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GEOLOGY

Local Geodynamics of Northern Sakhalin Based on Results of the Analysis of Lineaments

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Sakhalin Island attracts the attention of geologists owing to its location at the boundary of the Sea of Okhotsk and Amur lithospheric plates [1] expressed in a series of diverse faults [2, 3]. According to [2], the near-horizontal compression, which promotes the meridional extension of the island framework, is the major geodynamic force acting in the deep zones of the island. In northern Sakhalin, the horizontal movements are oriented to the northeast and north, the plate boundary is identified as the East Pil'tun Fault, and its northern extension manifested as the Ekhabi–Pil'tun and Langry strike-slip faults.

A sufficiently large number of geodynamic models of compression, extension, and shear have been published to date [5–9]. The available data show that the degree of ordering is a specific feature of the newly formed fractures at the initial deformation stage when relatively weak forces are applied. The compressive stress gives rise to a more ordered fracture pattern than the tensile stress. It would be interesting to reconstruct the modern geodynamics of Sakhalin Island on the basis of modeling and compare the result obtained with geodynamic reconstructions based on geological data.

For this purpose, we compiled a digital map of linear landforms using topographic maps as a basis. Using special computer programs as a basis, we calculated the general density of lineaments and density of lineaments of different orientations, compiled rose diagrams, determined their anisotropy, and so on. The vector sum of lineaments serves as a measure of anisotropy of their distribution along different directions. In the case of isotropic (disordered) distribution of lineaments, their vector sum is equal or close to zero, whereas the vector sum of anisotropic (ordered) distribution significantly deviates from zero. A hierarchically ordered system of blocks of various ranks was delineated from the prevalent strike of linear landforms (figure).

Based on density of lineaments and their prevalent orientation, the study region is divided into the Western, Central, and Eastern blocks separated by the NW-trending West Baikal and the Gyrgylan'i–Ossoi boundaries. In the south, the blocks are bounded by the near-latitudinal Askasai boundary. The Langry interblock boundary transects the blocks in their approximately middle parts.

The northern part of the Western Block is characterized by a prevalence of near-latitudinal lineaments. In its southern part, the lineaments primarily strike in a northwestern direction. The block is subdivided into small areas in terms of the density of linear landforms. In general, lineaments within this block are ordered. We failed to determine the prevalent direction of lineaments in the Central Block, except for in its northern part, where a sector with ordered arrangement of linear landforms is outlined. The Eastern Block demonstrates largely disordered orientation of linear landforms, but its northern (Okha Block) and southern (Paromai Block) parts, which are separated by the W- to E-trending Langry Fault [4], reveal some differences. The Okha Block consists of a series of small blocks with different orientations of linear landforms. Blocks with an ordered character of linear topographic elements alternate with blocks devoid of ordering. The Paromai Block includes two zones of lineaments. In the south, the lineaments are largely ordered and oriented in the near-meridional direction. In the north, they are oriented in various directions.

The interblock boundaries differ in their ages and are constrained by the age of rocks separated by the respective boundary. The oldest boundary is represented by the northwestern boundary that divides the Western and Central blocks of northern Sakhalin and

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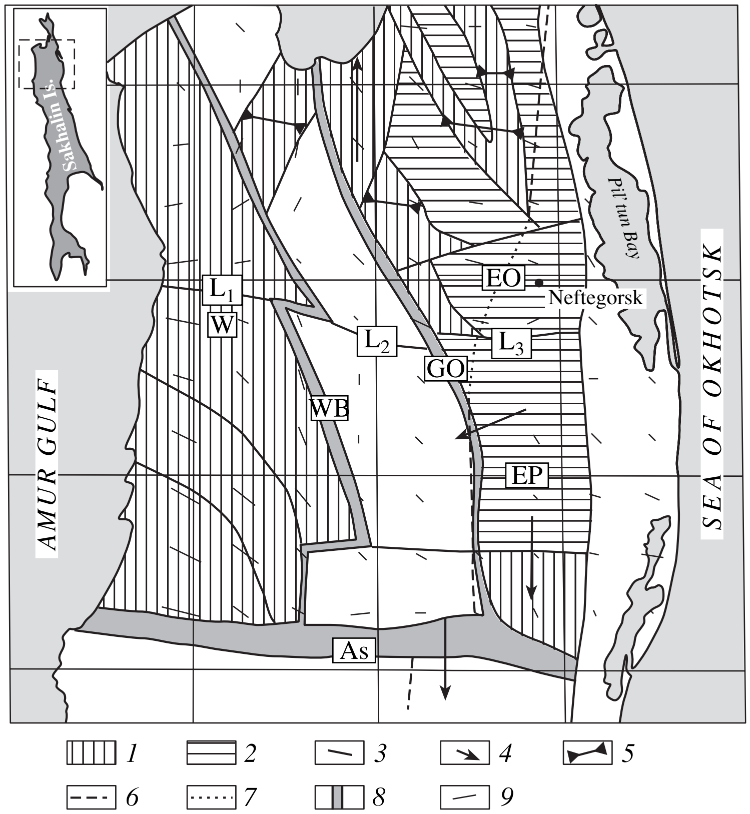

Map of local geodynamics of northern Sakhalin. (*1*) Compression zones, (*2*) extension zones, (*3*) prevalent orientation of lineaments (prevalent orientation in compression zones; rose diagrams are isotropic in extension zones; length of dash is proportional to the vector sum in rose diagrams; under extension, this sum is close to zero and increases in compression zones); (*4–6*), after [1]: (*4*) direction of horizontal movements, (*5*) zones of compressive stress based on geodetic and seismic data; strike-slip faults: (*6*) Ekhabi–Pil'tun and Davyk, (7) Upper Pil'tun; (*8, 9*) boundary of blocks of the (*8*) first and (*9*) second orders. Structural units and their boundaries (letters in map). Blocks: (W) Western, (C) Central, (EO) East Okha, (EP) East Pil'tun; block boundaries: (WB) West Baikal, (GO) Gyrgylan'i–Ossoi; near-latitudinal boundaries: (L_1, L_2, L_3) segments of the Langry boundary; (As) Askasai boundary. Inset shows location of the study area.

coincides with the West Baikal Fault. This boundary controlled the tectonic evolution in the Early Cretaceous (and, probably, earlier) and limited the spreading of the lower Miocene and older strata from the east.

Morphostructural features of northern Sakhalin are distinguished by two near-latitudinal boundaries—the northern Langry boundary, which crosses the Western, Central, and Eastern blocks, and the southern Askasai boundary. The Langry boundary passes along latitudinal segments of the Novye Langry and Mukhto rivers. This boundary controls the field of the lower Miocene clayey sediments in the south and north in the western and central areas, respectively. It is suggested that near-latitudinal strike-slip movements in the early and middle Miocene displaced the middle parts of the Western and Central blocks. Consequently, they were separated into northern and southern miniblocks. Judging from the age of crosscut rocks, the near-latitudinal Askasai boundary is younger. Similar strike-slip displacements may also have taken place along this boundary.

The NW-trending Gyrgylan'i–Ossoi boundary, which divides the Eastern and Central Blocks, coincides with the eponymous fault, which may have been formed later than the above-mentioned faults (probably in the middle to late Miocene). This fault extends for 100 km or more from the southern Baikal Bay to the latitude of the Val River.

In general, the pattern of blocks with different geodynamic stresses is simple and internally consistent: compressive stress prevails in the western island, and tensile stress dominates in the east. The central transitional zone does not reveal any specific geodynamic regime.

Calculation of the prevalent orientation of lineaments (anisotropy of rose diagrams) has shown that latitudinal and near-latitudinal lineaments sharply predominate in blocks, with compression prevailing. Blocks dominated by tensile stress usually do not demonstrate a prevailing orientation of lineaments. The minor prevalence of a certain type of strike recorded in some places is unstable. The orientation may drastically differ in adjacent segments; i.e., the prevalent strike of lineaments (and structures) is not formed in extension-dominated blocks. This is consistent with modeling results. Our map of local geodynamic stresses in northern Sakhalin is in good agreement with geodynamic reconstructions reported in [2]. The compression zone in the north indicated by maximum seismic wave velocity exactly coincides with the compression-dominated blocks identified on the basis of geodynamic interpretation of the linear landform pattern. Comparison of the map obtained with positions of the major faults in northern Sakhalin [2] showed that most segments of the Upper Pil'tun, Ekhabi–Pil'tun, and Gorel'sky strike-slip faults coincide with the boundaries of blocks with different geodynamic regimes. However, some fragments of the East Pil'tun Fault coincide with the central parts of blocks, although coincidence of their positions with the boundaries of blocks would have been more natural. The above data reflect the complex internal structure of strike-slip faults. In reality, their configuration is far from the rectilinear type commonly depicted on maps.

Thus, we can draw the following conclusions: (1) the stress state of the Earth's crust in northern Sakhalin is reflected in the modern lineament pattern, and (2) at least part of the lineaments existed for a long time (since the Early Cretaceous or probably earlier).

REFERENCES

1. V. E. Khain and M. G. Lomize, *Geotectonics with Principles of Geodynamics* (Mosk. Gos. Univ., Moscow, 1995) [in Russian].
2. S. M. Saprygin, V. E. Kononov, and V. N. Senachin, Dokl. Earth Sci. **398**, 1043 (2004) [Dokl. Akad. Nauk **398**, 538 (2004)].
3. S. M. Saprygin, V. E. Kononov, and V. S. Rozhdestvenskii, Dokl. Earth Sci. **386**, 870 (2002) [Dokl. Akad. Nauk **386**, 544 (2004)].
4. V. V. Kharakhinov, Yu. S. Mavrinskii, S. D. Gal'tsev-Bezhyuk, et al., in *Tectonics of Siberia* (Nauka, Novosibirsk, 1980), Vol. 9, pp. 95–102 [in Russian].
5. S. I. Sherman, K. Zh. Seminskii, S. A. Bornyakov, et al., *Faulting in the Lithosphere: Shear Zones* (Nauka, Novosibirsk, 1991) [in Russian].
6. S. I. Sherman, K. Zh. Seminskii, S. A. Bornyakov, et al., *Faulting in the Lithosphere: Extension Zones* (Nauka, Novosibirsk, 1992) [in Russian].
7. S. I. Sherman, K. Zh. Seminskii, S. A. Bornyakov, et al., *Faulting in the Lithosphere: Compression Zones* (Nauka, Novosibirsk, 1994) [in Russian].
8. S. Calassou and I. Moretti, Mar. Petrol. Geol. **20**, 1 (2003).
9. M. Panien, I. Moretti, and S. Galassou, Oil Gas Sci. Technol. **56**, 319 (2001).