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Neotectonic activity and parameters of seismotectonic deformations of seismic belts in Northeast Asia

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ABSTRACT

The Arctic-Asian and Okhotsk-Chukotka seismic belts bordering the Kolyma-Chukotka crustal plate are the subject of our study aimed at reconstructing the stress–strain state of the crust and defining the types of seismotectonic deformation (STD) in the region. Based on the degrees of activity of geodynamic processes, the regional principles for ranking neotectonic structures were constrained, and the corresponding classes of the discussed neotectonic structures were substantiated. We analyzed the structural tectonic positions of the modern structures, their deep structure parameters, and the systems of active faults in the Laptev, Kharaulakh, Koryak, and Chukotka segments and Chersky seismotectonic zone, as well as the tectonic stress fields revealed by tectonophysical analysis of the Late Cenozoic faults and folds. From the earthquake focal mechanisms, the average seismotectonic strain tensors were estimated. Using the geological, geostructural, geophysical and GPS data, and corresponding average tensors, the directions of the principal stress axes were determined. A regularity in the changes of tectonic settings in the Northeast Arctic was revealed.

1. Introduction

The aim of our study is to constrain the dynamics of formation of neotectonic structures and define the tectonic types of the crustal stress-strain state in the focal zones of strong earthquakes in the Kolyma-Chukotka crustal plate. This plate was recognized by Gusev as an independent tectonic taxon in the recently published map of the tectonic zoning of Russia (scale 1:10,000,000) (Gusev et al., 2016). It is the frontal western block of the North American plate in the interaction zone with the Eurasian lithospheric plate. In the east, it is in contact with the small Bering lithospheric plate (Fig. 1). The section in Fig. 2 shows the deep structure, deformation types of tectonic structures, and the main tectonic taxa in Northeast Asia. The perimeter of the Kolyma-Chukotka crustal plate is clearly marked by the active structures of the Arctic-Asian and Okhotsk-Chukotka seismic belts. In the area that this plate interacts with other tectonic taxa, a number of segments have specific parageneses of active structures, for which the kinematic types depend on the tectonic setting of the state of crustal stresses.

In this paper, we consider the following active structures of the Arctic-Asian seismic belt: the spreading Gakkel ridge; the system of rift basins in the Laptev Sea shelf; and the Chersky seismotectonic zone. The Koryak and Chukotka segments of the Okhotsk-Chukotka seismic belt are also discussed. The structural tectonic positions of these areas, deep structure parameters, and systems of active faults were analyzed on the basis of the regional field observations and materials published by our team and other researchers. Seismotectonic strain tensors were estimated from the earthquake focal mechanisms. The algorithm of our study allowed us to constrain the tectonic positions and structural dynamic pattern of the main fields of earthquake hypocenters in the study area, and to identify zones with different tectonic settings of the crustal stress-strain state. Having consolidated these results, we propose a regional structural-dynamic model of the main seismogenerating structures in the Northeast Arctic.

2. Methods of research

2.1. Geodynamic activity of neotectonic structures

The need to analyze the contemporary (Late Cenozoic) structures of the study area is based on the fact that the present day tectonics is the structural framework that encompasses active faults and other recent tectonic activity related to the regional seismicity. The regional principles used to classify the neotectonic structures of the northeastern sector of the coastal shelf in the Russian Arctic region were developed

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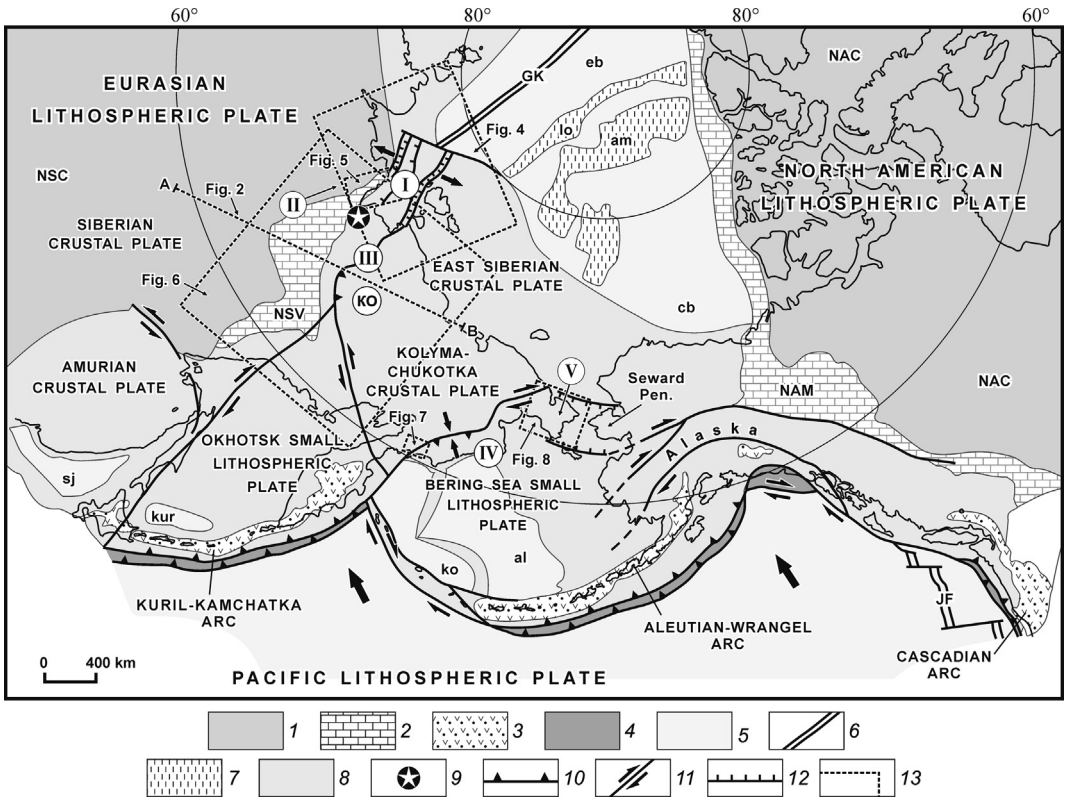

Fig. 1. Recent geodynamics and kinematics of plates in the Northeast Arctic (modified from Nokleberg et al., 2000; Tectonics, Geodynamics, and Metallogeny of the Territory of the Sakha (Yakutia) Republic, 2001). *1* – cratons: NSC – North Asian, NAC – North American; *2* – subsided margins of cratons (fossil passive continental margins): NAM – North American craton, NSV – North Asian craton (Verkhoyansk fold-thrust belt); *3* marginal continental and island magmatic arcs; *4* – accretionary wedges; *5* – oceans and basins with oceanic crust: eb – Eurasian basin, cb – Canadian basin, al – Aleutian basin, ko – Commander basin, sj – Sea of Japan, kur – South Kuril basin; *6* – mid-oceanic ridges: GK – Gakkel Ridge, JF – Ridge Juan de Fuca; *7* – intra-oceanic uplifts: lo – Lomonosov Ridge, am Alpha and Mendeleev ridges; *8* – collage of accreted terranes; *9* – location of the pole of rotation of the Eurasian and North American plates; *10* – thrusts; *11* – boundaries of plates with different directions of relative displacements; *12* – normal faults; *13* – boundaries and location of the figure. Segments of the Arctic–Asian seismic belt: I – Laptev, II – Kharaulakh, III – Chersky seismotectonic zone. Segments of the Okhotsk-Chukotka seismic belt: IV – Koryak, V – Chukchi. KO – Kolyma–Omolon block.

with regard to the degrees of activity and trends of geodynamic processes, and classes of neotectonic structures were substantiated (Gusev et al., 2016).

In our study, a domain is a neotectonic geodynamic spatial taxon of the territorial rank, which is considered an integral object with a specific location. Its main components show the multi-factor interaction features in the geological and geophysical profiles of the crust. We use the terms ‘domain’ and ‘neotectonic structure’ synonymously, and a

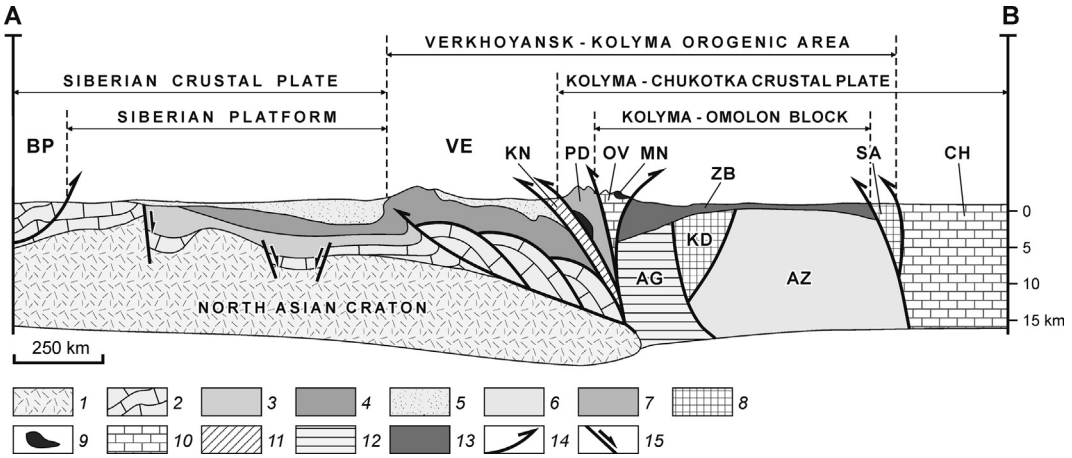

Fig. 2. Principal geological section of the main tectonic zones, Northeastern Asia (according to Tectonics, Geodynamics, and Metallogeny of the Territory of the Sakha (Yakutia) Republic, 2001). The line of this cross-section is shown in Fig. 1. *Northern Asian craton. 1* – Precambrian crystalline basement. Sedimentary and volcanogenic-sedimentary cover; *2* – Vendian – Early Paleozoic, predominantly carbonate sediments, and clastic and carbonate Riphean deposits in some locations at the base; *3* – Middle Devonian – Early Carboniferous sedimentary-volcanogenic riftogenic formations; *4* – Carboniferous and Permian clastic sediments; *5* – Mesozoic clastic sediments (BP – Baikal-Patom fold-thrust belt, VE – Verkhoyansk fold-thrust belt). *Collage of terranes in the Verkhoyansk-Kolyma orogenic area. 6* – island-arc terrane (Az – Alazeya); *7* – terrane of the A-type accretion wedge composed mainly of turbidites (PD – Polousno-Debinsky); *8* – terrane of the B-type accretion wedge composed mainly of oceanic rocks (KD – Kenkeldinsky, SA – South Anyuiskiy); *9* – ophiolite terrane (MN – Munilkansky); *10* – myogeosynclinal terrane of the passive continental margin (OV – Omulyovsky, CH – Chukotsky); *11* – turbidite terrane at the foot of the continental margin (KN – Kular-Nersky); *12* – turbidite terrane (AG – Arga-Tassky); *13* – Upper Jurassic – Cenozoic post-amalgamation and post-accretion formations (ZB – Zyriansky trough); *14* – thrusts; and *15* – normal faults.