increasing distance from Iceland mantle plume. In proximity with Iceland they are characterized by axial rise with long s-shaped axial volcanic ridges (AVRs) offset by small discontinuities. Far from Iceland the AVRs are short and offset by large non-transform offsets which are situated in axial valley. In conditions of ll these features are explained by influence of mantle flow from the Iceland mantle plum initiating the increasing of mantle temperature. It results in decreasing of lithospheric brittle layer with approaching to Iceland. In experimental sets reproducing conditions of proximate to Iceland part of the ridge were reproduced in sets with the widest weak zone and the smallest crustal thickness and vice versa. In sets reproducing conditions of proximate to Iceland received long and non-discontinued AVRs; on the other hand we received short and displaced AVRs. Higher obliquity of Reikjanes ridge results in formation of s-shaped strongly en-echeloned fractures.

Mohns ridge is spreading with obliquity of 55°. Its rifting zone consists of a set of magmatic segments connected by accommodation zones lacking magmatic activity, they orient subparallel to spreading direction. Their length is 30-55 kilometers. The main peculiarity of experimental sets was a formation of pattern of stably developing slip and semi slip semi extensive segments connecting perpendicular to extension segments of the ridge. All of them had almost equal length.

Knipovich Ridge obliquity varies from 33 to 63° on different parts of the ridge. It consists of short divergent magmatic segments and long transform-like amagmatic segments with unstable relation of slip and extension components. Length of amagmatic portions of the ridge varies from 40 to 150 kilometers. Experimental setting was the following. We emplaced three weak zones according to natural geometry of spreading modeling three neighboring ridges: Knipovich, Mohns, Gakkel. Short spreading segments orthogonal to direction of extension formed in area of Knipovich model zone. They were connected by subparallel to extension direction. Under increase of angle between extension direction and trend of “Knipovich” weak zone the length of slip segments gradually decreased and reached minimum under the angle of 50°.

Thus, experiments let to distinguish key peculiarities of structure-forming in rifting zones of these ridges. For Kolbeynsey and Reikjanes ridge this is a system of fractures which are used as channels for eruption and subsequent formation of AVRs, their parameters depend on distance from Iceland plume and thickness of crustal brittle layer. For Knipovich ridge this is an unstable system of pull-apart basins connected by long largely slip segments. For Mohns ridge this is a system of extension basins connected by accommodation zones with equal length.