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Recent Tectonics in the Northern Part of the Knipovich Ridge, Atlantic Ocean

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Abstract—The walls of the Knipovich Ridge are complicated by normal and reverse faults revealed by a high-frequency profilograph. The map of their spatial distribution shows that the faults are grouped into domains a few tens of kilometers in size and are a result of superposition of several inequivalent geodynamic factors: the shear zone oriented parallel to the Hornsunn Fault and superposed on the typical dynamics of the mid-ocean ridge with offsets along transform fracture zones and rifting along short segments of the Mid-Atlantic Ridge (MAR). According to the anomalous magnetic field, the Knipovich Ridge as a segment of the MAR has formed since the Oligocene including several segments with normal direction of spreading separated by a multitransform system of fracture zones. In the Quaternary, the boundary of plate interaction along the tension crack has been straightened to form the contemporary Knipovich Ridge, which crosses the previously existing magmatic spreading substrate and sedimentary cover at an angle of about 45° relative to the direction of accretion. The sedimentary cover along the walls of the Knipovich is Paleogene in age and has subsided into the rift valley to a depth of 500–1000 m along the normal faults.

Keywords: faults, sedimentary cover, seismic section, Knipovich Ridge

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INTRODUCTION

A detailed seismoacoustic survey of the northern Knipovich Ridge during cruises of the R/V *Akademik Nikolaj Strakhov* of the Geological Institute, Russian Academy of Sciences, and the Norwegian Petroleum Directorate afforded the unique opportunity to study the parameters of abyssal sedimentary cover and its deformations. Detailed systems of seismoacoustic measurements based on a regular grid are rare for abyssal zones, because the main scientific investigations in the ocean are focused on shelves, continental slopes, and axial zones of mid-ocean ridges—a tectonic fabric that produces the oceanic crust. The proximity of the geodynamically active zone of the Knipovich Ridge and its abyssal flanks to the shelf provenance makes this area unique for studying neotectonics by mapping recent deformations of the upper part of the sedimentary cover. Mapping of the exposed fault planes makes it possible to detect stresses in the crust. The bottom topography and slope angles in combination with the distribution of the sediment thickness yield important information on the morphology and genesis of structural elements. The reliability of interpretation is enhanced by paleontological evidence for the age of the dredged sedimentary rocks. The pattern of the anomalous magnetic field (AMF) always serves as a macrostructural background for interpreting tectonic processes in areas of spreading. We used this sort of evidence in combination with transformation of the AMF for consistent interpretation of the geological, geophysical, and seismoacoustical data collected on expeditions. The novelty of the factual data and maps compiled on their basis allowed us to narrow the scope of hypotheses concerning the origin and dynamics of the Knipovich Ridge.

VIEWS ON TECTONICS OF THE KNIPOVICH RIDGE

Views on the tectonics of the Knipovich Ridge can be conventionally separated into two categories. According to one view, the ridge axis is regarded as a spreading center, which has been functioning since the early Oligocene (anomaly 13 of the magnetostratigraphic scale) in a regime of ultraslow oblique spreading with a rate of <2 cm/yr to form a segment of the oceanic crust of the Mid-Atlantic Ridge about 650 km wide between Greenland and the western margin of the Barents Sea shelf (Fig. 1). In terms of the second category of models, the trough of the Knipovich Ridge is a result of extension axis jumping or breakup under conditions of shearing rather than a spreading center of the opening basin.

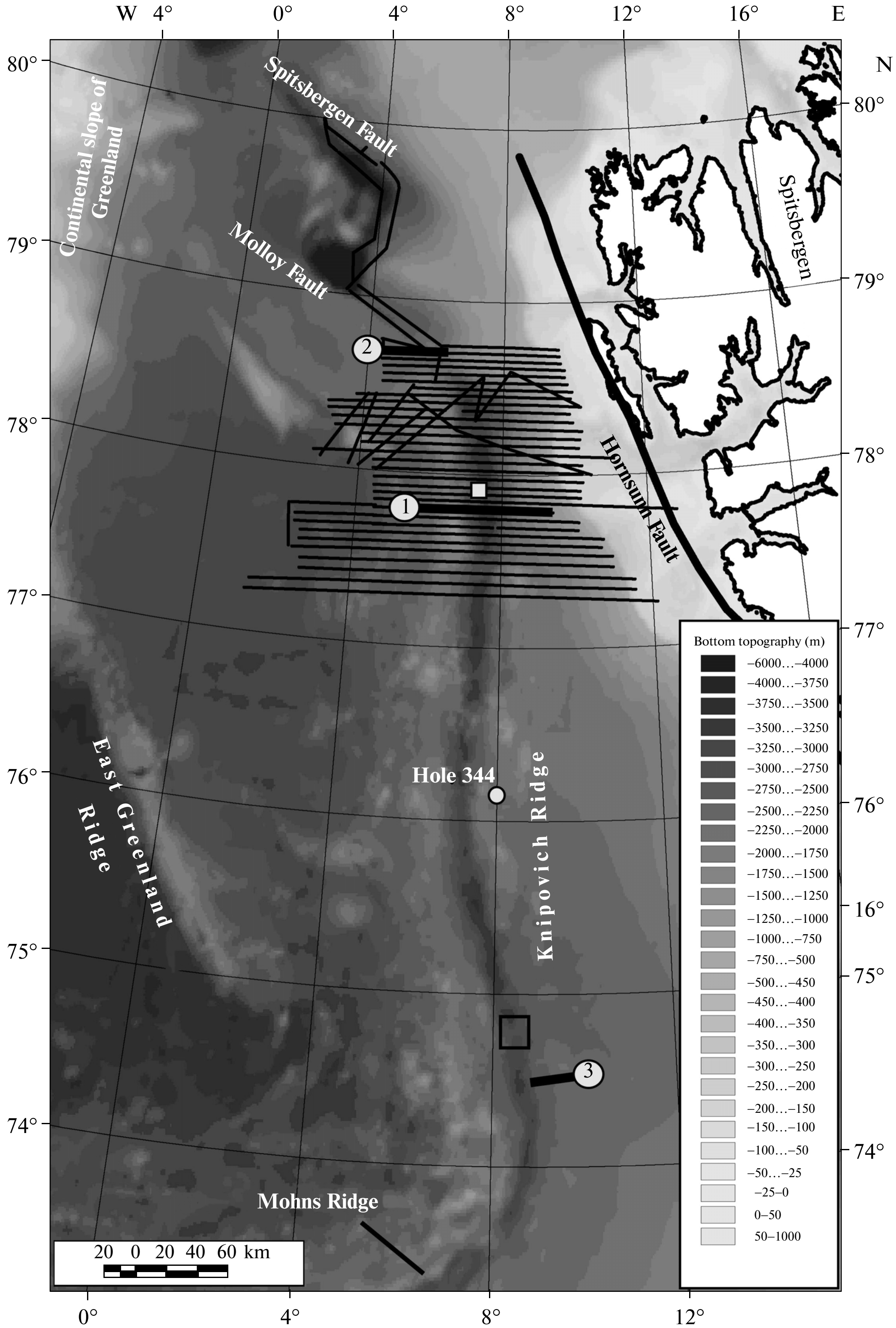

Fig. 1. Studied area of MAR near Knipovich Ridge and scheme of investigations during 24th cruise of R/V *Akademik Nikolaj Strakhov* (Geological Institute, RAS; Norwegian Petroleum Directorate, 2006). Cruise tacks are shown by black lines. Heavy lines with numbers in circles indicate used fragments of seismoacoustic profiles. White square is dredging station; black square is location of Fig. 4.

Publications [7, 9, 17, 19] and many others can be referred to the first category. Nevertheless, the unusual spreading setting of the Knipovich Ridge compels almost all researchers to have various reservations, which assume the contribution of a strike-slip component. In our view, such unanimity about the singularity of the Knipovich Ridge tells us that introduction of a strike-slip element into the model makes the actual tectonic setting explainable and fits the nature of this region. In [9], the tectonics of the Knipovich Ridge is considered to be a result of joint action of right-lateral offset along the Molloy Fault and extensional rifting along the ridge axis. In other words, atypical MOR structures are a result of the nonorthogonal fault line relative to the MOR axis. This implies either oblique spreading at an angle of 45°, which is unlikely, or normal spreading and a parallel jump of the ridge axis to the east, which contradicts the magnetic field configuration and cannot explain movement of the lithosphere along the Molloy Fault apart from ridge axis without assumption of oblique spreading. In [7], the authors specially emphasize that the strike-slip component increases southward along the ridge axis. The maximum offset is noted at that segment of the ridge, which is parallel to the Hornsunn Fault.

One of the first mentioning on the fault-controlled tectonic nature of the Knipovich Ridge was made in [14], where it was suggested that this structural element is a transform zone. The DSDP drilling (Hole 344) “did not allow the nature of the Knipovich Ridge to ascertain. The igneous rocks in its basement penetrated by the borehole are dolerite and gabbroic sills, which are three million years younger than the overlapping upper Miocene sediments. It is quite possible that this ridge was formed in the transform fracture zone rather than in the rift zone” [14, p. 53]. In addition, the geometry of structural elements in the basin near the Knipovich Ridge markedly differs from the conventional structural assembly of the MAR.

According to [3], the Knipovich Ridge cannot be referred to as a typical spreading ridge. The definition, which fits its origin, is a transform fracture zone with elements of a pull-apart fault. As was stated in [4], the Knipovich Ridge is a young oceanic rift rather than a spreading center despite the rift valley, submarine volcanism, seismicity, and hydrothermal activity.

Seven rift segments separated by transform fracture zones have been recognized at the oceanic bottom adjoining the Knipovich Ridge [23]. Among these segments, identification of the complete series of magnetic anomalies up to number 13 is hampered, so that the position of the spreading center as a source of recent positive anomalies remains indefinite. This is also aggravated by the lack of significant anomalies along most of the ridge’s extent. A quite reasonable tectonic evolution of the region has been proposed in [21], assuming that the spreading responsible for the formation of the magmatic basement initially developed in the normal direction relative to the axis segment oriented nearly parallel to the Greenland shelf. The recent divergence of Greenland and Eurasia is controlled by strike-slip offset along the Hornsunn Fault (Fig. 1). Therefore, interaction of plates resulted in the formation of the rectified plate boundary and the transtensional strike-slip zone. The Knipovich Ridge was a tearing-off zone, which crosses the previously existing spreading basement diagonally relative to the entire MAR segment from the Mohns Ridge to the junction with the Molloy Fault.

The idea of a rectified divergent boundary between plates [21] was developed in [11] based on processing of AMF data [22] by means of downward extrapolation of the field into the lower half-space. It is assumed that this boundary consists of at least four short offset segments along the transform fracture zones for a distance commensurable with the lengths of the rift segments themselves instead of one segment with normal but slow spreading. The trough of the Knipovich Ridge is considered to be a tension crack within the strike-slip zone oriented at an angle of ~40° relative to the master Hornsunn Fault rather than a pure transform fracture zone. In this paper, we advance the idea of the recent tectonics of the Knipovich Ridge as a result of rectifying the echeloned divergent boundary under conditions of shearing.

The tectonic evolution of the Knipovich Ridge is regarded as a result of strike-slip faulting parallel to the Hornsunn Fault between the Gakkel and Mohns spreading centers, which prevails in scope over the slip along the Molloy Fault.

SPREADING OF THE KNIPOVICH RIDGE AS EXPRESSED IN AN ANOMALOUS MAGNETIC FIELD AND TECTONIC INTERPRETATION

In contrast to axial zones of the Gakkel and Mohns ridges, the Knipovich Ridge is barely expressed in the AMF [22], and its axis is traced on the basis of bathymetric evidence. A sort of axial anomaly is observed in the northern part of this ridge adjoining the Molloy Fault. The linear segments of the AMF at the flanks of the ridge are poorly identified in the low-amplitude magnetic field (±150 nT, on average). To enhance weak anomalies, continuation of the field in the lower half-space has been calculated [11] (Fig. 2a). As a result, the pattern of linear anomalies became more distinct. Such a transformation of AMF made it possible to identify eight short spreading segments separated by transform offsets (Fig. 2b). Since there are no clearly discernible extensions of linear AMF segments, definite identification of anomalies remains

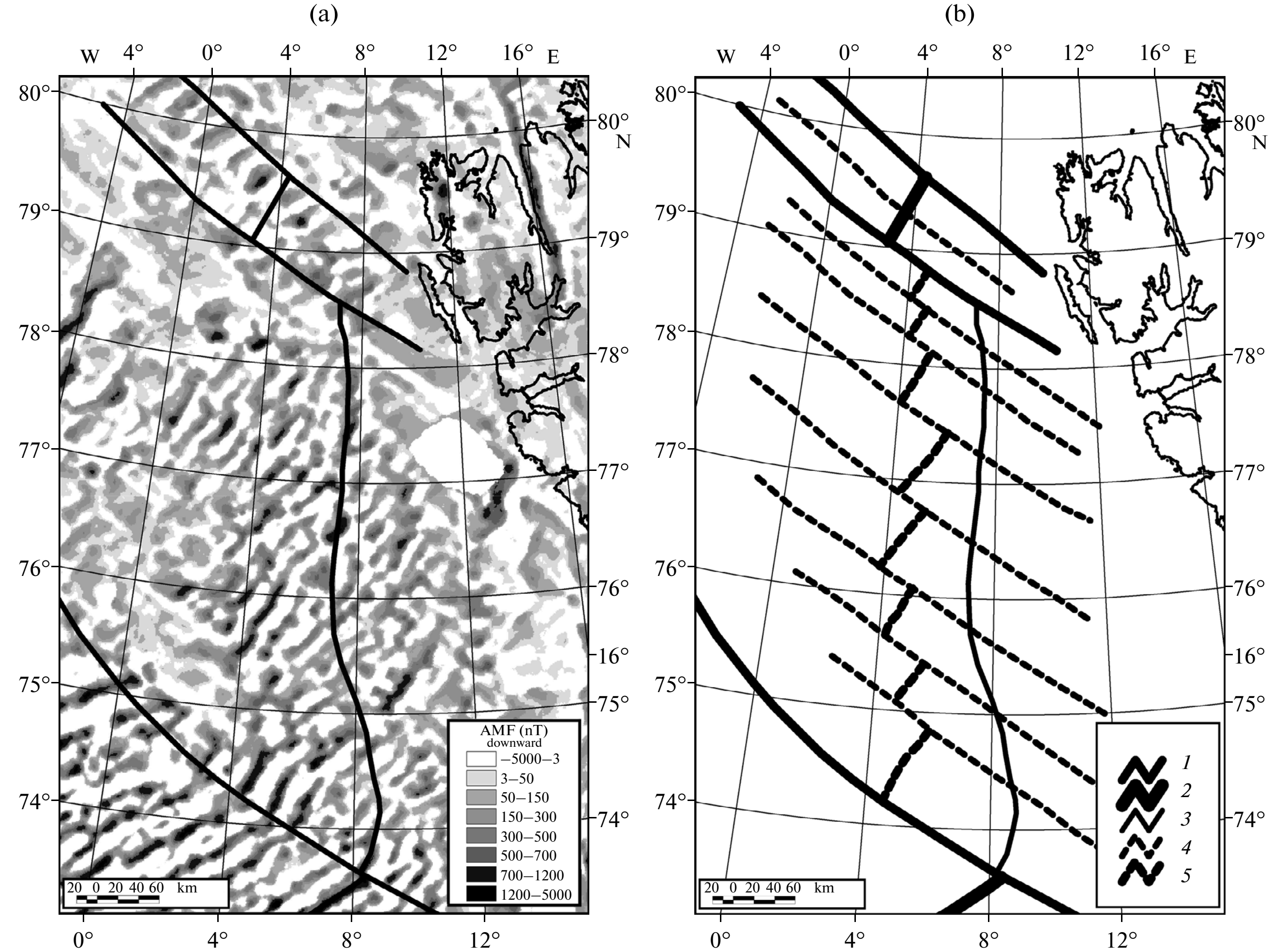

Fig. 2. (a) Anomalous magnetic field calculated downward to 20 km from Gauss formula using data from [22] as initial AMF after [11]; active faults and trough of Knipovich Ridge are shown; (b) tectonic interpretation, modified after [11]. (*1*) Active fault, (*2*) active rift, (*3*) trough of rift, (*4*) inactive fault, (*5*) inactive rift.

problematic. The position of the zeroth age zone of the magnetoactive layer built up by volcanic rocks is also questionable. The position of inactive rift segments (Fig. 2b) has been chosen from the location of the highest absolute AMF amplitudes. Despite obstacles, the patterns of identified anomalies actually exist. They have been obtained by straightening of the aeromagnetic profiles along the segments of the most distinct anomalies and the zeroth zones, which are neatly ulterior in the magnetic field [20].

The obliquely (40° to 50°) oriented axis of the Knipovich Ridge relative to the azimuth of linear AMF segments can hardly be explained by oblique spreading, because at those angles, interaction between plates is transformed from extension to shear [13]. The appearance of a tension crack in the shear zone is the most probable mechanism of trough formation (Fig. 3a). A conceptual scheme of recent divergent tectonics in the northern Atlantic and Arctic Region is shown in Fig. 3b. Taking into account the tectonic setting in the area affected by the action of two obvious Gakkel and Mohns spreading zones along the Lena Trough–Knipovich Ridge, a shear zone broadly coinciding in orientation with the Hornsunn Fault must exist. The offset along this zone is much larger than horizontal displacement along the Molloy Zone. As follows from the transformed AMF, the abyssal space and flanks of the Knipovich Ridge are also zones formed by spreading in combination with quasi-periodical (with a step of ~55 km) multitransform system of fracture zones. The axis of the Knipovich Ridge straightens a paleorift–paleo-offset structural system between the Molloy Fault and the eastern end of the Mohns Ridge. The relationship of the aforementioned structural elements is consistent with the configuration of shear assembly (Fig. 3a) and, as judged from the angular relationships, suits the transtensional structure.

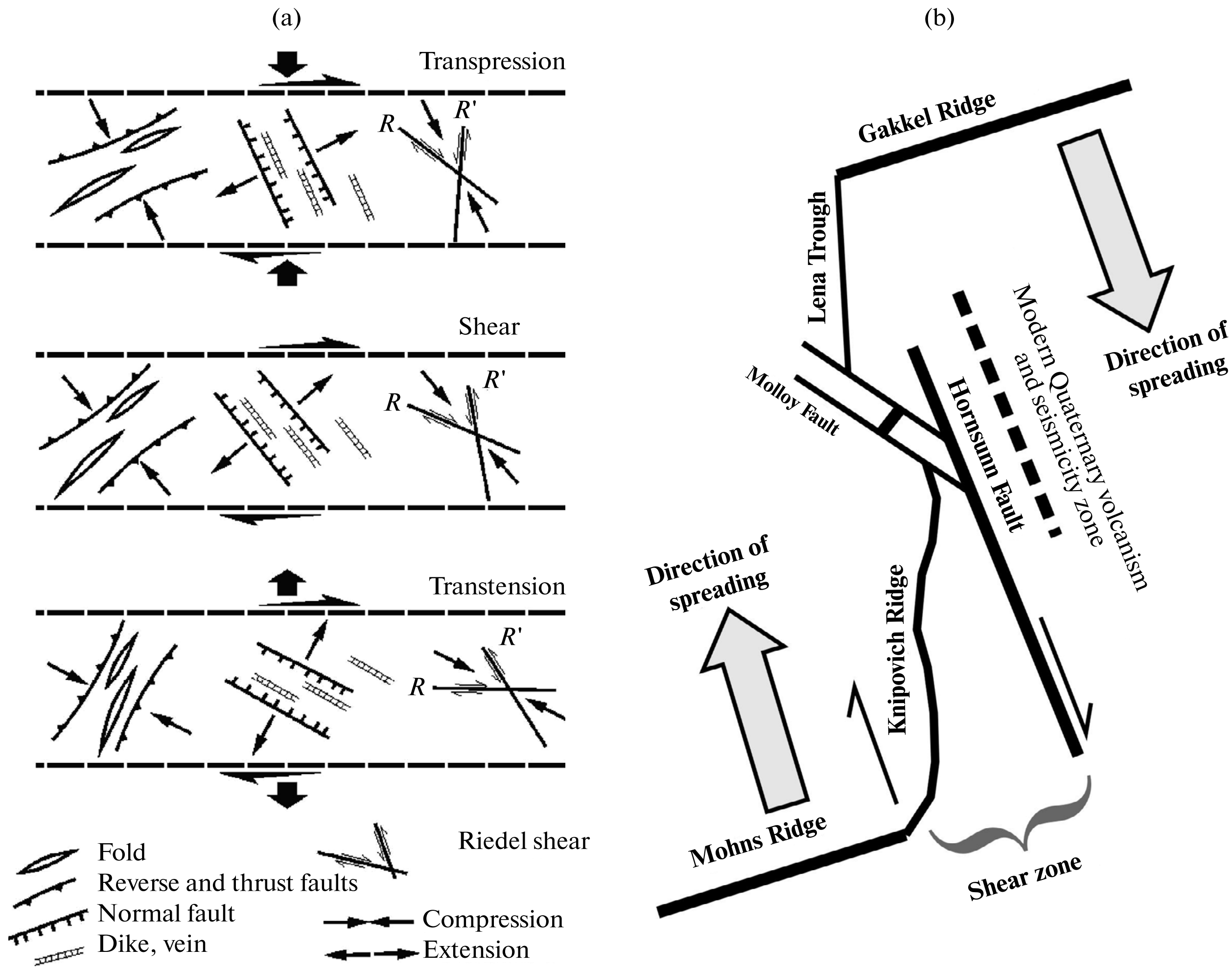

Fig. 3. (a) Orientation of main structural elements in various shear zones, modified after [6]; (b) conceptual scheme of recent tectonics in divergent structures of northern Atlantic and Arctic regions.

The formation of the tension crack, which dissects the spreading substrate produced since the Oligocene, minimizes the total length of regional divergent structures. The coincidence of its orientation with the zone of Quaternary volcanic activity on Spitsbergen and high-amplitude positive magnetic anomaly invading the archipelago from the north is evidence for the Quaternary age of the trough in the Knipovich Ridge devoid of an axial anomaly. This implies that spreading (buildup of the crust with magnetoactive layer variable in magnetization) along this structural element still has not started, being predated by rifting and growth of young central-type volcanic edifices (Fig. 4). The tension crack most likely propagated from north to south, because the northern part of the ridge's trough is the sole place where the axial positive magnetic anomaly is observed.

The general level of magnetic anomalies in this segment of the MAR (±150 nT) is markedly lower than in the Mohns Ridge (±350 nT) adjoining in the south and having typically spreading AMF structure. There are two reasons for this difference. The first is related to the deficiency of magmatic material in the components forming the magnetic minerals. According to [12], the quenching glasses dredged during cruise 24 of the R/V *Akademik Nikolaj Strakhov* contain 8 wt % FeO, on average, whereas the average FeO content in glasses along the MAR is 10 wt %. The lower content of iron in glass is indicative of the rocks making up the magnetoactive layer. The low magnetization and iron content in gabbroic rocks drilled in borehole 344 and the fast destruction of magnetic minerals under conditions of tectonic fragmentation were noted in [15]. This is supported by the mosaic AMF in the region. The second reason is the nonzero apparent width of the magmatic zone at any rate of spreading. At the Knipovich Ridge, this width is 5–7 km (Fig. 4). For the approximately one-million-year-long phase of recent positive polarity of the Earth's magnetic field and a spreading rate of 3 cm/yr, the lateral increment of the axial anomaly will be 30 km, whereas in the case of ultraslow spreading (0.5 cm/yr) at the Knipovich Ridge [19] should be 5 km. This value is comparable with the apparent width of the magmatic zone. Under such conditions, magmatism with inverse polarity will be superposed on the layer with the given polarity. This will lead to compensation of the total field rather than to its increase. Both reasons taken together can result in a decrease in the absolute AMF level.

SLOPE ANGLES, SEISMIC IMAGE OF SEDIMENTS, AND BOTTOM SAMPLING OF SEDIMENTARY ROCKS

The bottom topography of northern segment of the Knipovich Ridge is shown in Fig. 5 [5]. The width of the near-meridional rift valley in the studied site varies from 17 to 30 km. Their walls are asymmetric and complicated by terracelike scarps. The chain of the highest summits in crest zone of the ridge is related to the western wall. The rift zone is divided into several isolated echeloned basins 3100 to 3600 m in depth. The basins are separated by neovolcanic rises including volcanic edifices and NE-trending scarps. No disturbances of these scarps by NW-trending inactive transform fracture zones are observed. Based on the classical assembly of shear zones (Fig. 3a), these scarps are most likely Riedel shears that have inherited the orientation of fractures of the previously existing basement.

As seen from seismoacoustic data [5], quest-like uplifts occur everywhere in the studied area (Fig. 5). This indicates that rifting was accompanied by intense shortening at the periphery of the extension zone perpendicularly to the tension crack, as is consistent with the assembly of shear zones (Fig. 3a). Inactive transform offsets could have been the primary structures along which questas developed. Wavelike compression zones parallel to the rift axis correspond to zones of undisturbed sedimentary cover separated by deformation zones. This is indicated by smooth swells in the topography. The deformations, expressed as gentle folds in the topography and structure of the sedimentary cover, correlate in space. The fold hinges have a configuration called tectonic deformation waves.

Calculation of the angles of slopes in the studied area (Fig. 6) shows that almost all walls of the rift valley have slopes steeper than 10°. The walls are mostly inclined at angles of 15°–17°, which locally increase up to 35°. The unique localization of the Knipovich Ridge segment in avalanche sedimentation zone 60 km from the shelf edge makes this area suitable for studying deformation in the active zone under conditions of intense aggradation by sedimentary material in combination with disturbance of the sedimentary cover. The thickness of sediments estimated in [18] shows that the trough in the northern segment of the ridge nevertheless remains unfilled (Fig. 7). At the same time, in the southern framework of Spitsbergen, i.e., in the Pomorye Trough, which is fed by the same provenance, the predicted thickness of the Upper Paleogene–Quaternary sedimentary cover reaches 7 km [17]. Three terraces echeloned from north to south at the western and eastern walls of the trough with a sedimentary cover of 400–500 m are noteworthy for evaluating recent tectonic activity. Figure 8 shows the seismic section that crosses walls of the rift, where its shoulders are overlapped by the sedimentary cover. The slopes of walls are inclined here at angles reaching 35°.

The aforementioned facts can hardly be explained by buildup of the sedimentary cover from the axis of the spreading zone, where the young oceanic crust is forming. It is known that unconsolidated clay sediments are able to flow at slopes more than 1.5° [8]. The situation is aggravated by the high seismicity of the area, where earthquakes initiate slumping of the sedimentary material, reaching a critical stability. Thus, the formation and retention of unconsolidated sediments on rift shoulders sloping at angles up to 35° and fed from the margin of the Barents Sea are unlikely.

If the tectonic history of this MAR segment fits the classical scenario, the bottom of the rift at a depth of 1500 m would be filled by unconsolidated sediments more than 30 m in thickness and without attributes of pelagic stratification. This value is higher than the resolving capacity of applied single-channel seismic exploration. Using a high-frequency profilograph, stratified sediments no thicker than 40–50 m were revealed in the rift valley in northern part of the studied site [9] adjoining the continental slope and the Molloy Fault. The fact that sedimentary bodies at rift walls are not scoured along normal fault planes, maintain high angles at amplitude of up to 1 km, and have acoustic stratification (Fig. 8) implies consolidation of sediments and their long-term deposition off a deep trough, where they have been found only recently. This allows us to suggest that the rift was formed in Quaternary on the spreading basement overlain by the sedimentary cover as early as the late Oligocene. Additional arguments are given by the fact that acoustically transparent nonstratified sediments commonly accumulating in avalanche discharge zones are observed 50–80 km west of the rift axis [5, 16] and have a thickness larger than 1000 m (Fig. 7), whereas no unconsolidated sediments having a thickness above the seismic exploration resolution have been noted within the rift itself. Stratified sedimentary bodies have also appeared in the southern segment of the Knipovich Ridge [5].

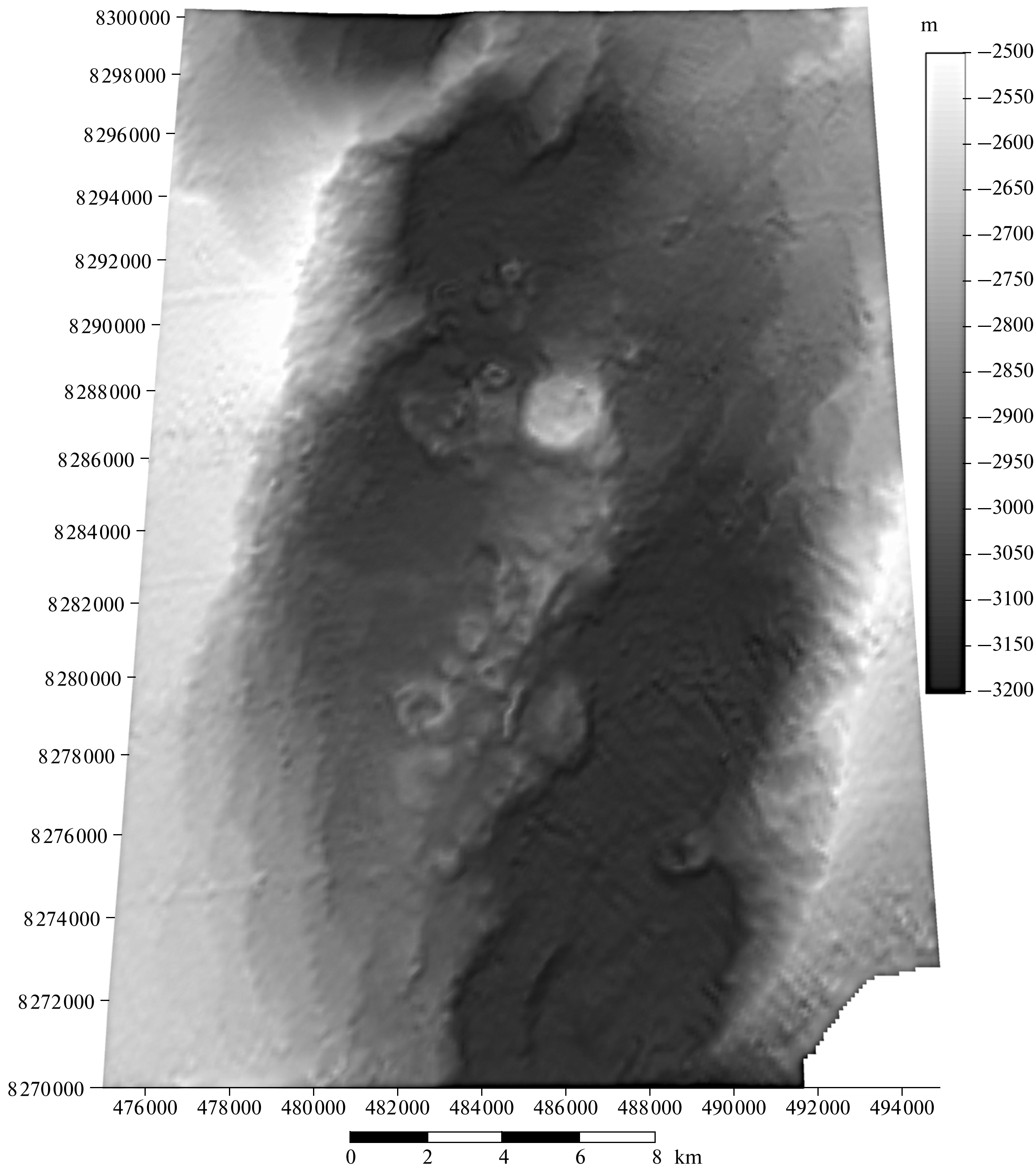

Fig. 4. Chain of volcanic edifices: data of 25th cruise of R/V *Akademik Nikolaj Strakhov* (Geological Institute, RAS; Norwegian Petroleum Directorate, 2007). See Fig. 1 for figure location. Universal Transverse Mercator (UTM32) coordinate system.

Dredging of the western sedimentary wall in this segment of the Knipovich Ridge was performed in 2000 during the 19th cruise of the R/V *Professor Logachev* at a latitude of 77°52′ N. "… Dark compact claystone and strongly altered basalts were carried up. The poor degree of roundness and fresh fractures of rock samples are evidence of proximal bedrocks and can hardly be explained by ice rafting… ." Contact of basalt with claystone with the chilled zone in the latter is observed in the largest sample, indicating the intru-

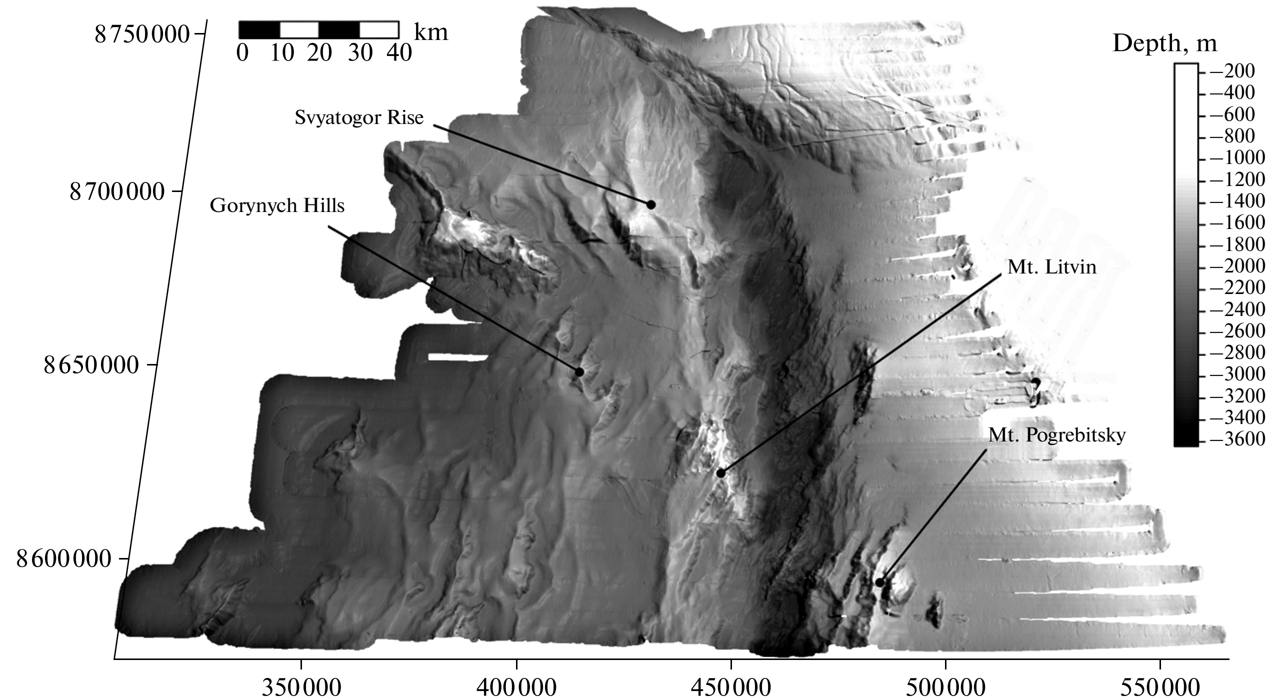

Fig. 5. Bottom topography in northern part of Knipovich Ridge: results of multibeam bathymetric survey during 24th cruise of R/V *Akademik Nikolaj Strakhov* (Geological Institute, RAS; Norwegian Petroleum Directorate, 2006), after [5]. UTM32 coordinate system.

sive origin of the basalt. It can be assumed that the found fauna occurs in situ rather than being alien or redeposited. ... The revealed plankton species do not determine age in a zonal scale but indicate the Oligocene age of sediments as a whole [2, p. 28]. It is noted further in [2] that the detected foraminifer complexes differ from those in coeval rocks on Spitsbergen. In all of this, the authors see confirmation of the idea of spreading axis jumping [19]. However, it should be noted that in most unchallenged cases of jumping (e.g., the Aegir Ridge → the Kolbeinsey Ridge), the new position of the spreading axis remained nearly parallel to the previous position and apparently retained the type and parameters of geodynamic mechanism, whereas in this case a turn through ~45° took place, indicating a change of the acting forces and their orientation. The angle value assumes that shear stresses became predominant.

The western wall of the northern segment of the Knipovich Ridge was also dredged during the 24th cruise of the R/V *Akademik Nikolaj Strakhov* [10, p. 88] at 77°54′ and 77°42′ N (dredges S2441 and S2434). The benthic foraminifers from the dredged samples correspond to the bathyal association and are dated at late Paleocene–middle Eocene. There are also reasons to consider the age of this sequence within the narrower interval of late Paleocene–early Eocene. "It can be suggested that the entire western wall of the Knipovich Ridge, at least between dredges S2441 and S2434 is composed of Lower Paleogene rocks."

Thus, the occurrence of autochthonous Paleogene sedimentary rocks is integral to the concept of extension zone jumping in this MAR segment and initiation of volcanic activity in the newly formed rift.

DEFORMATIONS OF THE UPPER SEDIMENTARY COVER

Seismic profiling and multibeam echo sounding during the 24th cruise of the R/V *Akademik Nikolaj Strakhov* was accompanied by high-frequency profiling with penetration into the upper part of the sedimentary sequence for 100 m. Reviews of results pertaining to the upper part of the section have been published [5, 9]. Numerous compression- and extension-related deformations have been found in the area of avalanche sedimentation in the active segment of the MAR, including reverse faults with an average amplitude of 5–6 m and particular displacements for 20 m (Fig. 9) and normal faults with an average amplitude up to 17 m and particular displacements for 100 m (Fig. 10) despite basalts being exposed within the fault zones. In the latter case, the amplitude increases up to 500 m. In addition, escarpments, bright and dull acoustic anomalies, folds, seepage above fault planes,

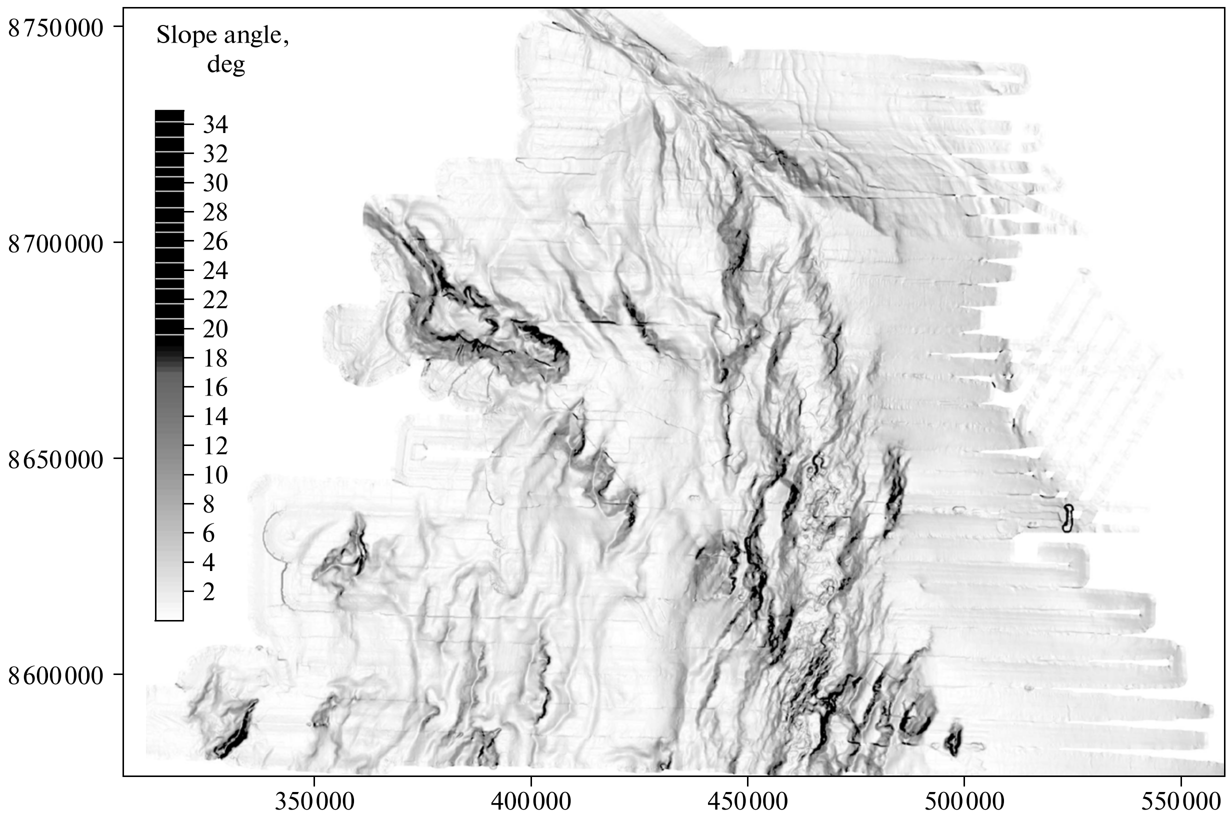

Fig. 6. Slope angles in northern part of Knipovich Ridge estimated from bottom topography in area shown in Fig. 5. UTM32 coordinate system.

zones of sediment discharge near walls, chaotic reflectors with transition to acoustic transparence, degassing of sediments into water, etc., have been revealed.

As concerns the neotectonics, the spatial distribution of normal and reverse dislocations in the upper part of the sedimentary cover is the most informative. It should be pointed out that the mainly latitudinal orientation of the profiles makes it impossible to trace dislocations having the same orientation. A number of near-meridional profiles and 3D image of the topography show that there are no significant gaps in the structure due to inadequate orientation of the observation system. As is clearly seen in Fig. 9a, the largest diapir with vertical acoustic transparency is related to the vertical fault. Percolation of fluids resulted in the complete elimination of primary sedimentary textures forming the acoustic field. The tectonic stresses and formation pressure that controlled the ascent of fluids along the deformations of faults were most likely related to the angular position between right-lateral deformation near the Molloy Fault and the tension crack of the Knipovich Ridge in the more brittle right-lateral system.

The distribution of normal and reverse faults in the upper part of the section in northern segment of the Knipovich Ridge is shown in Fig. 11. The map shows that the faults are grouped into a mosaic of zones represented by one of two types. Clusters of normal faults are more abundant than clusters of reverse faults. The largest of the latter are located at the western slope of the Knipovich Ridge in the zone that adjoins the active segment of the Molloy Fault. Such a distribution of dislocations reflects the stress field in the Earth's crust in this area. As is known [6], a dynamic couple in the form of a conjugated set of compressional and extensional structural elements with mirror symmetry near the end of active segment is formed along the line of simple shear. The strike-slip nature of the Molloy Transform Fault casts no doubt. In addition, normal splays occur in close proximity to the Knipovich Rift in the southeastern framework of its active segment (Fig. 5). The origin of the largest cluster of reverse faults in the same area remains ambiguous. As follows from the structure of the stress field in shear zones [1], including orientation and amplitude, the observed pattern can arise if the rift of the Knipovich Ridge is a part of the right-lateral system oriented in the near-meridional direction. In this case, a local anomaly of

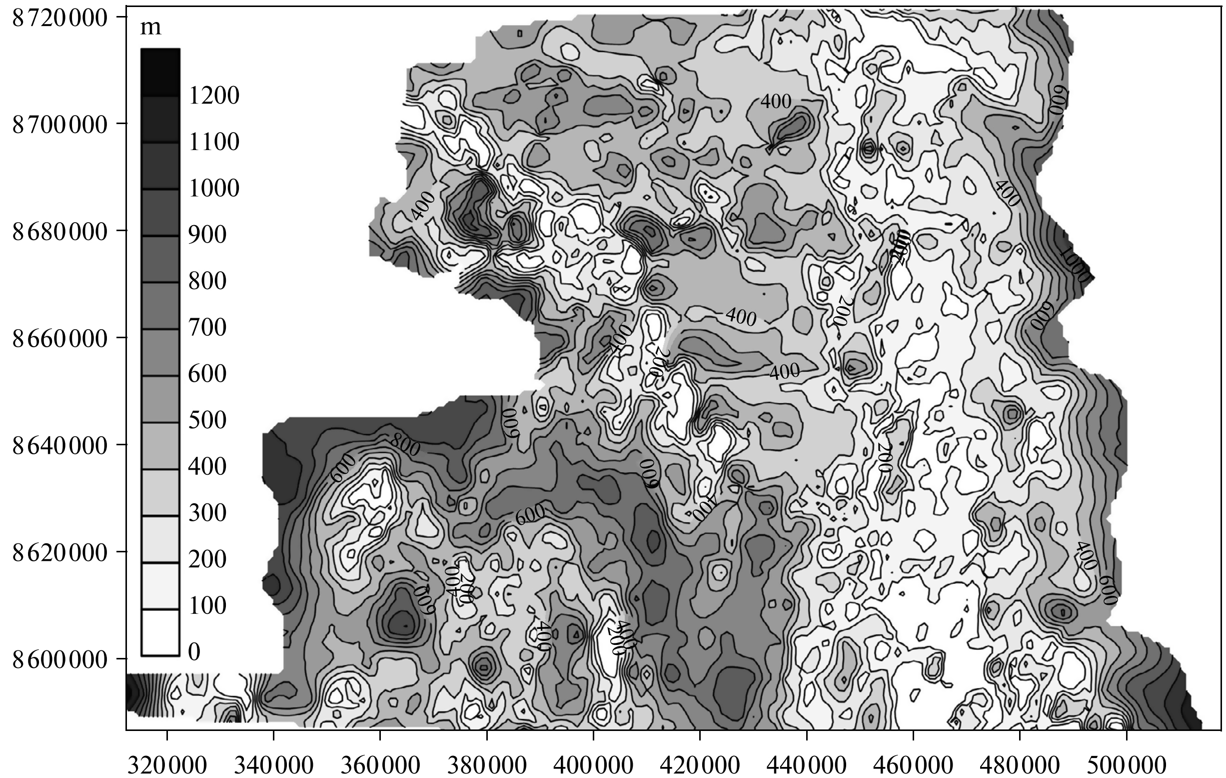

Fig. 7. Thickness of sedimentary cover, after [18]. UTM32 coordinate system.

compression amplitudes is formed in the shear system. The geometry of this system [11] allows rational explanation if the rift of the Knipovich Ridge is a tension crack arranged at an angle of ~45° to the main direction of shear between the Mohns to the Gakkel ridges perpendicular to tensile stress. This can explain the prevalent clustering of normal faults along flanks of the Knipovich Ridge and reverse faults in the angular uplift to the south of the Molloy Fault.

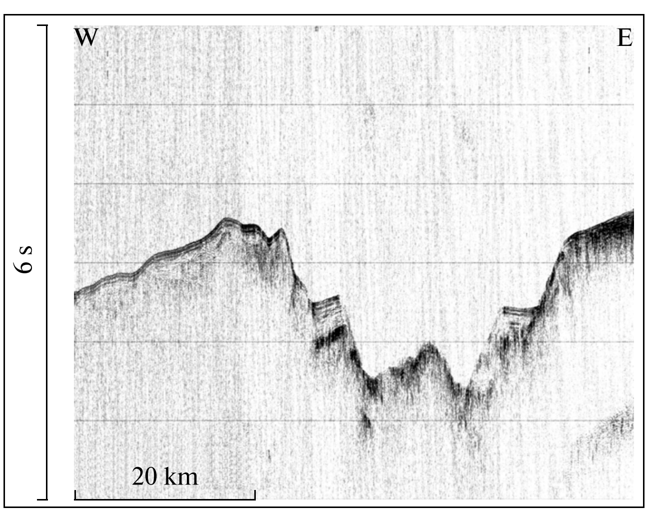

Fig. 8. Fragment 1 of seismic profile S24-P2-14, 24th cruise of R/V *Akademik Nikolaj Strakhov* (Geological Institute, RAS; Norwegian Petroleum Directorate, 2006). See Fig. 1 for location of fragment.

SYNTHESIS

(1) According to the anomalous magnetic field, the MAR segment of the Knipovich Ridge has been forming since the Oligocene as several (up to eight) segments with normal direction of spreading separated by a system of multitransform fracture zones. Such a setting with a high ratio of lengths of echeloned offset zones to lengths of rifts was most likely unstable, so that straightening of the boundary between interacting plates along a tension crack was a natural process. The tension crack dissected the previously formed oceanic basement along the shear zone representing the Knipovich Ridge.

(2) The walls of the Knipovich Ridge are complicated by groups of normal and reverse faults, as well as by tectonic and erosion terraces (Figs. 5, 10). These tectonic indicators, revealed with the help of a high-frequency profilograph, are grouped into domains with characteristic dimensions measuring a few tens of kilometers. These domains demonstrate cellular stress distribution in the studied area, which is emphasized by the faults mapped along the domain boundaries.

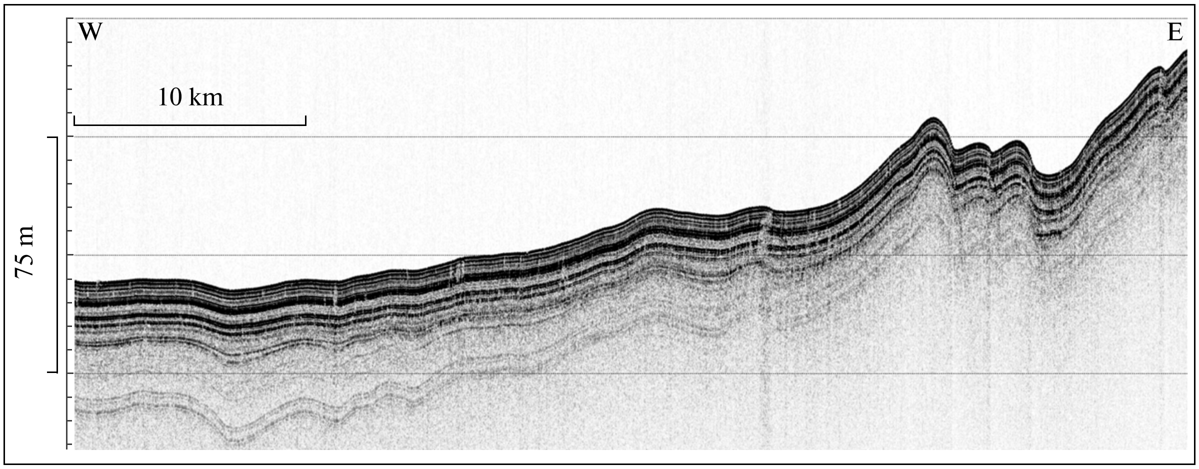

Fig. 9. Fragment 2 of CHIRP profile S24-P1-06, 24th cruise of R/V *Akademik Nikolaj Strakhov* (Geological Institute, RAS; Norwegian Petroleum Directorate, 2006). See Fig. 1 for location of fragment.

Under these conditions, groups of tectonic indicators make up a complex superposition of compression and extension zones that formed on the structured spreading substrate. Since the studied area is situated in the avalanche sedimentation zone, neotectonic movements are readily identified from disturbances of the uppermost sedimentary cover.

(3) The stress pattern is a combination of two shear dynamic couples along the right-lateral Molloy Transform Fault and primarily along the right-lateral shear zone between the Hornsunn Fault and end of the Mohns Ridge (Fig. 3b). The recent structure of the Knipovich Ridge forms as a chain of extension duplexes in a pull-apart setting. The structure of the Knipovich Ridge develops on the older spreading substrate oriented at an angle of ~45° relative to the present-day position of the ridge.

(4) The structure of the sedimentary cover of the Knipovich Ridge shows that Paleogene consolidated and acoustically stratified sediments overlap rift walls and sink into the rift itself along normal faults. The samples of dredged sedimentary rocks corroborate their autochthonous character. Acoustically transparent sedimentary bodies inherent to avalanche sedimentation have been found at the western flank of the ridge far from the rift valley in contrast to the valley itself, devoid of unconsolidated sedimentary fill. Rifting most likely is Quaternary in age, and all oceanic layers, including the sedimentary cover, have been broken up during its initial stage.

(5) The total length of the strike-slip zone between the spreading center axes of the Gakkel and Mohns ridges is about 1130 km. The segment near the Molloy and Spitsbergen faults is singular, which is not straight. As follows from the general tendency of evolution, this segment will most likely be rectified in the future with the formation of a single master fault oriented nearly perpendicular to the main Mohns and Gakkel spreading centers. This fault zone is similar to the Romanche Fracture Zone in the central Atlantic in scope and relationships of plates to the obvious extended spreading centers. The Romanche Fracture Zone is the

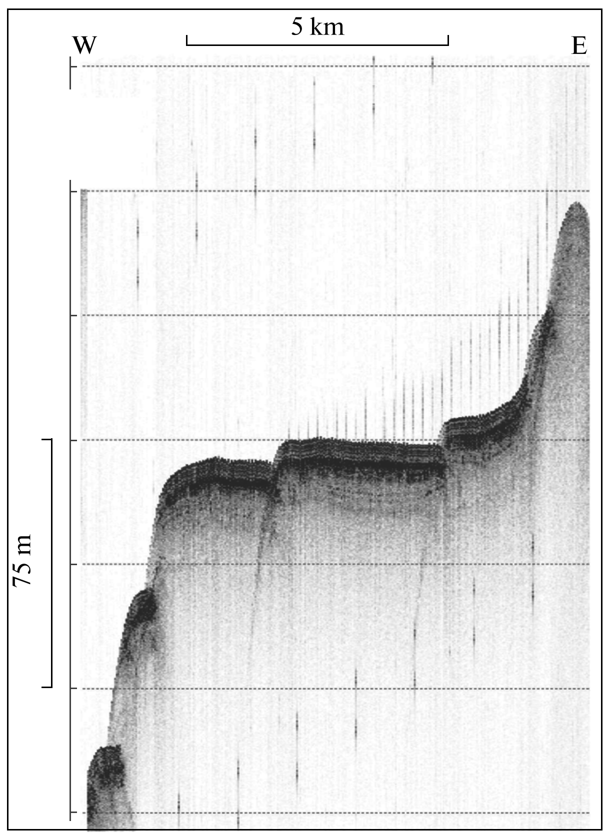

Fig. 10. Fragment 3 of CHIRP profile S25-P5-08, 25th cruise of R/V *Akademik Nikolaj Strakhov* (Geological Institute, RAS; Norwegian Petroleum Directorate, 2007). See Fig. 1 for location of fragment.

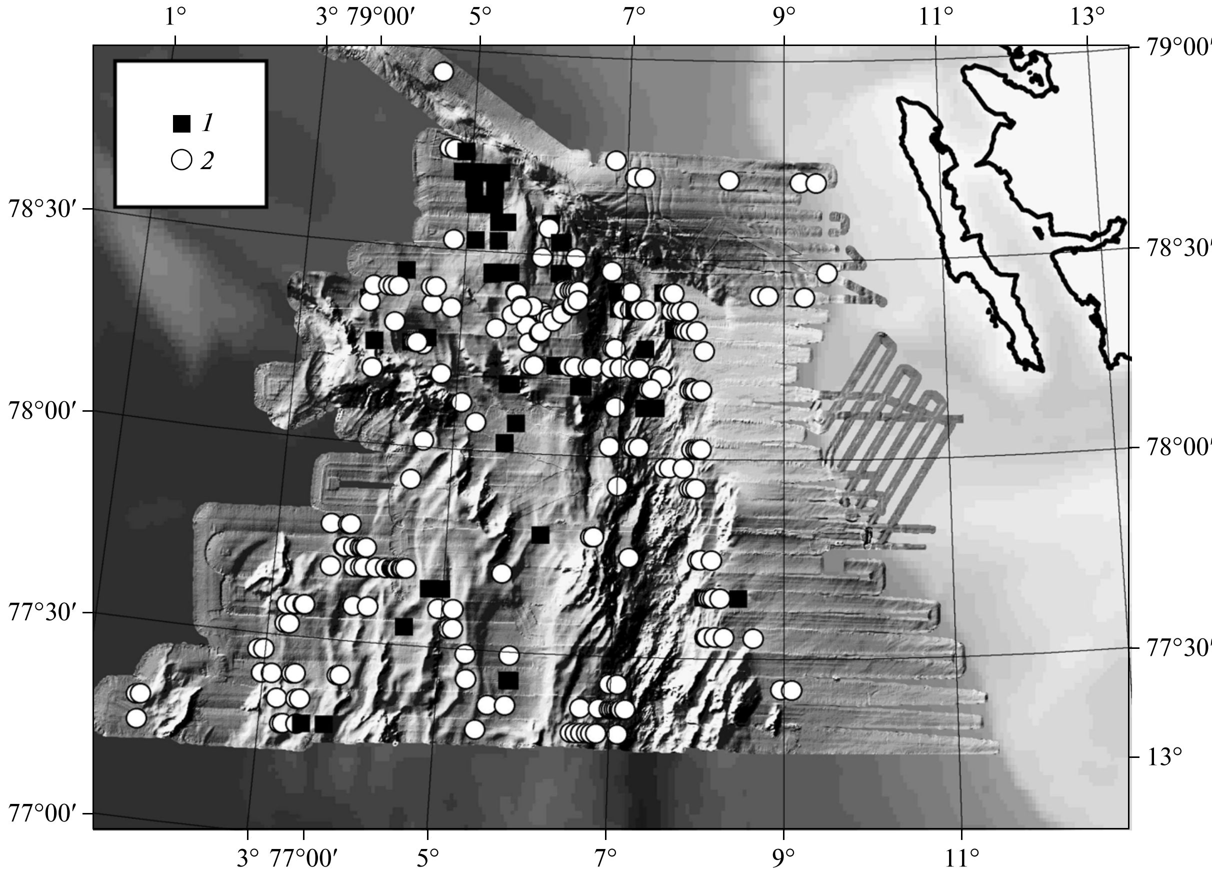

Fig. 11. Distribution of (*1*) reverse and (*2*) normal faults in the upper part of sedimentary cover in northern segment of Knipovich Ridge from 77°20′ to 78°40′ N.

major demarcation fault in the evolving Atlantic–Arctic ocean system.

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