Physics of the Earth and Planetary Interiors 114 (1999) 59–70

PHYSICS
OF THE EARTH
AND PLANETARY
INTERIORS

Geodynamics of the zone of continental continuation of Mid-Arctic earthquakes belt (Laptev Sea)

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Received 5 December 1997; accepted 14 November 1998

Abstract

On the basis of a generalization of all available data on the distribution of earthquake epicenters and their focal mechanisms, the opinion is expressed that there is no thorough splitting of Laptev Sea lithosphere associated with the divergent boundary between the Eurasia and North American plates. There are two fragments of this boundary which are laterally separated by hundreds of kilometers. The northern fragment is the end of the oceanic segment of the boundary and is situated within the limits of the northern end of the branch of mesozoids of Northeastern Eurasia which extends here and a part of the superposed Omoloy graben. The southern fragment extends from the continent along the flexural-fault boundaries of the Lena–Taymyr zone of boundary uplifts. It is postulated that with continuation of operation of the geosource of dilatational forces in the Laptev Sea, either a microplate or a zone of transform faults of the Spitsbergen type may be formed.

Keywords: Plate tectonics; Seismotectonics; Earthquake; Arctic; Laptev Sea

1. Introduction

Conviction of the singularity of the recent tectonics of the Laptev Sea shelf developed long ago on the basis of the fact of its location in the transition zone from the ocean to the continent of the Mid-Arctic earthquake belt, tracing the most northerly fragment of the unified global system of mid-oceanic rift ridges—the Gakkel Ridge. East Africa and the Western United States are now in an identical situation if this tectonic criterion is applied.

In any seismically active region, the greatest amount of information on its geodynamics is contained in materials from seismological observations. This situation is all the more evident in the case of sea areas where the collection of direct geological data is limited by the shore configuration and by islands.

According to now-prevailing concepts, the Laptev Sea shelf is interpreted as a unified continental rift system, being the connecting link of the ocean-continental Mid-Arctic rift belt—the Gakkel–Momskiy rift (Grachev, 1973; Gramberg et al., 1990). In general, it is impossible not to agree with these con-

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0031-9201/99/$ - see front matter
PII: S0031-9201(99)00046-1

cepts, but the presently available data on the distribution of earthquake epicenters and focal mechanisms make it possible to refine and supplement them.

2. Structural-tectonic position

In the tectonic classification, the prerift structure of the Laptev Sea shelf is defined as a marginal-continental platform, which, as a unified geostructure, corresponds to the Upper Cretaceous–Cenozoic structural stage of the sedimentary layer: a platform complex (Gramberg and Pogrebitsky, 1984).

The structural plan of the platform complex experienced changes during the period of the Paleogene stage of tectonic activation, genetically related to riftogenesis in the Eurasian subbasin and leading to the formation on the shelf of a system of grabens (downwarps), now compensated by sediments and separated by marginal and internal uplifts. In the gravity field, the system of downwarps is reliably fixed by reduced gravity field values. In addition, the contrasting tectonic movements caused by the recent activity of the Laptev Sea lithosphere lead to fragmentation of the platform complex by subvertical and vertical fault dislocations, quite reliably discriminated using the refracted waves correlation-method (RWCM) (Vinogradov et al., 1987; reports of Polar Expedition of the 'Sevmorgeo' Scientific Production Association) and the reflected waves-common depth point method (RW-CDPM) (materials provided by L.A. Savostin).

By the mid-1960s, a structural-tectonic inhomogeneity of the basement of the Laptev Sea platform was postulated on the basis of indirect estimates based on geological data for its continental and island margins.

The shore zone of Laptev Sea is controlled by heterogeneous geological structures of different age. In the west it passes along the foot of the arched-block uplifts of the Taymyr–Severnaya Zemlya system, at the base of which there are folded complexes of the Mesozoic tectogenesis. The southern margin of Laptev Sea is the ancient Siberian platform, but from the Lena delta and to the east, the folded mountain structures of the mesozoids of Northeastern Eurasia. The arched-block structures made up of folded complexes of Cimmerian age form the eastern margin.

Modern concepts concerning the structural-tectonic characteristics of the Laptev Sea platform were formed on the basis of an analysis of materials from multiyear geophysical investigations carried out by different methods directly in sea areas, among which in the first stages, the key role was played by on-ice gravimetric reconnaissance (Reports of the Polar Expedition of the Scientific Research Institute of Arctic Geology—'Sevmorgeo' scientific Production Association for 1964–1988). Whereas the magnetic field over the entire sea area is poorly expressed and virtually free of anomalies, two regions are discriminated on the basis of gravity field characteristics: western and central with broad isometric anomalies, but also eastern, for which the frequent alternation of linear, quite narrow high-gradient anomalies of northwesterly, less frequently meridional strike, with a common higher background of gravity field values, is characteristic. In comparison with the western and central zones, in the eastern zone an increased dislocation of the principal gravity-governing object and its shallower depth in general are evident. The results of seismic work by the RWCM in 1979 in the western part of the sea area at the outlet of Khatanga Bay, and DSS in 1973 in the southeastern part in the neighborhood of Buorkhaya Gulf (Kogan, 1974; Gramberg and Pogrebitsky, 1984) were in good agreement with the gravimetric data. A comparison of the registered seismic sections also made it possible to conclude that the Laptev sedimentation basin was formed on a heterogeneous basement (Gramberg and Pogrebitsky, 1984). In the west, a sedimentary layer with a total thickness of 6–8 km and the crystalline basement underlying it are identical with the corresponding stratigraphic elements of the Siberian platform, whereas in the east high-velocity deposits, identified with the Mesozoic basement, lie directly beneath the platform complex.

We feel that the most weighty arguments in support of the representation of heterogeneity of the basement of the Laptev platform were materials from sea seismic work by the RW-CDPM (Ivanova et al., 1989) carried out during 1986–1988, which in combination with all the materials mentioned above make it possible to plot a map of the principal tectonic elements of Laptev Sea most realistic for today (Fig. 1). According to these data, the bottom of the plat-

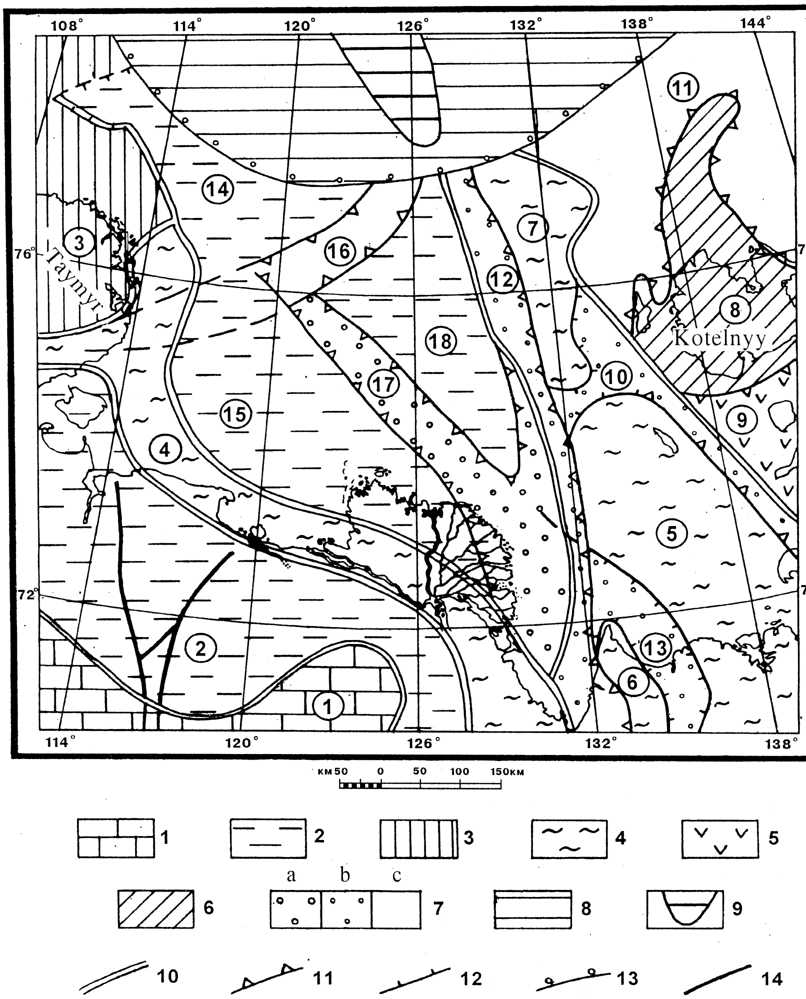

Fig. 1. Sketch map of tectonic elements of Laptev Sea (prepared by D.V. Lazurkin with simplification); (1) epi-Karelian platform complex; (2) epi-Karelian paraplatform complex; (3) Early Mesozoic folded complex; (4–5) Late Mesozoic folded complex (mesozoids of Northeastern Eurasia); (4) miogeosynclinal, (5) eugeosynclinal; (6) median mass; (7) platform layer in inherited and superposed downwarps: (a) on paraplatform basement, (b) on folded basement, (c) nature of basement unclear; (8) abyssal basin; (9) mid-oceanic rift zone. Boundaries of structural-tectonic complexes: (10) areas of different tectogenesis ages; (11) large structures of Laptev sea shelf; (12) local structures within the large structures; (13) upper boundary of continental slope; (14) faults. Structural-tectonic elements (figures in circles): (1) Anabar anteclise of Siberian platform; (2) Marginal depressions of Siberian platform; (3) Taymyr Early Mesozoic folded system; (4) Lena–Taymyr zone of boundary uplifts; (5) Shelon structural terrace; (6) Buorkhaya rise; (7) Eastern Laptev uplift; (8) Kotelnyy median mass; (9) Novosibirsk folded system; (10) Belkovo–Svyatonos trench; (11) Anisiy–Novosibirsk downwarp; (12) Omoloy graben; (13) Yana graben; (14) Western Laptev downwarp; (15) Southern Laptev downwarp; (16) Northern graben; (17) Ust–Lena graben; (18) Central Laptev rise.

form complex is reliably detected over the entire sea area, but the lower-lying part of the section differs fundamentally in the West Laptev and East Laptev regions. The first of these five other reflecting horizons are traced beneath the platform complex, which on the basis of all available geological–geophysical information are identified with the epi-Karelian paraplatform stage in the Laptev platform basement. The fragmentarily traced lowermost horizon is identified with the top of the crystalline basement of the

Archean–Early Proterozoic tectogenesis. The West Laptev region is bounded on the west by the block-folded structures of the Taymyr folded system, and on the southwest by the Lena–Taymyr zone of boundary uplifts separating the structures of the Laptev platform proper from the marginal depressions of the Siberian platform. Over the entire extent of the East Laptev region between Yana Bay and Belkovskiy Island below the reflection from the bottom of the platform complex, the record has a chaotic character which cannot be correlated. This horizon has an extremely dissected character, clearly corresponding to the curve for the gravity field, in which even its small details with horizontal and vertical dimensions of 5 km and 300 m, respectively, are noted. The thickness of the platform complex averages 1–1.5 km, in the arches of horst uplifts decreasing to 0.5–1 km. On the basis of available geological–geophysical information for the Yana Coast and Stolbovoy Island regions, where folded structures of mesozoids of Northeastern Eurasia have been established, Ivanova et al. (1989) draw the entirely correct conclusion that the platform complex in the East Laptev region lies directly on the Mesozoic basement, and accordingly, it all must be regarded as the northerly continuation of structures of the Verkhoyansk folded system on the shelf. On the east, the East Laptev region is bounded by the Belkovo–Svyatonos fault trench, traceable from an intensive bandlike negative anomaly and separating the mio- and eugeosynclinal regions of mesozoids.

The suture zone between the paraplatform Western Laptev and folded Eastern Laptev regions according to RW-CDP data runs in a NNW direction within the superposed Omoloy graben in the region 130–131°E.

3. Distribution of earthquake epicenters

Information on the seismicity of Laptev Sea and its margins until recently was based for the most part on data from distant stations, which made it possible to have extremely approximate ideas concerning the characteristics of the distribution of epicenters. Only the disappearance of a clearly expressed linearity of the Mid-Arctic earthquake belt with transition from the oceanic part of the sea area to the shelf was evident. The existence of an axial seismically active zone of riftogenesis, linked to the Ust–Lena downwarp, passing through the central part of the shelf and to the east of the Lena delta through Buorkhaya Gulf, emerging onto the continent, and also two lateral zones, eastern and western, of induced (‘passive’) seismicity, caused by the release of stresses generated in the axial zone in weakened parts of the lithosphere (Avetisov, 1975, 1983), was postulated.

Beginning in the mid-1980s, after organization of several new stations on the southern coast of Laptev Sea by the Yakutsk Institute of Geological Sciences, Siberian Department, USSR Academy of Sciences, the energy level of the reliably registered earthquakes decreased sharply and now, in place of the former $M = 4.5$, for the northern half of the sea area it is 3–3.5, but for the southern half and the Lena delta it is 2–2.5. In the course of the expeditionary seismological observations of the ‘Sevmorgeologia’ Scientific Production Association, carried out using 12 ‘Cherepakha’ recorders during the course of the spring–summer field seasons of 1985–1988 in the Lena delta and on the shores of Buorkhaya Gulf, weaker events also were reliably registered (Avetisov, 1993).

In constructing a map of epicenters in the Laptev Sea and along its margins, a bank of seismological data for the Arctic region organized at the ‘Sevmorgeologia’ Scientific Production Association was used. It was compiled on the basis of the Regional Catalogue of the International Seismological Center, as well as catalogues for individual regions, the basis for which was data from local networks of stations, in particular, the observations made by the ‘Sevmorgeologia’ Scientific Production Association itself. The basis for selecting the material plotted on the map was the principle ‘better less than worse’, the realization of which was expressed in the use, for the most part, only of earthquakes since 1970 when the network of arctic stations became sufficiently well-developed. Among the earlier events, only the strongest were taken. The map was constructed using an ES-1037 computer at the Computer Center of the ‘Sevmorgeologia’ Scientific Production Association.

On the basis of the totality of available data (Fig. 2), the pattern of distribution of earthquake epicenters in the Laptev Sea and along its margins is now represented in the following way.

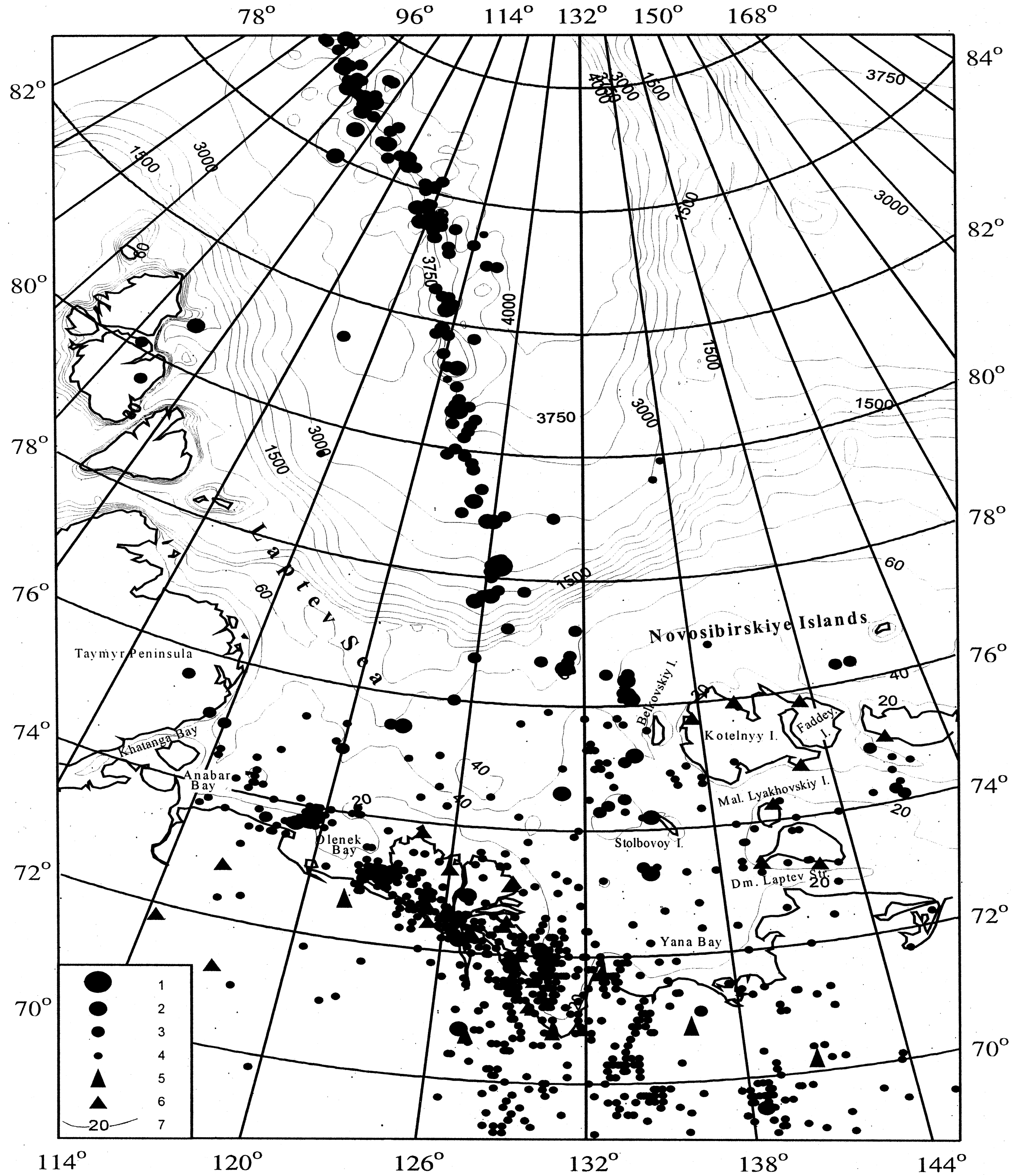

Fig. 2. Map of epicenters of earthquakes and bathymetry data in Laptev Sea and on its margins (bathymetry data compiled by E.D. Daniel). Magnitude: (1) $6 \leq M$: (2) $5 \leq M < 6$; (3) $4 \leq M < 5$; (4) $M < 4$; Stations: (5) stationary; (6) expeditionary; (7) depth in meters.

The linearity of the Mid-Arctic belt persists with intersection of the continental slope and within the limits 200–250 km of the northern part of the shelf to 76–76.5°N. The indicated line of epicenters is directed mainly not into the central part of the shelf, the Northern and Ust–Lena downwarps, but to the southeast, through the northern tip of the Omoloy graben in the direction of the Novosibirskiye islands. At a distance 50–100 km to the northwest of Belkovskiy Island, it becomes appreciably broader and changes its strike to submeridional, extending to Stolbovoy Island, to the south of which it degenerates. In the southeast part of the sea area, the density of the epicenters is appreciably lower and their distribution is close to dispersed. Only latitudinally oriented chains of epicenters are detected in Eterikan and Dm. Laptev Straits. Within the limits of the eastern margins of Laptev Sea, it is possible to postulate a bending of the epicenters around an aseismic lithospheric block, including Belkovskiy, Kotelnyy, Faddeyevskiy and M. Lyakhovskiy Islands. In any case, long-term seismological observations of the 'Sevmorgeologia' Scientific Production Association over the course of the field seasons 1972–1976 directly in the Novosibirskiye Islands did not reveal even a single epicenter within the limits of the mentioned sector.

To the west of 130–132° the nature of the distribution of epicenters is substantially different. Two sublinear zones, diverging fanlike northwestward from the Buorkhaya Gulf region, are traced here.

One of them, the more evident, runs along the western shores of Buorkhaya Gulf, intersects the delta and then with some interruption extends through Olenek and Khatanga Bays to the eastern shores of the Taymyr. Within its limits there have been events with a magnitude 5.5, for some of which macroseismic information is available. In particular, for the earthquake of January 2, 1980, in the southeastern part of Olenek Bay, there are zones of scale units 6 and 7 of an oval configuration with the major axis of a northwesterly direction coinciding with the strike of the line of epicenters.

The second zone in its southern part in a dense band traces the axial and near-axial region of Buorkhaya Gulf and then northward, thinning out appreciably, which possibly is associated with increasing distance from registry stations, runs in a northwesterly direction along the Ust–Lena downwarp in the central part of the sea area where it attenuates sharply in the region 120–123° without reaching parallel 76°. Earthquakes with a magnitude up to 5.5 also are known here. Only individual epicenters are noted beyond the limits of these zones in sea areas and in the northern part of the delta.

South of Buorkhaya Gulf on the continent, the epicenters in a broad band extend to the southeast into the region of the mesozoids of Northeast Eurasia. In Western Yakutia, individual epicenters were detected in the region of the northeastern margin of the Siberian platform.

It must be noted that we have not established any correlation between the depth of the hypocenter, which in the overwhelming majority of cases does not exceed 30 km, and its lateral position. In the Lena delta and in Buorkhaya Gulf, according to data for numerous weak earthquakes, there is a gravitation of the foci to crustal reference seismic boundaries, including the bottom of the crust (Avetisov, 1993).

4. Focal mechanisms

Data on focal mechanisms also were taken from the databank of the 'Sevmorgeologia' Scientific Production Association, in which all available information for our own country and foreign countries has been incorporated. It must be noted that for a number of earthquakes there are determinations by different methods, which in principle need not necessarily coincide, and determinations by the same method by different authors, which should coincide, but in actuality differ substantially from one another. In order to bring the data together, information obtained by the centroid-moment tensor solution (CMT) (Dziewonski et al., 1981) and the first arrivals of longitudinal waves methods (Balakina et al., 1972), most widely used in actual practice, and in essence capable of leading to substantially different results, has been represented separately (Fig. 3). In addition, for the maximum possible decrease in ambiguity of the solutions, the determinations made by the first arrivals method were inspected. This involved sampling the most reliably registered events, national and foreign bulletins were exploited in making more precise determinations of the signs on the first arrivals using a single method (Aptekman et al., 1979) and a computer determination and redetermination of the mechanisms was made. For individual earth-

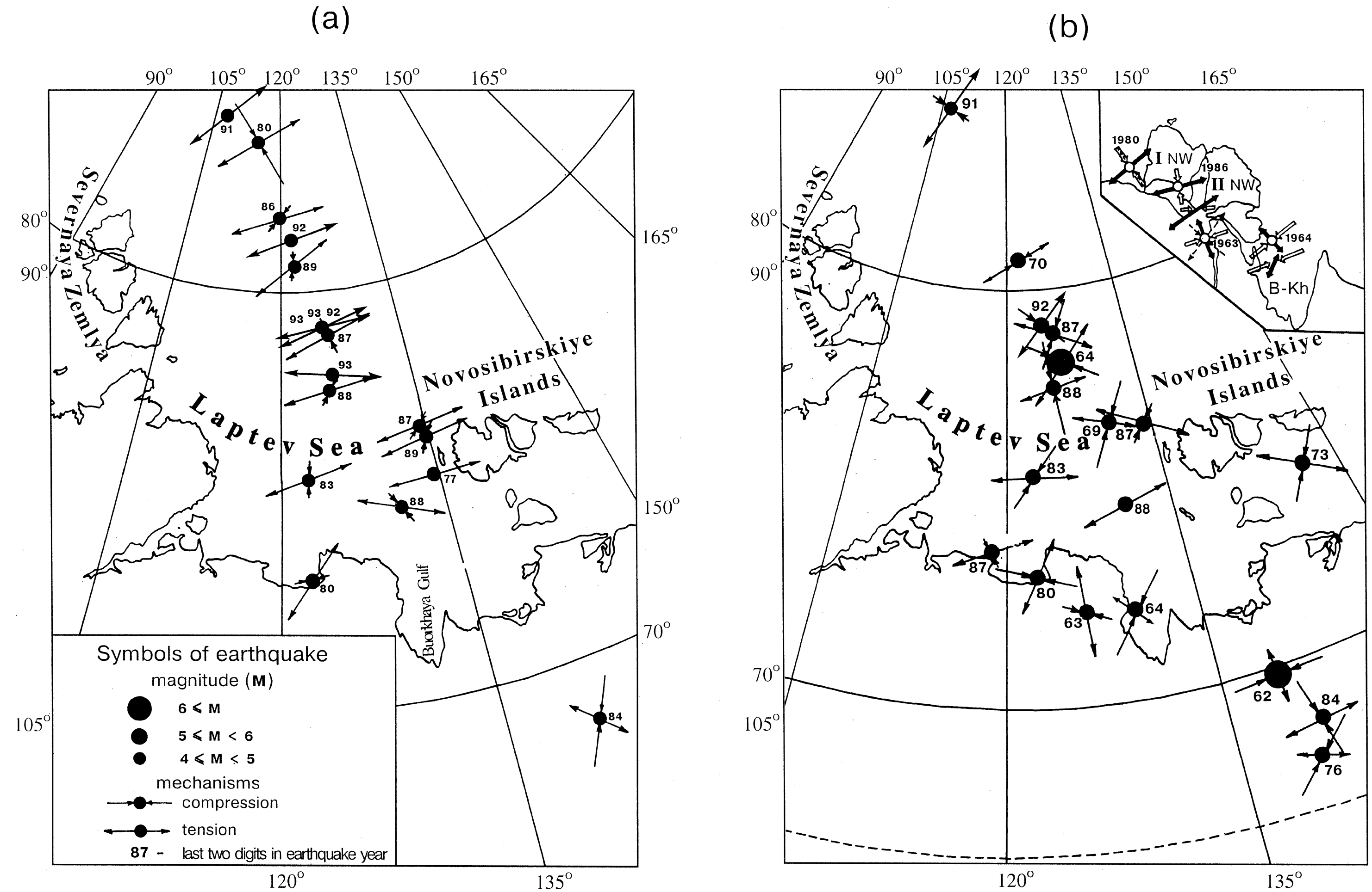

Fig. 3. Focal mechanisms of earthquakes of Laptev Sea and along its margins: CMT method. First arrivals method (inset from Avetisov, 1993. I NW, II NW, B-Kh—names of sectors for focal mechanisms were determined by the group method). Arrow length is proportional to the angle cosine between axis and horizon (plunge).

quakes for which the indicated procedure could not be carried out, the best variant was selected from among the available variants of different authors. In such cases, we were guided by the quantity of information given by the author (availability of data for a local network of stations) and its quality (possibility of obtaining information directly from seismograms). Thus, for the region considered in this study in disputable cases, the preference was given to data supplied by Yakut seismologists (Parfenov et al., 1987).

At the present time, for the earthquakes of Laptev Sea and its margins, there are 19 known solutions of focal mechanisms by the first arrivals method and 16 by the CMT method; for several events there are solutions by both methods (Avetisov, 1996).

In the northern part of the sea area, in the epicentral zone directly associated with the oceanic part of the seismic belt, there is an obvious predominance of a normal fault mechanism with a dilatation axis oriented suborthogonally to the general strike of the line of epicenters. This is particularly conspicuous from determinations by the CMT method, according to which the stress field here in no way differs from that obtained for Gakkel Ridge. According to data obtained by the first arrivals method, the dispersal in the orientation of axes is more considerable and individual solutions give a normal fault-strike slip mechanism, which in general seems geologically more realistic because it is difficult to expect an identical reaction to the operative stresses by the thin oceanic crust forming and being transformed under the influence of these stresses and by the thick heterogeneous ancient continental crust, even if the deep source of stresses is the very same. The predominance of subhorizontal dilatation also is established in the most southwestern seismically active zone. The strike of the axis of this stress, although it experiences rather appreciable variations, evidently caused by the characteristics of ancient fault tectonics, on which modern processes are superposed, nevertheless gravitates to suborthogonal relative to the strike of the zone of epicenters. The data from individual solutions for the strong earthquakes of this zone find good confirmation in the results of group determinations made using numerous weak tremors registered by the expeditionary stations of the 'Sevmorgeologia' Scientific Production Association and the regional network of Yakutian stations (Avetisov, 1993).

Meanwhile, a predominance of subhorizontal compression, near-orthogonal to line of epicenters, is established in the central part of Buorkhaya Gulf on the basis of data for the earthquake of 1964 (Bykovo earthquake) (Parfenov et al., 1987), as well as the totality of weak earthquakes. In the northwestern fragment of this zone (earthquake of 1983), a normal fault mechanism was found by both methods.

In the continental part of the seismic belt to the southeast of Buorkhaya Gulf, the stress mechanisms change stably to upthrust and slip-upthrust mechanisms.

5. Geodynamic model

It is evident that the degree and character of transformation of the lithosphere under the influence of some tectonic processes in principle are caused by the overall influence of two principal factors: intensity and direction of the operative forces and the real properties of the initial lithosphere. On the basis of the finding, evidently disputed by no one, that there is a single riftogenic nature of the tectonic forces determining the modern geodynamic conditions in the Eurasian subbasin and the Laptev Sea shelf which is an abutting position with it, it can be asserted that the variations of the parameters of the tectonic regime detected on the basis of seismological data are a result of the filtering influence of the properties of the prerift real geological medium. In an isotropic medium, the orientation of the rupture plane will be determined by the laws of mechanics and will be dependent only on the orientation of the imparted forces. With the existence of a weakened zone in the prerift medium, the rupturing line forming in the riftogenesis process one way or another is rotated from the theoretical position in the direction of this weakened zone. In cases of incidence on a lithospheric block for one reason or another not amenable to rupturing, the rupturing line along a near-orthogonal fault or a series of echeloned faults will bend around this block. Data on the Mid-Arctic seismic belt show that all three of the mentioned variants are represented here. The typically rift Gakkel Ridge belongs to the first, the region of the so-called 'oblique' dilatation of the Knipovich Ridge in the Norwegian–Greenland basin belongs to the second, and the zone of transform faults, in particular, one of the most typical among them, the Spitsbergen transform fault, belongs to the third.

From the point of view of the thesis of a character of the newly forming rupture superposed on the prerift structure of the lithosphere, available seismological data make it possible to assert that with transition across the continental slope on the Laptev Sea shelf, a weakened zone was detected mainly not in the Northern graben, as assumed earlier, but to the east, in the region of the folded complexes of mesozoids of Northeastern Eurasia, to which also extended a line of epicenters penetrating into the zone of contact between the shelf and the Novosibirskiye Islands block directly to the west of Belkovskiy Island. It should be noted that attention was drawn to this for the first time by Kim (1986). Farther to the south, the dispersal of epicenters gives evidence of the transformation of one principal weakened zone into a series of less evident zones, which cannot be regarded as unexpected in folded regions, but to the south of Stolbovoy Island, where the seismically active zone in actuality degenerates, there is an increase in lithospheric monolithicity and the further propagation of a rupture in this region is impossible. The continuing operation of riftogenic forces should result and has resulted in the appearance of weakened zones in other sectors. The position of these ancient weakened zones is now marked, in our opinion, by the entire branched system of downwarps mentioned above, within whose limits strong earthquakes occur. This is manifested most clearly in the example of the Ust–Lena downwarp, without question in some stage being an axis of riftogenic dilatation. This is indicated, in particular, by the reduced velocities of seismic waves in the upper mantle established in the Buorkhaya Gulf zone on the basis of DSS (Kogan, 1974) and seismological data (Avetisov and Guseva, 1991). However, the information cited above on the predominance of horizontal transverse compression in the southern part of the downwarp shows that now the dilatation axis does not pass here. We feel that the seismological data force us to acknowledge its present-day position in the region of contact between the peripheral flexural-fault limits of the southwestern part of the Laptev platform and the Lena–Taymyr zone of boundary uplifts. The 'skipping' of the axis is evidently genetically related to the movement of the pole of rotation of the North American and Eurasian plates from the south into the region of Buorkhaya Gulf occurring 1–3 million years ago (Cook et al., 1987). At the same time, in the Momskiy graben, there was a change in the riftogenic regime to the transverse compression regime which has now been established on the basis of seismological data. As indicated by the cited seismological data, now being the most complete, the finding that there is a continuity of the boundary of the Eurasian and North American plates on the Laptev Sea shelf can be regarded as correct only at the first approximation level, that is, if the entire shelf is regarded as a sector of the boundary. This is adequate for understanding the general kinematics of plate tectonic movements, but it does not satisfy regional research requirements. It must be acknowledged that there are two 'blind' segments of this boundary, one of which in the eastern half of the shelf is the end segment of the oceanic part of the boundary, extending from the Eurasian basin, whereas the second is continental, running from Eastern Yakutia. The close geographical positioning of sectors of predominant horizontal dilatation and compression to one another also makes it possible to speak of violation of the postulate of 'rigidity' of lithospheric plates, confirming the thesis which we advanced earlier on the existence of a region of induced compression on the flanks of dilatation zones. Geological data for the Novosibirskiye Islands (Savostin and Drachev, 1988) also support this.

A distinctive fact is the nearly oval-shaped southern end of the Eurasian subbasin and its great width (500–600 km) in the zone of juncture with the Laptev Sea continental slope. According to data published by Karasik (1968), who traced the entire spectrum of spreading magnetic anomalies from the oldest of them (No. 24–56 million years) to the most recent (No. 5–10 million years) virtually to the slope, the width of the spreading zone is commensurable with the width of the subbasin. In this case, it becomes quite difficult to explain the abrupt disappearance of such a broad spreading zone with transition across the continental slope. The thought of a transverse displacement of the 'shores' of the Eurasian subbasin, in particular the Lomonosov

Ridge relative to the shelf, which initially seemed possible, had to be discarded because it was evident that such movements would not have occurred without seismic manifestations, which it would not have been possible to miss, even taking the remoteness of the region from registry stations into account. It remains only to postulate the fact of a special plasticity of the Laptev Sea shelf lithosphere, allowing the formation of only a series of local fractures and impeding their joining into a single rupture. It is entirely possible that anomalous elastic properties of the lithosphere in this region also are a cause of frequent variations in the kinematics of movement, established from repeated meridional displacements of the spreading pole.

Another interpretation, not requiring assumptions concerning the anomalousness of the elastic properties of the lithosphere of the Laptev Sea shelf, can be proposed if the map of the axes of magnetic anomalies represented in (Coles and Taylor, 1990) is taken as a basis. According to data from foreign researchers, with southward movement there is a gradual disappearance of more ancient anomalies and only the most recent of them reach the foot of the continental slope. The width of the spreading zone at the southern end of the Eurasian subbasin in such a case also must be estimated as the distance between a pair of axes of this anomaly (50–60 km). In order to explain the great width of the subbasin here, it is necessary to assume that it had a prerift existence, that is, absence in this place of contiguity of the Lomonosov Ridge to the Severnaya Zemlya continental slope. Such an assumption, as one of the variants for explaining the 50–100-km band with a negative magnetic field beyond the limits of anomaly No. 25, was made earlier by Vogt et al. (1979). It is possible that the ancient Mesozoic basins controlled the position of the initial line of splitting of recent spreading.

We feel that the presented seismological data for the of the Laptev Sea shelf make it possible to say that the formation of a unified boundary between the Eurasian and North American plates here is controlled by two counter movements of its sundered fragments: to the south through the region of mesozoids in the eastern part of the shelf and to the northwest along the fault boundaries of the Lena–Taymyr boundary uplifts. At present, it is possible to express only general considerations concerning the nature and place of possible juncture of the sundered fragments in the case of continuation of the operation of riftogenic dilatational forces. It is evident that the anticipated position of the unified boundary will again be determined to a great extent by the position of weakened zones in the region. The following possible variants seem realistic.

(1) Further southward advance of the eastern fragment of the rupture along the Omoloy graben and the southern part of the Ust–Lena graben and its juncture with the continental part of the boundary to the east of the Lena delta; further advance of the western fragment to the north–northwest along the contact between the Taymyr folded system and the western part of the Laptev platform and its arrival at the continental slope. This results in the formation of the Laptev microplate and a triple juncture in the region of the southern coast of Buorkhaya Gulf. Within the framework of this variant, the arrival of the western fragment of the rupture at the continental slope through the Northern graben is possible.

(2) The stoppage of further advance of the ruptures along the directions indicated in the first variant and the joining of the now-established ends of the fragments of the boundary along a line of northeasterly strike, coinciding with or close to the Northern graben. In this case, it is necessary to expect formation of a system of transform faults of the Spitsbergen type on the Laptev Sea shelf.

6. Summary

Modern geodynamic conditions in Laptev Sea are determined by its location in a region of direct arrival of the riftogenic zone of the Eurasian subbasin of the Arctic Ocean on the shelf.

On the basis of the considered materials, a quite good correlation is established between the distribution of earthquake epicenters on the Laptev Sea shelf and its structural-tectonic characteristics. The relatively great dispersal of epicenters in the eastern part of the shelf is determined by the corresponding reaction to the operative stresses in the considerably fragmented and small-block Mesozoic folded basement; the more ordered distribution of epicenters of the western part is controlled in general by the contacts of quite large, more ancient lithospheric blocks.

The system of superposed Mesozoic grabens manifests pre-rift weakened zones, but not one of them played the role of a general rupture.

In general, at the present time on the Laptev Sea shelf, it is not possible to trace a single continuous rupturing of the lithosphere which can be identified with the boundary of the North American and Eurasian lithospheric plates, reliably established in the oceanic part. Two fragments of this rupture are discriminated: northeastern, coinciding with the most northerly end of the branch of mesozoids of Northeastern Eurasia and the part of the Omoloy graben superposed on it and with a line of epicenters traceable to the rift zone of Gakkel Ridge, and also southwestern, running from the region of mesozoids of Northeastern Eurasia along the Lena–Taymyr zone of boundary uplifts. A regime of transverse subhorizontal dilatation has been established in both fragments on the basis of seismological data.

With the persistence of the now operative tectonic forces, it is possible to expect the appearance within the limits of the Laptev Sea shelf either of the Laptev microplate and a triple juncture in the Buorkhaya Gulf region, or an echeloned system of transform faults of the Spitsbergen type.

A stable subhorizontal compression regime is observed to the southeast of Buorkhaya Gulf.

In ending this article, it must be noted that despite the considerable advances in geophysical study of Laptev Sea during the last 7–8 years, this region, unique in its tectonic position, nevertheless remains relatively poorly studied. The virtually complete absence of seismic information on the deep structure of the crust and upper mantle is felt most strongly. Unfortunately, it must be said that in the coming years, it is scarcely possible to expect any appreciable improvement in the status of matters in this respect.

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