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MORPHOLOGY OF THE KNIPOVICH RIDGE AREA

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Abstract

Knipovich Ridge is the northernmost part of the Mid-Atlantic Ridge system. It is located between Mohns and Molloy spreading centers in the Greenland Sea. The scientific team of the R/V “Akademik Nikolaj Strakhov” (Geological Institute RAS, Russia) surveyed this area in 2006, 2007, 2009 and 2010 using the deep-water multibeam echosounder RESON Seabat 7150 with working frequency 12 kHz. The total surveyed area is up to 82000 km² including 65000 km² covering rift valley and flanges of the ridge.

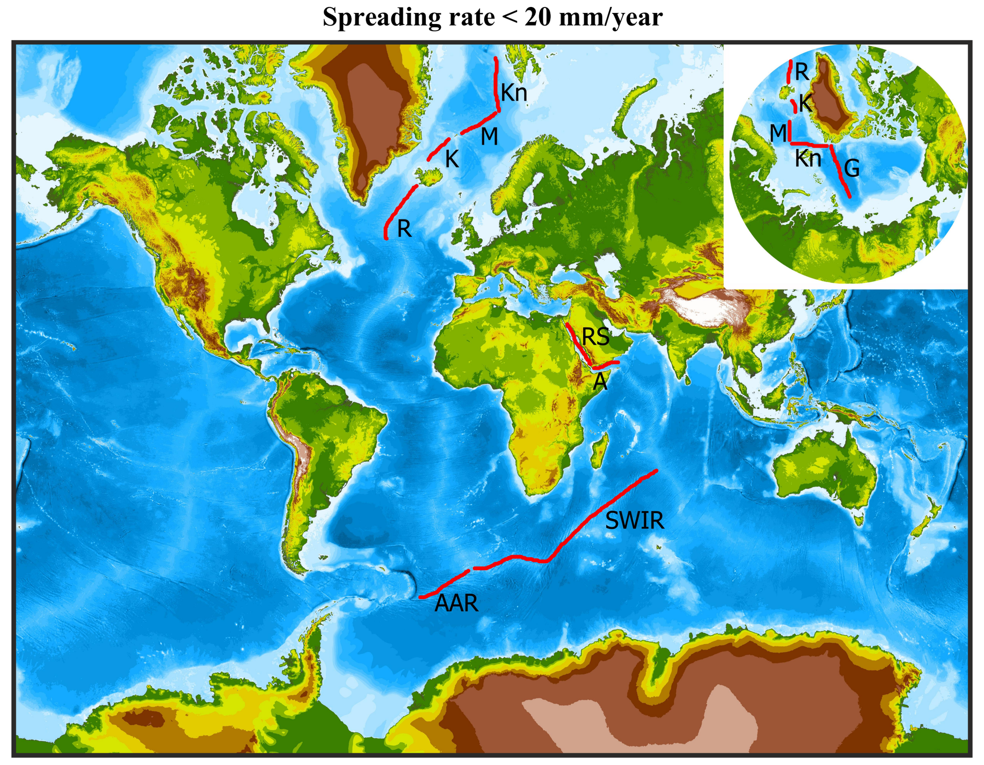
Knipovich ridge is classified as an ultraslow oblique spreading center with spreading rate around 1,4 cm/y. Its large-scale morphological features are reduced in number comparing to other mid-ocean ridges. Eastern flange is buried under the continental slope sediments and only the rare highest peaks rise above this cover. Western flange is fully developed and consists of several ridges prolonged parallel to the rift valley. Ridges are supplemented with individual highs. Rift valley is 20-40 km wide and 500 km long. Its depth is 3300-3700 m. Valley slopes have terraces and ledges of different amplitudes. The bottom of the valley is echeloned by 5 volcanic axial highs rising 400 - 1000 m above it.

Spreading obliquity is imprinted in the ridge morphology. The global models predict a plate motion vector of 307°. The main ridge axis has general orientation of 350°. Rift valley follows this direction from the South, and on the half way to the North turns to azimuth of 2°. The detailed bathymetry shows that small-scale features orientation differs from that of the large-scale. Rift axial highs and individual flange highs are prolonged NW-SE under azimuth 30°. This orientation is sub-perpendicular to the plate motion vector (83°) and oblique to the ridge axes (40°). The multibeam bathymetry shows no sing of transform faults or non-transform discontinuities along the Knipovich ridge rift valley. There is one strong lineation in the northern part of the ridge. It includes flange and axial highs and continues from the eastern flange through the second northern axial high to the western flange under the azimuth of 320°. It is an indication of long-term magmatic activity in this segment.

Detailed bathymetry reveals small-scale features that are important for the understanding of the ridge nature.

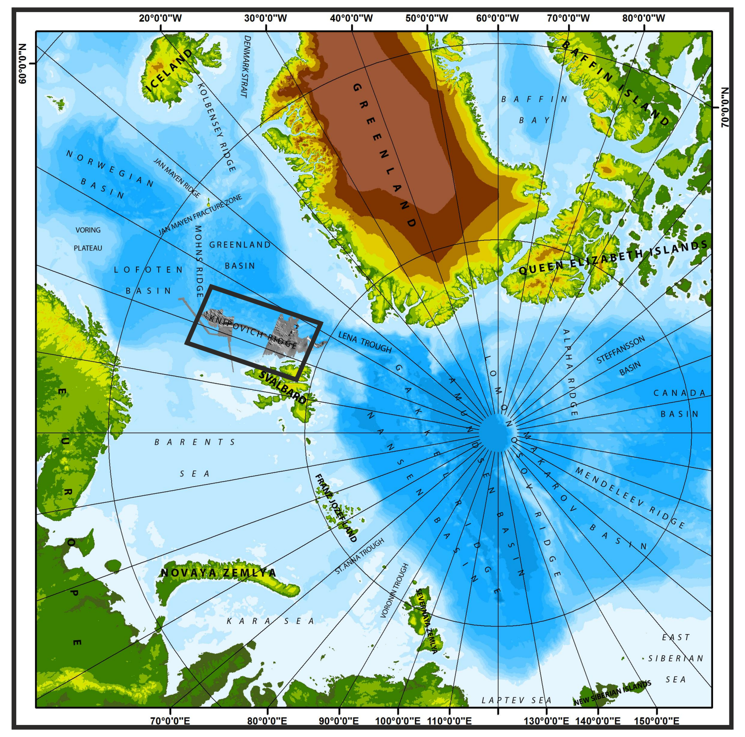
Ultraslow spreading class of ocean ridges

Spreading rate < 20 mm/year



Ultraslow spreading ridges (red lines): G - Gakkel Ridge, Kn - Knipovich Ridge, M - Mohns Ridge, K - Kolbeinsey Ridge, R - Reykjanes Ridge, RS - Red Sea Rift, AB - Aden Ridge, AAR - American-Antarctic Ridge, SWIR - Southwest Indian Ridge. Bathymetry - GEBCO, 2008.

Survey Area



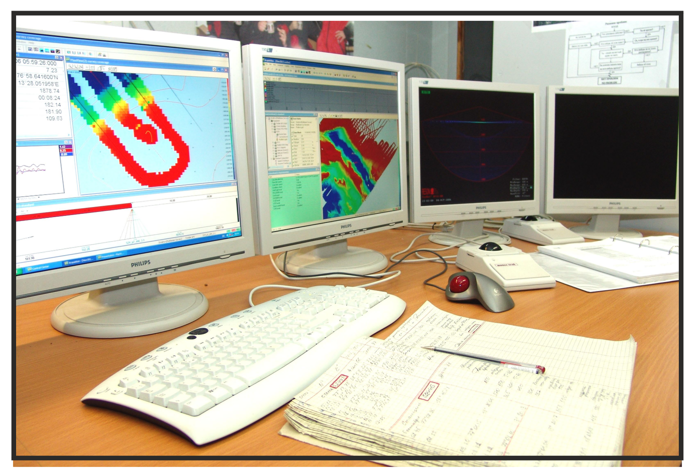
Arctic bottom topography map. Bathymetry - IBCAO 2.23 (Jakobsson, M., et al., 2008). Grey polygon shows R/V “Akademik Nikolaj Strakhov” (Geological Institute RAS, Russia) survey area in cruises of 2006, 2007, 2009 and 2010. Total surveyed area is up to 82000 km².

Methods

Deep water multibeam echosounder
RESON SeaBat 8150 (7150)

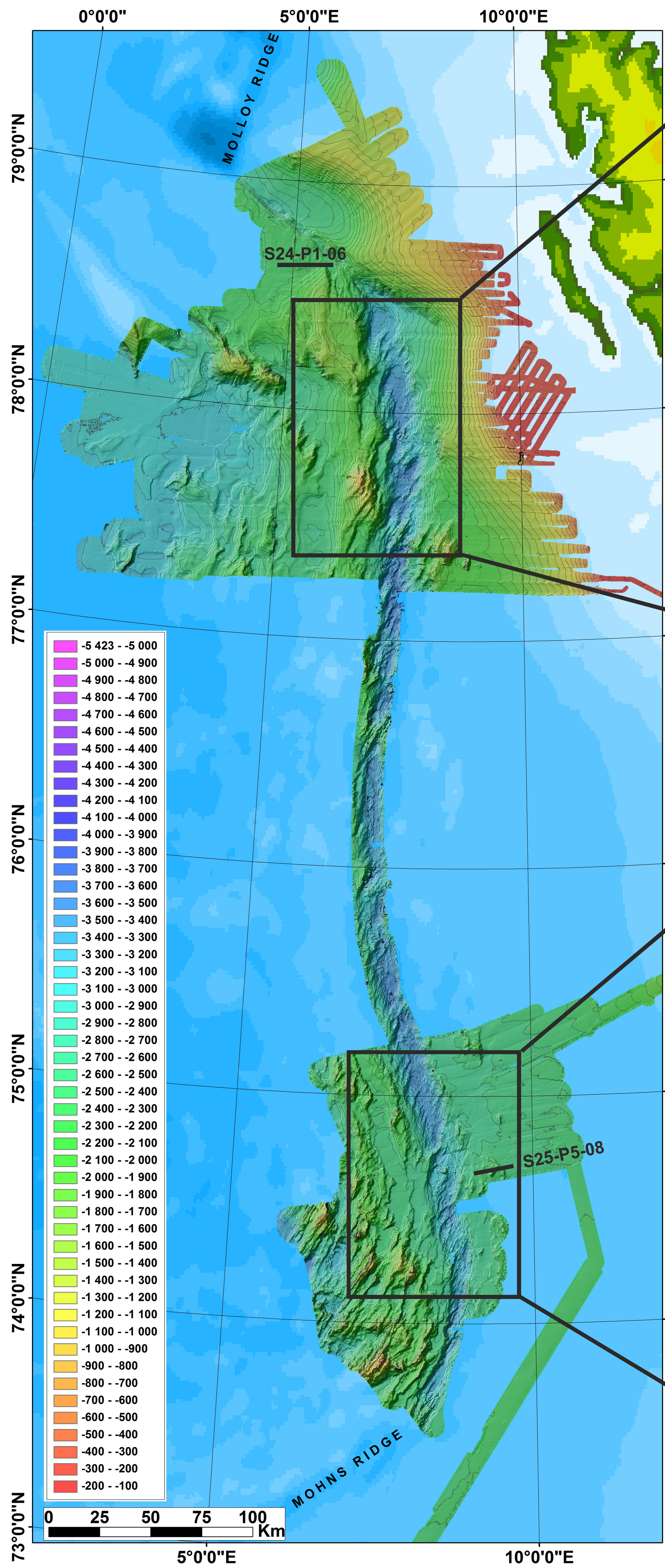
- frequency - 12 kHz
- 234 receiver beams across swath
- 2°x2° beams
- swath coverage 150°
- distance between tracks – 4 - 7 km
- horizontal datum - WGS84
- vertical datum - mean sea level
- data acquisition and processing onboard in PDS2000

Result - digital terrain model (100x100 m)

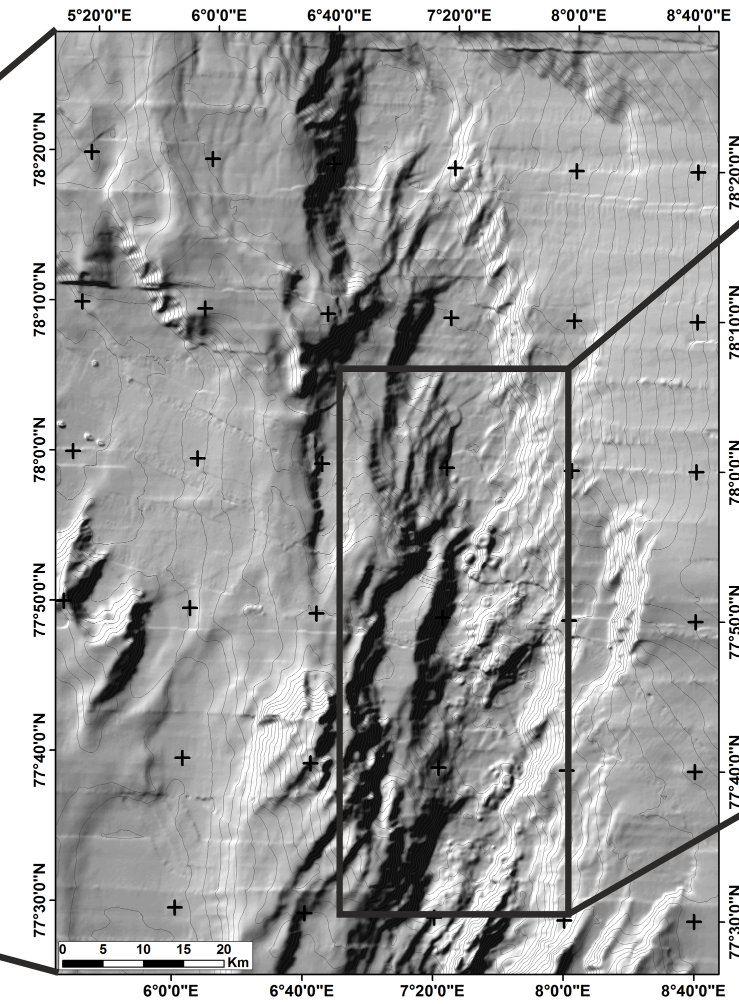


Multibeam echosounder working station onboard R/V “Akademik Nikolaj Strakhov”.

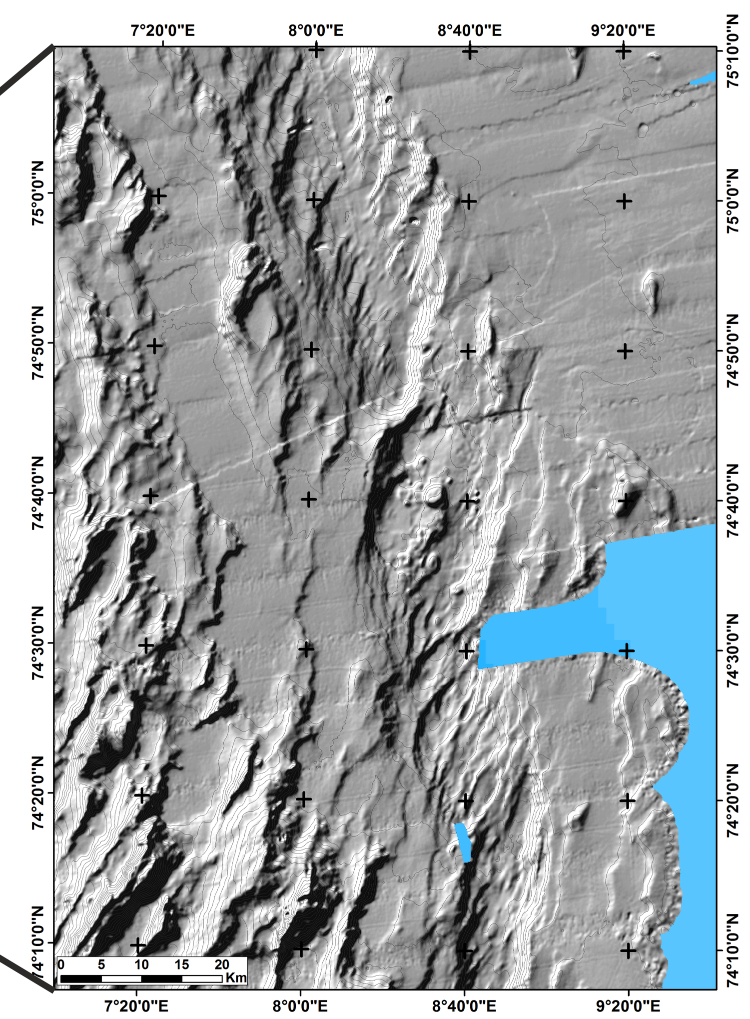
Installation of multibeam echosounder gondola on R/V “Akademik Nikolaj Strakhov”.



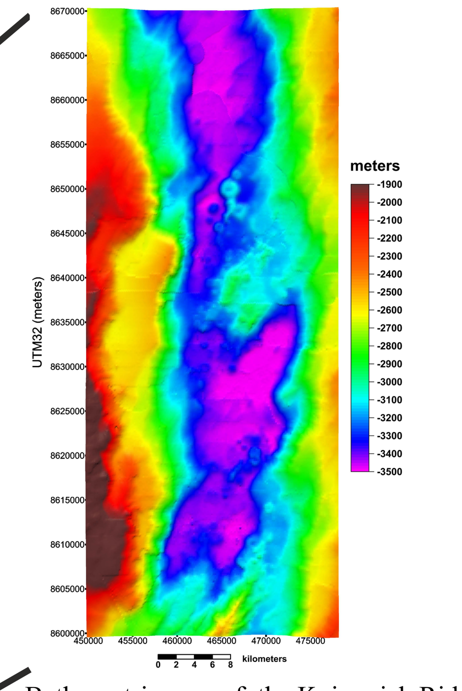
Detailed bathymetric map of the Knipovich Ridge. Contour interval is 100 m. Lines show the location of the CHIRP profiles.



Shaded-relief multibeam bathymetric map of the northern part of the Knipovich rift valley illuminated from the northwest. Contour interval is 100 m. The detailed bathymetry shows the small-scale features. General rift valley azimuth is 2°. Rift axial highs and faults are prolonged NW-SE under azimuth 30° oblique to the ridge axes (28°)

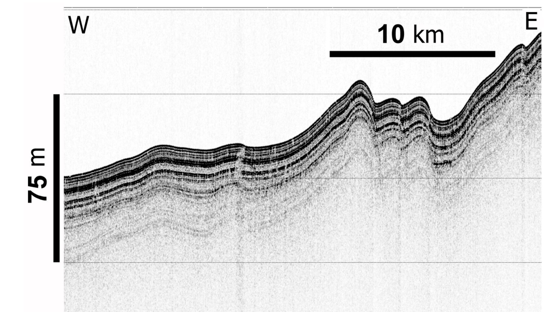


Shaded-relief multibeam bathymetric map of the southern part of the Knipovich rift valley illuminated from the northwest. Contour interval is 100 m. General rift valley azimuth is 350°. Rift axial highs and faults azimuth is 30° as in the northern part. Obliquity to the ridge axes is 40°.

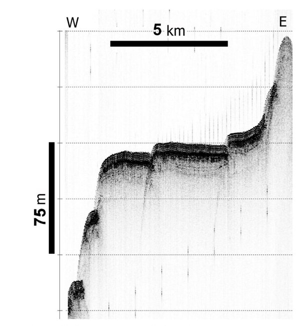


Bathymetric map of the Knipovich Ridge magmatic segment
The detailed bathymetry shows multiple volcanic structures of central types.
Elevation of volcanic structures above the bottom of the rift valley is 500 m.

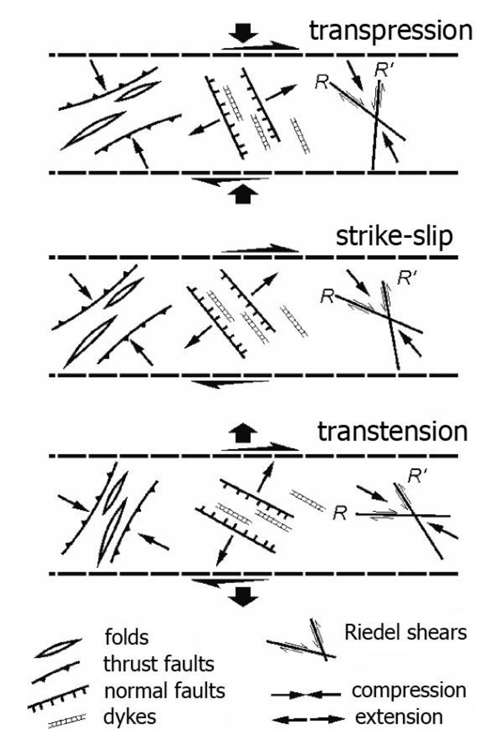
R/V “Akademik Nikolaj Strakhov”



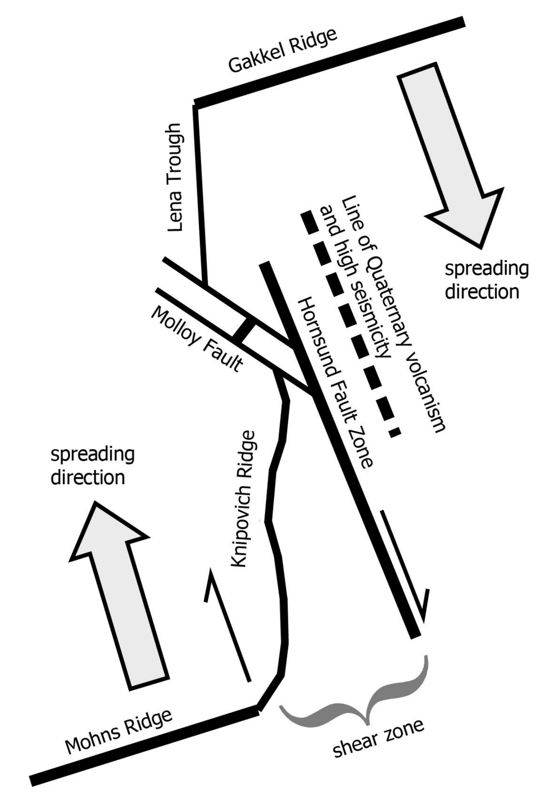
CHIRP profile S24-P1-06 fragment.
The profile shows thrust faults on the northern part of the Knipovich ridge west flange.



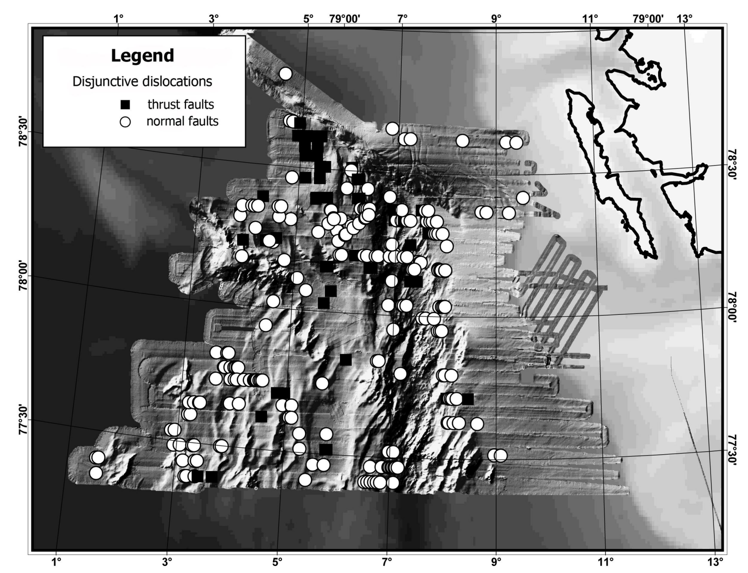
CHIRP profile S25-P5-08 fragment.
The profile shows normal faults on the southern part of the Knipovich ridge east flange.



Orientation of the main structures in shear zones of different types (Kirmasov, 2011).



Schematic diagram of the modern tectonics of the North Atlantic and Arctic divergent structures (Sokolov et al., 2014).



Thrust faults and normal faults distribution scheme for Northern part of the Knipovich Ridge between 77°20’ N and 78°40’N according to the interpretation of the disjunctive dislocations of the upper sediment layer in high-frequency seismic profiles (Sokolov et al., 2014).

Conclusion

The Knipovich ridge is the key structure for understanding tectonic and geodynamic nature of the transition zone between the North Atlantic and Arctic spreading centers. Detailed bathymetry depicted small-scale features such as faults, hills and volcanic structures within the rift valley and on ridge flanges. Morphology of the structures shows incoherent orientation of the small-scale feature and the rift axis. Orientation and distribution of the normal and thrust faults as well as general orientation of the system of the spreading and transform centers between Mohns and Gakkel ridges suggests that the plate boundary develops within the big transtensional shear zone.

Acknowlegements

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