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GEOLOGY

Structure of the Ocean Bottom in the Junction Area of the King's Trough and Gnitsevich Plateau (North Atlantic)

S. G. Skolotnev[a,*], A. A. Peyve[a], S. Yu. Sokolov[a], K. O. Dobrolyubova[a], I. A. Veklich[b], A. N. Ivanenko[b], V. A. Bogolyubskii[a], N. P. Chamov[a], V. N. Dobrolyubov[a], A. P. Denisova[a], I. S. Patina[a], V. L. Lyubinetskii[b], A. A. Tkacheva[a], D. M. Ilyukhina[b], and V. V. Fomina[a]

[a] *Geological Institute, Russian Academy of Sciences, Moscow, 119017 Russia*

[b] *Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, 117997 Russia*

**e-mail: sg_skol@mail.ru*

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Abstract—The structure of the northwestern part King's Trough and the Gnitsevich Plateau is explored, based on the data obtained during the 57th expedition of the R/V *Akademik Nikolai Strakhov*. These structures form a mesostructural cluster located on the eastern flank of the Mid-Atlantic Ridge in the North Atlantic. Bathymetric and hydromagnetic surveys, seismoacoustic profiling, and bottom sampling by dredging were carried out. It has been established that this part of the trough consists of six deep parts of different depths. These subparallel deeps continue each other along a strike and are separated by median ridges and ledges. The flanks of the trough are formed by volcanic plateaus, which are built up by multi-dimensional cone-shaped volcanic edifices. At the same time, the southern and northern flanks are complementary to each other both in depth and in morphology, and merge into a single plateau in the area of the northwestern closure of the trough. An area of volcanic edifices of various sizes and morphology was formed around the King's Trough: cone-shaped structures, calderas, and the Gnitsevich Plateau, which involves several seamounts on the common basement. It is shown that the anomalous magnetic field of the study area is a superposition of linear and isometric anomalies; the latter is associated with large volcanic seamounts. Linear anomalies C6n and younger are located to the northwest of the King's Trough and are not interrupted, and linear anomalies between the C6n and C13n chrons are found only on the trough flanks, whereas they are absent in the area of deeps. The recovered rock material can be divided into two main associations: spreading (nonporous basalt, dolerite, gabbro, mylonite) and intraplate (porous volcanics close to basalts). The rocks of the first of them form the sides of deeps and median ridges, those of the second form plateaus and volcanic edifices. Limestones, breccias, and Fe–Mn crusts are found in both associations. Seismoacoustic studies, along with seismic facies, previously established in the upper part of the King's Trough sedimentary cover, have revealed channel drifts formed by the deposition of clastic material transported by near-bottom (contourite) currents. Preliminary conclusions about the origin of the mesostructural cluster of King's Trough and the Gnitsevich Plateau are as follows: the formation of the King's Trough was preceded by the formation of a northwest-striking arched rise, which became the scene of intense intraplate volcanism. The arch rise was formed as a result of uplift of the oceanic crust formed in the axial zone of the Mid-Atlantic Ridge The near-axial part of the volcanic plateau subsided between 33.2 and 18.75 Ma as a result of northeast–southwestward tension of the ocean floor along two subparallel fractures that expanded up to intra-trough deeps. This volcanism also intensified magmatism in the nearest parts of the axial part of the Mid-Atlantic Ridge up to the appearance of the large volcanic edifices that formed the Gnitsevich Plateau.

Keywords: Mid-Atlantic Ridge, King's Trough, spreading, volcanic edifices, linear magnetic anomalies, seismic facies, channel drift, sound-scattering objects

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In 2024, the Geological Institute, Russian Academy of Sciences, arranged and conducted the 57th cruise of the R/V *Akademik Nikolai Strakhov* (ANS) in the North Atlantic. The complex of geological and geophysical studies carried out during this cruise was a continuation of the work carried out during the 55th cruise of the R/V *Akademik Nikolai Strakhov* in order to obtain new data on magmatic, tectonic, and hydrothermal processes, as well as the geodynamic conditions of the King's Trough formation and its adjacent area (King mesostructural cluster) located on the eastern flank of the Mid-Atlantic Ridge (MAR) in the North Atlantic (Fig. 1).

The reasons for scientific interest in the King's Trough were discussed in the work devoted to the results of the 55th cruise of the R/V *Akademik Nikolai*

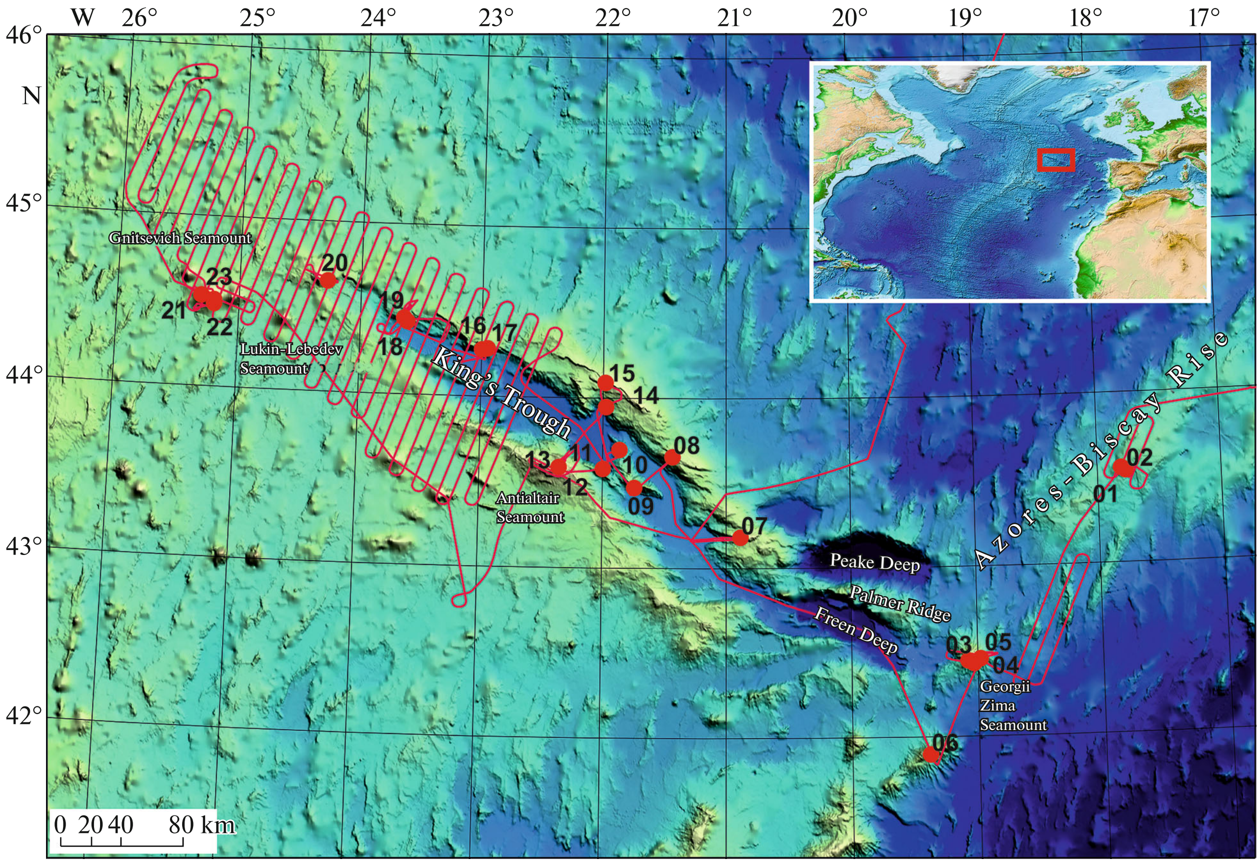

Fig. 1. The scheme of the work area of the northwestern end of the King's Trough. The red lines are the transects of multibeam echo sounding, seismoacoustic profiling, and hydromagnetic survey. Compiled on the basis of the GEBCO map [12]. Red circles are the location of dredging stations, next to them are the station numbers (the indicated number corresponds to the following number in Table 1: 01, S5701; 02, S5702, etc.).

Strakhov [1]. Briefly, their essence is that the northwestern-striking King's Trough, obliquely located in relation to the MAR structures, is a unique mesostructure, which combine structures formed during both tectonic and volcanic processes in a single ensemble. At the same time, the trough is surrounded by other mesostructures: the Azores-Biscay Rise and the Gnitsevich Plateau. Its origin, despite years of study [2–9], remains debatable. There are two main types of models for the formation of the King's Trough. According to one of them, it was formed in the place of an aseismic ridge, which arose as a result of uplift of the plume of the deep mantle, with subsidence of its axial part [5].

Other hypotheses associate the King's Trough with an ancient intraplate boundary of the strike–slip type [10, 11].

From our point of view, understanding of the origin of the King's Trough is fundamentally impossible without the construction of a bathymetric map based on multibeam echo sounding data with 100% coverage and detailed sampling, which was performed during two cruises.

This paper presents new data and the first results of their processing and interpretation, mainly concerning the northwestern part of the King's Trough and Gnitsevich Plateau. These studies will make a great contribution to understanding the nature of intraplate tectonic and magmatic processes occurring on the ocean floor.

Bathymetric and hydromagnetic surveys, as well as the collection data on the sedimentary cover of the ocean floor during the cruise, were carried out on a system of parallel and crossing transects with a total length of 6746 km (Fig. 1). The SeaBat 7150 deep-water multibeam echosounder, EdgeTech 3300 and Parasound DS Sub-Bottom profiler P-35, and Sea-POS2 magnetometer were used. Bottom rocks were sampled by dredging (Fig. 1).

RESULTS OF PROCESSING OF THE ECHO SOUNDING DATA

The bathymetric map on a scale of 1 : 100 000 with an area of 39 065 km^2 was constructed on the basis of processing of the echo sounding data, performed in

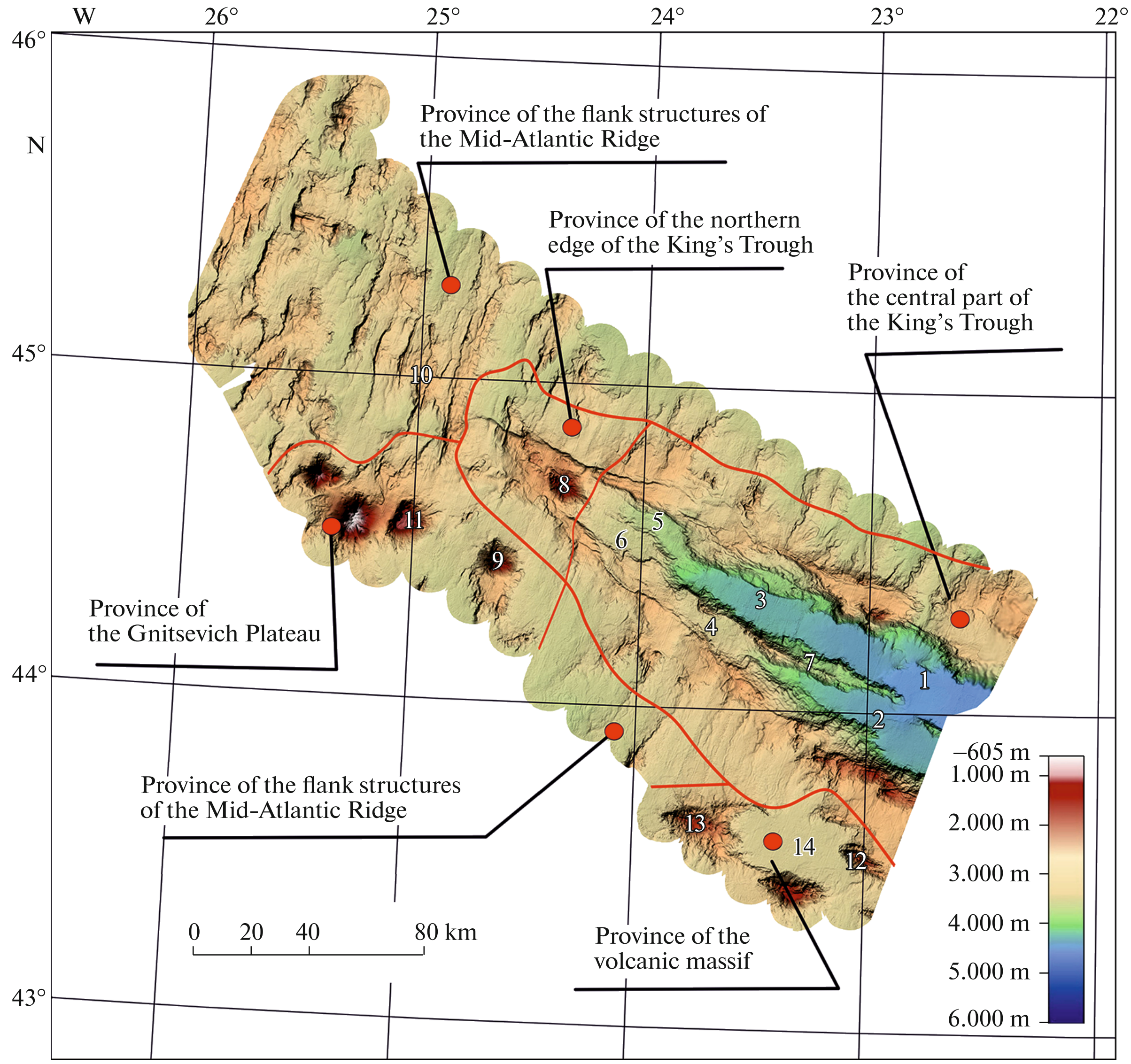

Fig. 2. The bathymetric map of the site and boundaries of the morphostructural provinces (red lines). Numbers indicate morphostructures discussed in the text under the same number.

the TeledynePDS software, version 4.4.8.16. Five morphostructural provinces were identified within the studied site (Fig. 2). Two of them represent the King's Trough and its associated structures. These provinces are the central part of the King's Trough and the northwestern end of the King's Trough. The other three characterize the morphology of the structures framing the King's Trough: the flank structures of the MAR, the Gnitsevich Plateau, and the southern volcanic massif.

The province of the central part of the King's Trough is located in the axial part of the site. The southeastern part of this province was studied in the 55th cruise of the R/V *Akademik Nikolai Strakhov* and described in [1]. The northwestern part of this province, mapped in the 57th cruise, has a similar structure. A number of deeps in the trough itself and volcanic structures on its flanks are also observed here. There are six deeps in the province section, united into three links, extending and succeeding each other in the northwesterly direction. Each link contains two subparallel deeps, with the more northerly deeps with greater width and depth. In the southeasternmost link, the deep, located to the north (conditionally Middle King) (Fig. 2, point 1 (hereinafter the number after point corresponds to the number on the bathymetric map (Fig. 2)), extends along an azimuth of 123°, its width is about 20 km with a length of 59 km within the site. The average depths of the leveled bottom are 4550–4560 m. Parallel to it, the narrower deep (conditionally Small King) extends 90 km to the south (Fig. 2, point 2). Its maximum width in the central part is 18 km. The deep, spindle-like in plan, narrows towards the marginal parts. In these directions, its depth decreases from 4450 to 3750 m. In the more northwestern part of the link, the northern deep (conditionally Upper King) (Fig. 2, point 3), with an average width of 15–17 km and length of 85 km, narrows to the western edge to 8 km; its depth decreases stepwise to the west from 4400 to 4100 m. The parallel southern deep (Fig. 2, point 4), about 50 km long and 10–12 km wide, is morphologically indistinct and located at a significantly higher level; its bottom rises to the northwest from 3500 m to 3000 m. In the most northwestern part of the link, the more northerly deep (conditionally King's Crown) (Fig. 2, point 5) is 6–7 km wide; its bottom at an average depth of 3750 m rises gently upward over a length for 48 km. The parallel deep (Fig. 2, point 6) is about 40 km long, with an average depth of 3500 m and a width of 5–6 km. In each pair, the parallel deeps are separated by extended discontinuous crests and crest-like ridges (median ridge) (Fig. 2, point 7) with relative heights of 100–1000 m and widths of 0.5–5 km.

The flank structure of the described deeps in different areas varies from the gentle stepped flanks with a 5°–7° steepness to the 30°–35° steep flanks without steps. Their edge reaches depths of 2800–3200 m. Landslides up to 12 × 15 km in size are often developed at the base of the slopes.

Both flanks of the King's Trough in this area include several segments 30–50 km long, which superpose each other in an echelon-like manner along a strike of the trough. The segments on each flank are located on the common base with steepness of the external slopes averaging 2°; their inner slopes are the sides of the above-described deeps. The visible top surfaces of the base are at the depths of 3150–3250 m.

The segments themselves vary distinctly in width, height, and morphology. Segments 15- to 25-km-wide with gentle hilly surfaces confined to depths of 2900–2750 m, sometimes up to 2500 m, predominate. Their surfaces have slight gradients of 4°–8° on slopes external to the trough. Because of the predominance of such flattened segments, the flank parts of the King's Trough can be morphologically identified as plateaus. Flat segments alternate with segments represented by narrow rectilinear crest-like ridges 3–7 km wide with summit depths at 3100–2900 m.

The plateaus are modified by a large number of conical, domed, or volcanic edifices elongated along the rim 200–400 m high and up to 1–2 km across. On the southern flank directly from Seamount Antialtair, there is a ridge about 60 km long crowning the plateau. The top surface of this ridge rises 400–500 m above the adjacent plateau reaching 1800–2100 m deep. The opposite slopes of the ridge are generally symmetrical, with a steepness of 12°–15°. In turn, several volcanic edifices 240–415 m high rise above the surface of this ridge.

The complementarity of the structures of the northern and southern flanks is clearly visible on the cross sections in terms of both depth and morphologic features. This is typical of the flank plateaus and their bases, which indicates that earlier they might have been a single whole in the form of an northwestern-striking arched rise, and then, with the opening of the King's Trough, they have been divided into two opposite flank parts. The structures, which are built up along the plateaus and located on the shoulders of the trough—cone-shaped edifices, ridges, which are spurs of large volcanoes—are not complementary; they have slopes close to symmetric, which allows us, among other things, to assume that they formed after the opening of the trough.

The province of the northwestern end of the trough is about 40 km long and has a triangular shape in plan with a sharp northwestern angle. Morphologically, it is a plateau with a width of about 20 km in the eastern part. It has a shallow hilly relief and average depths of about 2400 m. To the west, the plateau gradually descends to 2550 m. In the southeastern part, a volcanic edifice is observed. The depth above the edifice reaches the minimum depths of 1180 m (Fig. 2, point 8). It is stretched along the strike of the trough (120°), with a length of 16 km along the long axis and 10 km along the short axis.

In general, the following features of the King's Trough structure within this province can be noted. In the northwesterly direction, there is a decrease in the width and depth of deeps, as well as in the total width of the King's Trough itself, including its flank parts. This indicates that the amplitude of dip, and hence the intensity of tectonic movements, increased in a southeasterly direction. At the last 40 km, the flank plateaus unite into a single plateau, thinning out at the extreme northwestern point. The width of this plateau roughly coincides with the total width of the near-flank plateaus of the King's Trough, which allows us, among other things, to assume that the subsidence of the trough may have been caused by tension of the previously formed arched rise. The presence of a system of parallel deeps indicates that, in the case of tension, there were at least two axes of tension. In this case, the crest-like ridges separating the parallel deeps of the trough are residual, nonsubmerged fragments of the arched rise.

The province of the flank parts of the MAR surrounds the structures of King's Trough and its flanks. Smoothed relief is observed to the north and south of the King's Trough. The ridges, 3–6 km wide and 150 m high in the south and 200–250 m high in the north, are spaced 12–20 km apart. The average depths of the ridge tops are 3100 m in the south and 3000 m in the north. To the south of the trough, the ridges are relatively straight with a strike of 30°–32°, while to the north they are often sinuous, with a wide range of a strike of 0°–32°. Overlapping volcanic edifices can be seen above some ridges, rising up to 750 m above the plain. The largest of them is represented by the Lukin–Lebedev Seamount (Fig. 2, point 9), located south of the King's Trough, opposite to the comparable-in-size mount formed in the province of the northwestern end of the King's Trough (Fig. 2, point 8). The Lukin–Lebedev Seamount is located on the base about 15 km wide and 30 km long, extending in a direction transverse to the King's Trough; its edges rise above the plain by 400–500 m. The mount is cone-shaped, and its diameter is 13 km. Its height is 1500 m, and its summit is at a depth of 1200 m.

Significantly more mountainous relief was formed on the northwestern continuation of the King's Trough within the described province. Here, in most cases, the ridges are located in groups and have a common base. The distance between ridge structures is 9–17 km. The bases are raised above the inter-ridge depressions by 125–250 m. The ridges themselves are about 1 km wide and vary in height from 25 to 150 m; the average depth level of the ridge tops is 2800 m. Inter-ridge spaces do not exceed several hundred meters in width.

On some of the raised bases, there are not only ridges, but also dome-like structures, apparently of volcanic origin. They have an isometric or slightly elongated shape and are often attributed to the central parts of the base rises. The diameter of the domes varies from 4–5 to 8 km; their height from the surface of the base rises does not exceed 300 m.

Immediately on the continuation of the King's Trough, the ridge structures are the longest (50–75 km) and have a lenticular shape (Fig. 2, point 10). In the central part of these structures, the width and height (up to 2600 m) are the greatest and decrease toward their distal parts. These features indicate that the most intense magmatic crustal accretion occurred in this area during its formation in the axial spreading zone, which is obviously caused by the impact of the King's Trough on the processes that took place in the axial spreading zone. As will be shown below, in accordance with the anomalous magnetic field data, this influence continued for at least about 3 Ma between the linear magnetic anomalies C5Cn.1n (y) (16 Ma) and C6n (18.75 Ma).

Northwest of the King's Trough, the strike of the ridge structures changes to about 26°. This suggests that the King's Trough was formed during the structural reorganization of the MAR, when the spreading direction changed significantly by about 6°. This event could have been the cause of the lithospheric tension that led to the formation of the trough.

The Gnitsevich Plateau Province is located southwest of the edge of the King's Trough and includes three seamounts: the Big Gnitsevich, Middle Gnitsevich, and Small Gnitsevich seamounts (Fig. 2). The Gnitsevich group of seamounts is located on the same base with a diameter of about 40 km, the edges of which rise above the plain by 400–500 m, at depths of 2600–2700 m. The seamounts are almost cone-shaped; at the same time, all of them are elongated in the southwesterly direction, perpendicular to the strike of the King's Trough. The diameter and depth of the tops are different: Big Gnitsevich is 17 km and 700 m (in some places, up to 605 m), Middle Gnitsevich is 14 km and 1250 m, and Small Gnitsevich is 13 km and 1010 m, respectively. The tops of Big Gnitsevich and Small Gnitsevich are slightly flattened, while at Middle Gnitsevich (Fig. 2, point 11) the top is broad and flat, which characterizes it as a guyot. Therefore, the Gnitsevich group of seamounts was raised above sea level after the end of their volcanic activity, and during their lowering the seamounts were affected by wave abrasion to a greater or lesser extent. Taking into account that the strike of volcanic structures in this province is close to the strike of the flank structures of the MAR and, in some cases, their spurs pass into rift ridges, it can be assumed that the Gnitsevich seamounts were formed near or in the axial zone of the MAR during the intensification of magmatic activity caused by the impact on the crustal accretion from the side of the King's Trough.

The province of the southern volcanic massif is located southwest of Antialtair Seamount and adjacent to the base of the flank plateau of the King's Trough. It includes two large submarine volcanoes and several short ridges of various sizes and strikes (Fig. 2). Together, the ridges form a ring structure, possibly a caldera with an average diameter of about 35 km, complicated by two later large and numerous smaller volcanic structures.

The caldera-forming structures vary from small ridges (up to 1 km wide, up to 50 m high, and about 3100 m deep) to ridge-like structures (up to 4 km wide, up to 150 m high, and about 2900 m deep) and massive ridges (up to 10 km wide, up to 300 m high, and about 2500 m deep). The latter are developed in the area of large volcanoes. In addition to them, there are other ridges, distinguished by a significantly greater height (width up to 7 km, height up to 1200 m, depth to 1800 m) (Fig. 2, point 12). They are also confined to the caldera boundaries, but are concordant with them, because they always have a northwestern strike parallel to the King's Trough. Large volcanic structures (diameter up to 10 km, height 1000–1300 m) (Fig. 2, point 13) are located on the caldera boundaries. They are subisometric, but somewhat elongated also in the direction parallel to the King's Trough. They have a broad flattened top at depths of 1750–1800 m, which characterizes them as guyots and volcanoes that formerly emerged above sea level.

The plain (Fig. 2, point 14), bounded by caldera-forming ridges, is located 150 m below the surrounding caldera floor (3150 m depth) and, where these ridges are absent, is separated from it by ledges. The

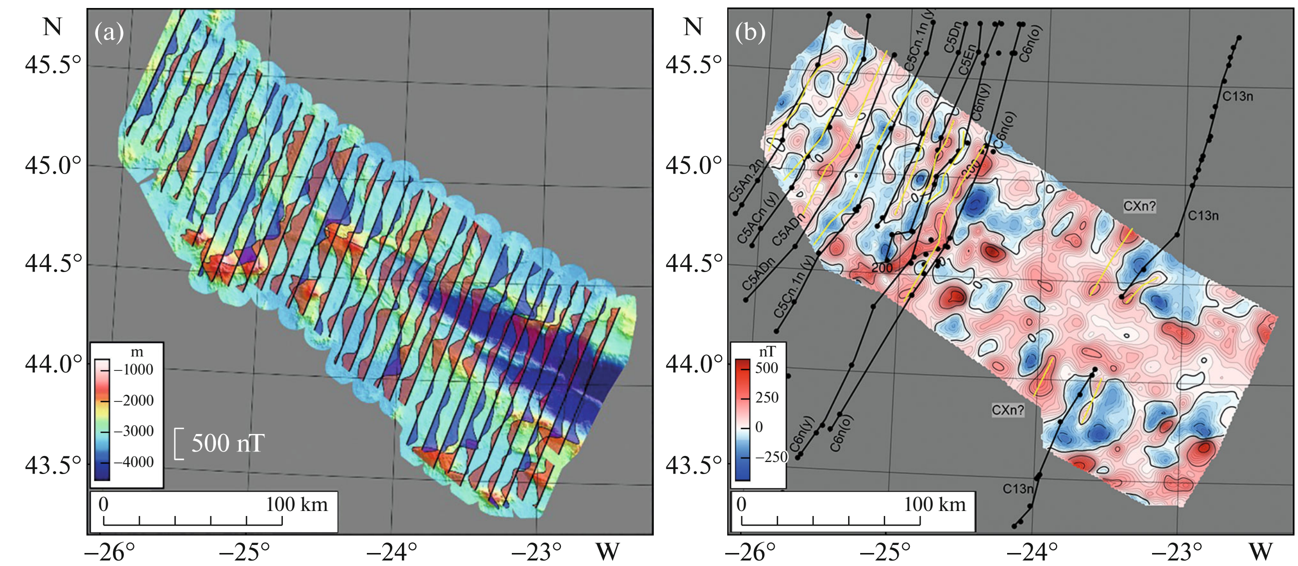

Fig. 3. (a) The map of the AMF plots superimposed on the bathymetric map. (b) Map of the AMF isodynamics. The dots show the axes of the numbered linear magnetic anomalies from the catalog [14], and the yellow lines mark their clarified positions.

bottom of the plain is weakly concave with a slight slope to the margins.

Taking into consideration the presence of the same geomorphologic levels and the similarity of the strikes of the later volcanic structures between the southern flank of the King's Trough and the province of the southern volcanic massif and their spatial proximity, we can conclude that the formation of the caldera is synchronous with the formation of the flank plateaus of the King's Trough, and the large volcanic structures were formed simultaneously with Antialtair Seamount and other late volcanic structures of the flank parts of the King's Trough.

RESULTS OF PROCESSING THE HYDROMAGNETIC SURVEY

Based on the results of processing the hydromagnetic survey in the MATROS-IV software, a summary map of the anomalous magnetic field (AMF) (Fig. 3a), combined with a detailed map of the seafloor relief, and the AMF map (Fig. 3b) were compiled. After linking the transects using the advanced Crosserr1 technique [13], the RMS error of the survey was 1.4 nT and the maximum residual error was 8.7 nT.

The contrasting structural and morphological appearance of the site is reflected in the heterogeneous, in some places mosaic, character of the AMF (Fig. 3b). In its northwestern part, outside the King's Trough, alternation of sign-variable linear magnetic anomalies of average intensity of 100–200 nT dominates. Comparison of these anomalies with those identified earlier [14] gives us grounds to identify them as the spreading chrons of C5An.2n (12.2 Ma), C5ACn (y) (13.7 Ma), C5ADn (14.2 Ma), C5Cn.1n (y) (16 Ma), C6n (18.75 Ma), and C13n (33.2 Ma) (ages taken from [15]). We clarified the position of the axes of the described chrons due to the higher quality of our data. The pattern of the linear magnetic anomalies has a regular order, which indicates the conservative, stable history of the magnetically active layer in the flank structures of the MAR located here. At the same time, according to our estimates, the spreading rate during the formation of the oceanic crust in the area west of the King's Trough averaged 15 mm/year.

Spreading anomalies are not traced within the trough. In the area of the Upper King deep, there is a rupture of the linear anomaly C13n, observed only on the flanks of the trough. The location of the rupture is known from the catalog of linear magnetic anomalies [14]. In accordance with our data, the axis of this anomaly runs along the chain of positive anomalies 7 km east of the one indicated in the catalog (Fig. 3b). Two more chains of the linearly oriented field maxima and minima, subparallel to the spreading anomalies of the site, are observed 25–30 km to the west of the C13n chron. They appear to be numbered linear anomalies and also are affected by the rupture in the King's Trough.

The linear anomalies are complicated by local magnetic field extrema up to 650 nT above the seamounts of the Gnitsevich Plateau, Lukin–Lebedev, the northwestern end of the King Trough, and the province of the southern volcanic massif. The presence of intense anomalies above the seamounts clearly indicates the volcanic nature of the rises. The apical part of volcanoes corresponds to isometric positive magnetic anomalies, which indicates their formation in the epoch/era of positive magnetic polarity, apparently as a result of single-act magmatism.

Therefore, the AMF study allows us to determine the time of completion of the King's Trough formation as a single mesostructure by the change in the AMF character: to the west of the edge of King's Trough, regular magnetic anomalies prevail, while to the east they are preserved only on the sides of the trough. King's Trough was formed between 18.75–33.2 Ma between chrons C6n and C13n. No linear magnetic anomalies of spreading origin have been detected within King's Trough, because their sources were likely destroyed/demagnetized during the formation of the trough. With a few exceptions, the extensive area of positive long-period anomalies corresponds to the King's Trough. The anomalies, apparently, have a deep nature with an average intensity of 100–200 nT. Their source may be either serpentinized rocks of the upper mantle, exhumed during trough formation, or products of late volcanism that flooded the bottom of the trough formed during one of the epochs of positive polarity.

RESULTS OF SEISMOACOUSTIC PROFILING

On the 57th cruise of R/V *Akademik Nikolai Strakhov*, seismoacoustic profiling was generally focused on studying the structure of the sedimentary cover in the deeps of the entire King's Trough. The rise, build by with sediments, was formed in the eastern part of the most southeastern Freen Deep [1]. The thickness of the seismic sequences within the rise increases in its arched part, indicating that these sediments are channel drift deposits (Fig. 4-I). The sedimentary sequence of this rise is disrupted by reverse faults, whereas in the western part of the Freen Deep, normal faults are developed (Fig. 4-I). The possible cause of this fault-forming is transient processes of isostatic leveling.

In the southern part of the Lower King Deep [1], the rise was identified with the thickness of sedimentary complexes increasing towards its arch (Fig. 4-II). This shape is also interpreted as a channel drift. The sedimentary material of the two detected drifts is thought to have been brought by bottom (contourite) currents running across the King's Trough from northwest to southeast. In the northern part of the Lower King Deep, a piercement structure (Fig. 4-II) has been established. The thickness of the near-surface seismic complex decreases above this structure (the thicknesses of deeper complexes are constant), indicating modern growth of the structure and erosion of the uppermost part of the section. In the central part of the deep, deposits of a clastic flow up to 35 m thick have been established. The flow disrupted its original stratification formed over another piercement structure (Fig. 4-II). The flow origin is interpreted as landsliding under the conditions of rapid sediment accumulation on the steep slopes of the trough.

In the Middle and Upper King deeps, there is alternation of acoustically stratified sequences and clastic flows (Fig. 4-III). The stratified part of the section shows folded structures of the box-fold type, between which there are depressions with increasing thickness down through the section.

Signs of sound scattering objects (SSOs) in the water column were detected on the Gnitsevich Plateau (Fig. 4-IV). SSOs are recorded above the tops of two seamounts. The Big Gnitsevich Seamount contains the SSOs detected by the data of sonar mode of the SeaBat 7150 multibeam echosounder, which generates series similar to the side-scan sonar data. The SSO is located near the top of the seamount and has an elevation of ~250 m above the bottom. The Middle Gnitsevich Seamount has a SSOs above the top, detectable from the profiler data with a CHIRP-type signal in the frequency range of 2–5 kHz, with a height above the top of ~200 m. These facts may indicate modern hydrothermal activity in this structure, removed from the active inter-plate boundary of the MAR.

Thus, the sedimentary cover in the deeps of the King's Trough, as a single mesostructure, is generally well stratified and contains signs of drift deposits and clastic flows. The cover is disrupted by faults of multidirectional kinematics; folded structures of the box-fold type are established. Sedimentation occurs over a series of piercement structures associated with median ridges.

RESULTS OF DREDGING

A series of structures of the Azores–Biscay Rise, Gnitsevich Plateau, sides of the King's Trough, slopes of flank plateaus and crowning cone-shaped edifices, and median ridges were sampled during dredging. Approximately 800 kg of rock were obtained at 23 dredge stations. Data on the dredges and their positions are given in Table 1 and Fig. 1. Along with the rocks, classified by us as bedrocks, a large amount of both rounded and sharp-angled fragments of various sizes, mainly of granite and granite–gneiss composition, were collected. These rocks are the products of ice drifting and have been excluded from consideration.

Two stable rock associations are distinguished in the King's Trough section. The first one is predominantly aphyric nonporous greenstone-altered basalts, dolerites, gabbroids (gabbro, olivine gabbro, gabbro-anorthosite), and mylonite formed during the tectonic–metamorphic transformation of these rocks. This association of rocks is formed during accretion of the crust in the axial spreading zone. Taking into consideration the presence of numbered linear magnetic anomalies on the flanks of the King's Trough, continuing on the eastern flank of the MAR, it is obvious that these rocks have been formed in the axial part of the MAR. They are found in the lower parts of the sec-

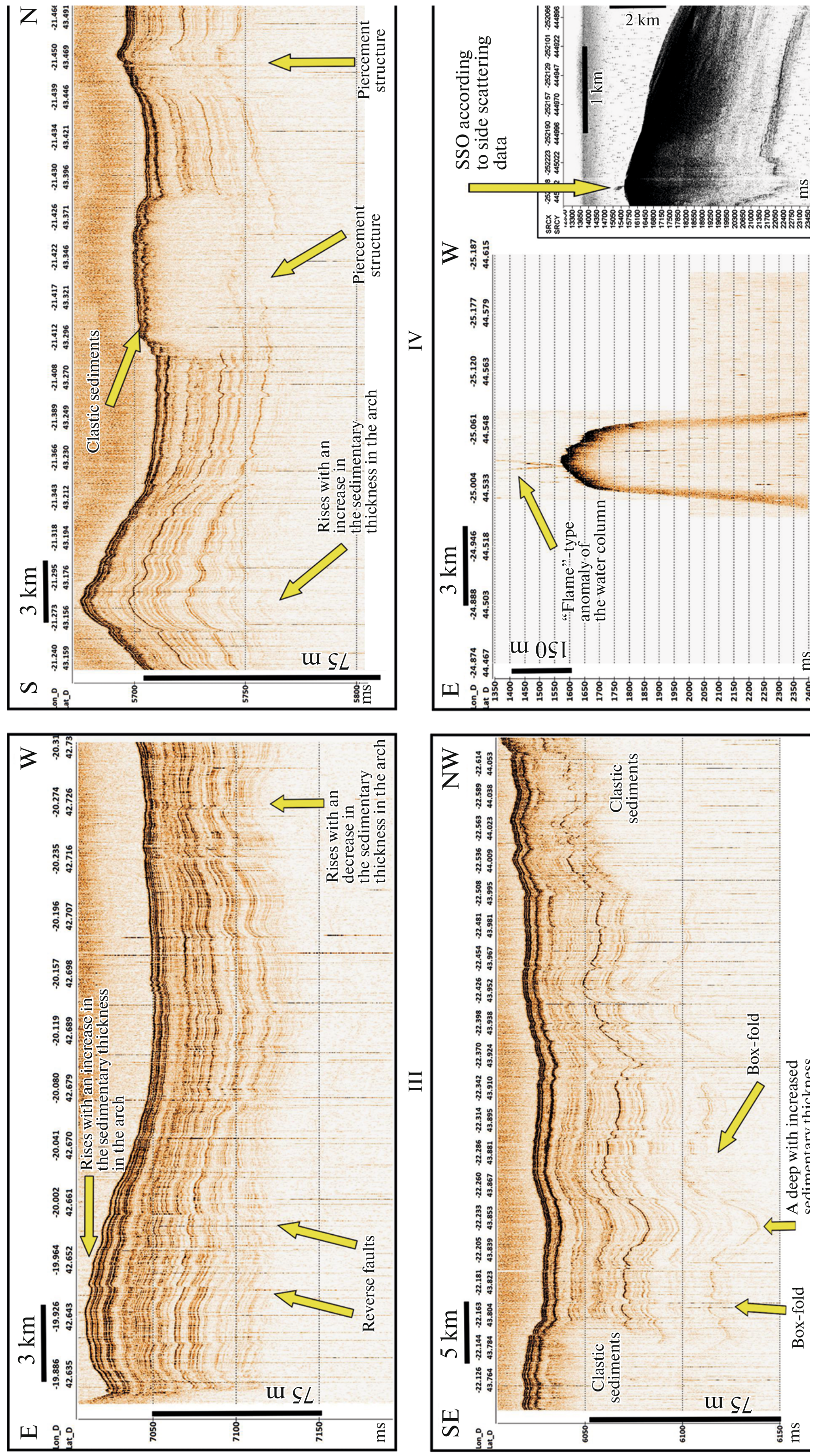

Fig. 4. Fragments of the ANS57 seismoacoustic sections (ParaSound and EdgeTech). I, In the Freen Deep; II, in the Lower King Deep; III, in the Middle King Deep; IV, sound scattering objects in the water column in the Gnitsevich Plateau area. Explanations of the points, indicated by arrows, are given in the text.

Table 1. Location of dredging stations and brief characterization of bedrock material

Dredge number	Latitude N	Longitude W	Depths (m)	Percentage of rocks excluding ice drift material	Weight (kg)
S5701	43°33.3′	−17°46.4′	3100–2900	Limestones 95%, basalts 4%, Fe–Mn crusts 1%	40
S5702	43°32.9′	−17°47.1′	3850–2800	Basalts 100%	0.2
S5703	42°27.9′	−18°59.5′	3000–1870	Limestones 90%, Fe–Mn crusts 10%	3
S5704	42°29.32′	−18°54.7′	3870–3250	Limestones 80%, Fe–Mn crusts 15%, basalts 5%	0.7
S5705	42°29.3′	−18°59.5′	2500–2300	Limestones 80%, basalts 19%, Fe–Mn crusts 1%,	100
S5706	41°54.1′	−19°23.9′	2300–2040	Limestones 100%	1.5
S5707	43°11.9′	−20°54.0′	2300–2000	Limestones 80%, Fe–Mn crusts 20%	0.7
S5708	43°39.2′	−21°25.9′	2300–2250	Basalts 65%, breccias 15%, limestones 10%, Fe–Mn crusts 10%	15
S5709	43°28.9′	−21°44.9′	3300–2500	Gabbro 80%, basalts 10%, sedimentary breccias 10%	10
S5711	43°34.7′	−21°59.6′	3400–3270	Gabbro 50%, basalts 30%, dolerites 10%, mylonite 5%, sedimentary breccias 4%, limestones 1%	40
S5712	43°38.9′	−22°18.2′	2150–1760	Limestones 55%, gabbro 15%, basalts 15%, dolerites 10%, mylonite 3%, Fe–Mn crusts 2%	150
S5713	43°35.1′	−22°22.3′	1490–1180	Fe–Mn crusts 50%, sedimentary breccias 30%, volcanics 10%, carbonate rocks 10%	10
S5714	43°57.4′	−21°59.3′	3580–3270	Limestones 60%, clayey–carbonate rocks 30%, dolerites 4%, gabbro 3%, basalts 1%, mylonite 1%, Fe–Mn crusts 1%	30
S5715	44°05.0′	−21°59.2′	2775–2420	Basalts 70%, limestones 20%, claystones 6%, grass 2%, Fe–Mn crusts 2%	30
S5716	44°15.9′	−21°59.0′	3500–3200	Fe–Mn crusts 50%, basalts 35%, gabbro 10%, 5% mylonite	25
S5717	44°17.6′	−22°57.3′	2350–2100	Basalts 80%, sedimentary breccias 10%, Fe–Mn crusts 9%, limestones 1%	100
S5720	44°39.1′	−24°16.7′	2800–1800	Fe–Mn crusts 40%, basalts 30%, limestones 25%, sedimentary breccias 5%	200
S5721	44°29.1′	−25°12.2′	2400–2200	Basalts 75%, limestones 25%	5
S5722	44°29.7′	−25°12.9′	1550–1380	Basalts 100%	30
S5723	44°32.5′	−25°18.8′	1625–1400	Limestones 100%	2

tion of the trough flanks, as well as on the median ridges and in the lower parts of the section of Antialtair Seamount at depths up to 2150 m, indicating that they form the arched basement of the flank plateaus. The second rock association is represented by volcanics, which we conditionally named as basalts. However, taking into consideration the composition of phenocrysts, more acidic varieties may be encountered among them. Basalts are mostly substantially porous and to some extent significantly altered by low-temperature hydrothermal metamorphism. The latter is evidenced by low-temperature secondary minerals common in these rocks: smectite, iron hydroxides, and calcite. The volcanics are aphyric and porphyritic, with plagioclases predominating among phenocrysts, sometimes in association with olivine or clinopyroxene, less often with hornblende. The rocks of this association compose flank plateaus and cone-shaped volcanic edifices, including those that are part of the Azores–Biscay Rise and Gnitsevich Plateau. The petrographic features of these volcanics, the morphology of the volcanic edifices they compose, and the structural position of these edifices indicate that these rocks were formed under the off-axis intraplate conditions.

Limestones, clastic rocks, and Fe–Mn crusts are almost always encountered together with rocks of both associations. Limestones are mostly pelitomorphic and have different degrees of lithification: from marble-like to loose, easily broken by hand. Organogenic-clastic varieties, formed by crinoid and coral fragments, were lifted from the flat top of Big Gnitsevich Seamount. Among the clastic rocks, breccias predominate; grass, sandstones, and siltstones are encountered less frequently. The composition of clasts in breccias corresponds to the rocks in the association with which they are found. The cement is fine sandy–carbonate, sometimes possibly phosphate. Fe–Mn crusts are characterized by different thickness (0.5–80 mm), morphology, and internal structure. Cone-shaped formations with the maximum thickness of up to 8 cm, which have convoluted layering resulting from alternation of Fe–Mn material and terrigenous–carbonate layers, are of particular interest among the crusts. They are found in the vicinity of the Antialtair Seamount and volcanic seamount in the province of the northwestern edge of the King's Trough and are probably of hydrothermal origin.

The studies confirmed the conclusions drawn from the results of the 55th cruise of the R/V *Akademik Nikolai Strakhov* in the southeastern part of the King's Trough that the formation of the King's Trough was preceded by the formation of the extended northwestern–southeastern striking arched rise, which became the scene of intense intraplate volcanism, followed by subsidence of the near-axial part of the volcanic plateau formed between 33.2 and 18.75 Ma [1]. New data have detailed and expanded these ideas. Namely, a number of facts indicate that the subsidence of the ocean floor is a consequence of the oceanic lithospheric tension in the northeast–southwest direction. At the same time, the volcanic plateau was split along two longitudinal subparallel fractures, which later became the axes of tension.

The results of dredging suggest that the base of the volcanic plateau is composed of rocks that formed in the axial spreading zone and experienced intense vertical movements, possibly, as a result of tectonic compression.

The intraplate volcanism that occurred in the area of the King's Trough has at least two stages: (1) preceding the trough formation and leading to the formation of the volcanic plateau, and (2) after the trough formation, which was realized in the formation of cone-shaped edifices of different sizes and their spurs. It manifested itself not only within the flanks of the King's Trough, but also in the area immediately adjacent to it from the south in the form of the southern volcanic massif, the Lukin–Lebedev Seamount, and other smaller cone-shaped structures. This volcanism also intensified magmatism in the axial spreading zone of the MAR up to the appearance of large volcanic edifices that formed the Gnitsevich Plateau.

The active tectonic and volcanic processes that led to the formation of the King's Trough are probably also the cause of neotectonic movements, revealed by the analysis of the seismoacoustic profiling data, causing the transient processes of isostatic alignment.

The intraplate volcanics are affected by widespread low-temperature hydrothermal metamorphism, which, judging by the detection of SSOs on the Gnitsevich Plateau, may still be ongoing.

The sedimentary cover of the study area was formed on the oceanic basement affected by neotectonic movements and deformations during background pelagic sedimentation, landsliding, and formation of debris flows and owing to material brought by near-bottom currents.

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CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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