
GEOLOGY

A New Electronic Map of Active Faults for Southeastern Siberia

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One of the key problems concerning the assessment of seismic hazard and regularities in the seismotectonic process is connected with the unavailability of electron cartographic projects, which would integrate various information sources at the level of advanced technologies. The purpose of this communication consists in gathering, organizing, and critical interpretation of geological–structural, geophysical, hydrogeological, paleoseismological, and seismological data integrated with field mapping, interpretation of topographic maps (1: 200 000), digital models of the relief (SRTM-90), and bathymetric maps [1, 2] selected for the test area. Such studies in the area with coordinates of 100°–114° E and 50°–57° N resulted in development of a new electronic map of faults that which were active during the Neogene–Quaternary, for southeastern Siberia and a corresponding database, which contains data on known parameters of faults and indications of their activity. The structure of the database was developed and published earlier [3]. It should be noted that we used in this work the original data on >900 points of structural–geological observations, the regional catalog of earthquakes compiled at the Baikal Branch of the Geophysical Survey (Siberian Branch, Russian Academy of Sciences) (<http://www.seis-bukl.ru>), series of maps, and 48 publications with descriptions of faults and necessary corresponding information [4–15, and others].

The electronic map includes 1218 faults consisting of 1808 segments. Among them, 765 fractures are proved and 1043 are hypothetical (Figs. 1, 2). Their distinct reflections in the surface topography in form of scarps, linear valley, or lineaments of the hydrographic network (a series of small similar elements) were accepted as a criterion for fault defining.

The structures were considered as proved when they were confirmed by at least one of the following direct indications: fracture zones and/or well developed (principal) system of fissures of a certain strike in compact and/or poorly lithified (incoherent) rocks, seismogenic deformations, linear arrangement of earthquake epicenters with $K_p \geq 10$ along the assumed fault, fault planes documented by underwater devices, and seismoacoustic data on displacement of sediments. In exceptional situations, the active fault interpreted from geological–structural observations could be indistinguishable in the surface topography and river network. The indirect engineering–geological, hydrogeological, and geophysical indications of activity were also used as additional criteria for substantiating the assumed fault.

Most fractures in the map are oriented at 40°–70° N. The minimal and maximal lengths of segments are 1 and 329 km, respectively. Most of the fractures extend for <25 km. Electronic map of the active faults and its fragments in raster form as well as shp-failes presenting fault information are available at the site <http://lab.crust.irk.ru/proekt/pages/maps.htm>. With the advent of additional information, the map of active faults and accompanying information should be updated in the online regime.

The compiled database represents a basis for compiling (by electronic queries) maps of active faults differing in the degree of trustworthiness (Fig. 1), kinematics (Fig. 2), activity degree (Fig. 3), and time of the last activation. The statistical parameters of completeness of the present-day database (table) indicate that the amount of knowledge on active fault tectonics in southeastern Siberia, as well as the interrelated geodynamic processes and phenomena, is still insufficient. The available data indicate that active segments of fractures in the study test area are dominated by normal faults, with the subordinate share of downdip–strike-slip and strike-slip–downdip faults. Third in abundance are strike-slip faults. An insignificant share of fractures is represented by reversed and updip–strike-slip faults. This conclusion is natural, since

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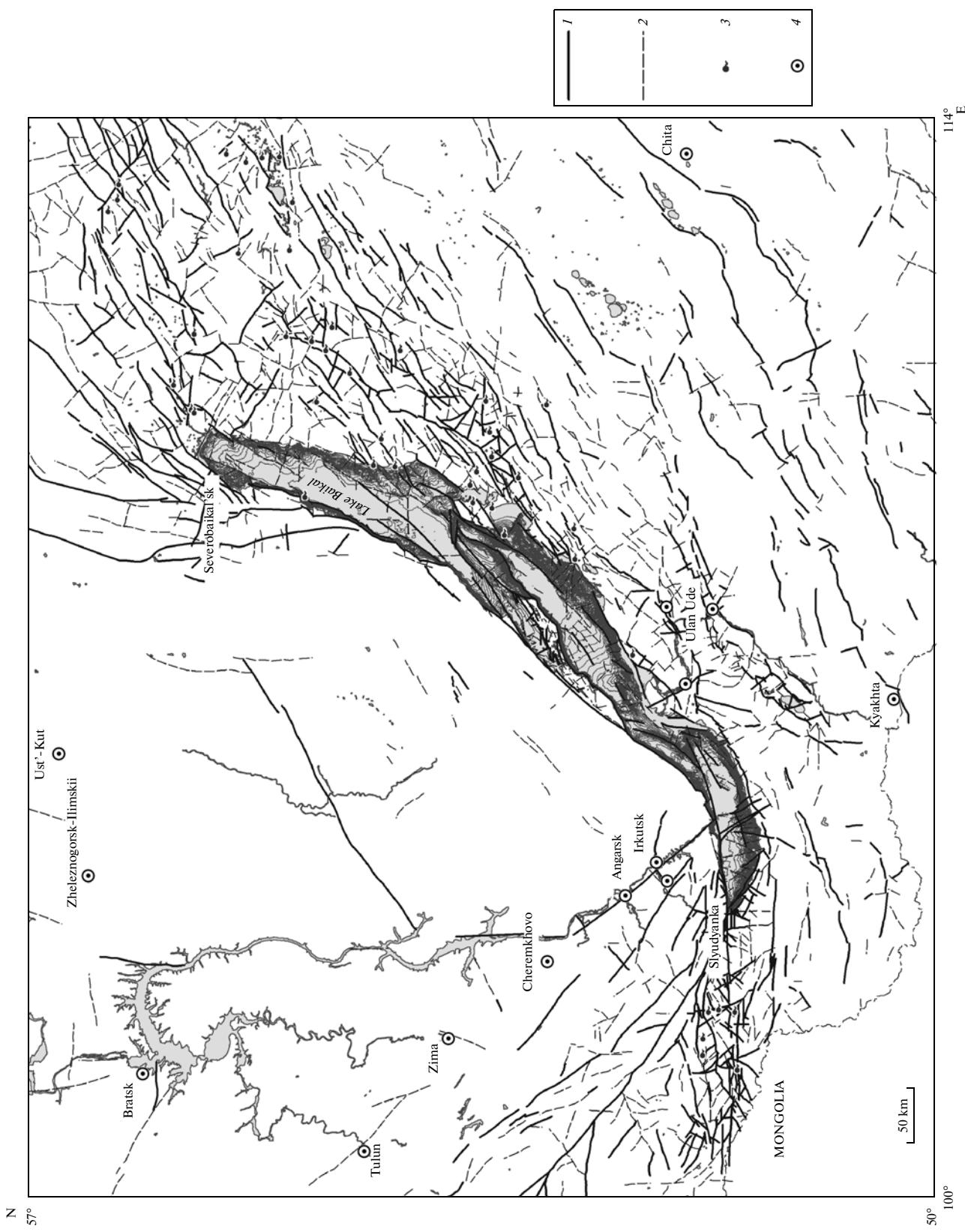


Fig. 1. The electronic map of active faults for southeastern Siberia (the basic part of the computer project). (1) Proved faults; (2) assumed faults; (3) thermal and subthermal springs with a high yield; (4) most significant settlements.

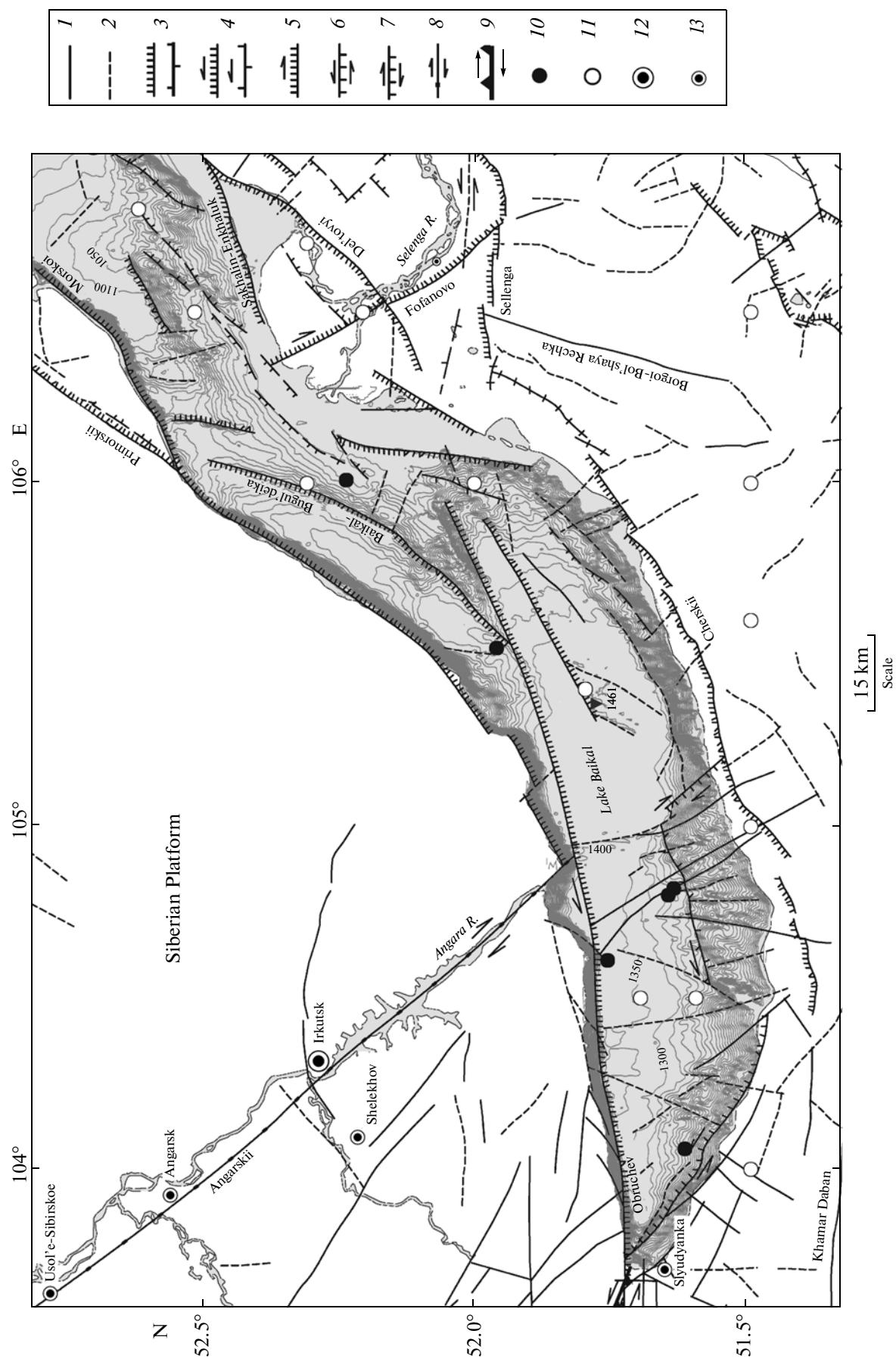


Fig. 2. Processed fragment of the electronic map with active faults in southeastern Siberia differentiated according to their trustworthiness and kinematics. Faults: (1) proved, (2) assumed; kinematic types: (3) normal faults; (4) left-lateral strike-slip–down-dip faults, (5) right-lateral strike-slip–downdip faults, (6) left-lateral downdip–strike-slip faults, (7) right-lateral downdip–strike-slip faults, (8) right-lateral up-dip–strike-slip faults, (9) left-lateral up-dip–strike-slip faults; earthquakes with $M \geq 5.5$: (10) documented by instrumental observations for the period of 1950–2009 (according to regional catalogue of BFGS SB RAS, <http://wwwseis.bfkl.ru>), (11) data taken from doctoral thesis by A.V. Chipozubov; settlements: (12) regional centers, (13) other settlements.

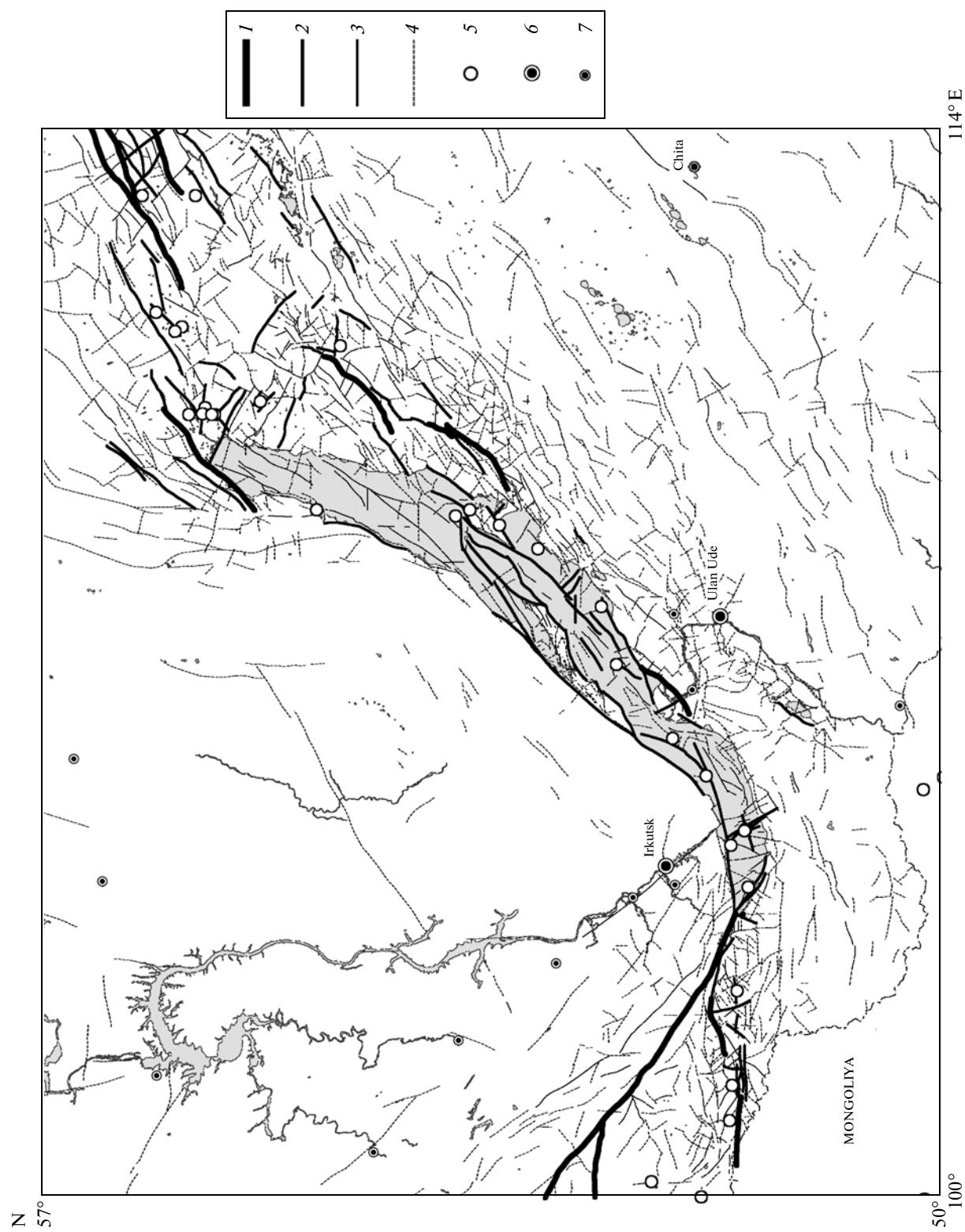


Fig. 3. The electronic map with active faults of southeastern Siberia differentiated according to their activity calculated in line with the technique in [10]. (1–4) Faults with the different degrees of activity: (1) high (21–30 points), (2) medium (11–20 points), (3) elevated (11–20 points), (4) low (6–10 points); (5) earthquakes with $M \geq 5.5$ documented by instrumental observations for the period of 1950–2009; (6) regional centers; (7) other settlements.

Statistical parameters of the completeness degree of the database for Neogene–Quaternary faults in southeastern Siberia (December 2009)

Characteristics	Number of faults	Share of faults, %
Time of last activation		
Historical	23	1
Holocene	40	2
Quaternary	65	4
Neogene–Quaternary	1680	93
Fault kinematics		
Normal fault	328	71
Left-lateral strike-slip–downdip fault	26	17
Right-lateral strike-slip–downdip fault	18	
Left-lateral downdip–strike-slip fault	23	
Right-lateral downdip–strike-slip fault	13	
Left-lateral updip–strike-slip fault	7	2
Right-lateral updip–strike-slip fault	1	
Left-lateral strike-slip–updip fault	0	
Right-lateral strike-slip–updip fault	0	
Left-lateral strike-slip fault	29	8
Right-lateral strike-slip fault	10	
Reverse fault	7	2
Type unclear	1346	—
Fault activity degree		
Minimal value in the database: 1	—	—
Average value in the database: 2.95	—	—
Maximal value in the database: 30	—	—
Weak (1–5 points)	1417	78
Medium (6–10 points)	289	16
Elevated (11–20 points)	90	5
High (21–30 points)	12	1

Note: The activity degree of the fault segment is calculated in line with the technique described in [10].

most of the mapped Neogene–Quaternary faults are localized in the Baikal Rift zone.

The percentage of faults with different kinematics in southeastern Siberia shown in the table is consistent with previously established proportions of different stress tensors (under the condition that percentage contributions of normal faults with extension, downdip–strike-slip, and strike-slip–downdip faults with extension are compared with strike-slip faults) constituting the structure of the crust strain fields in different areas of the Baikal rift zone (Table 5.1 in [10]). A substantial difference consists in the greater contribution of normal faults (71%, table) as compared with local strain fields reflecting extension (51–57%) derived from fissuring and seismological data for the particular

area (Table 5.1 in [10]). This again indicates significant heterogeneity and variability of the strained crust state in fault zones.

It is of significance that the proportions of faults with different degrees of activity calculated independently for southeastern Siberia (table) using the new database and previously estimated for its separate areas (Table 3.11 in [10]) coincide with each other. The present-day knowledge of the area with coordinates of 100°–114° E and 50°–57° N allows us to define only an insignificant share (6%) of the proved and assumed fault segments (Fig. 3) representing a potential hazard with regard to tectonic, seismic, and engineering–geological processes, which are dangerous for the health of the population, ecology, and economics. These are disjunctive fractures with an elevated and high degree of activity. In other fault zones, the relative intensity of movements is substantially lower. At the same time, precisely the whole system of active fractures determines the structure of the geological medium and, consequently, its permeability for fluids as well as the distribution of seismic waves, anomalous geophysical fields, and dangerous natural and technogenic phenomena.

The new electronic map of active faults in southeastern Siberia may be used for different seismotectonic and geodynamic reconstructions, applied maps for prediction of dangerous natural processes related to crustal destruction included. Combined with the database, it represents reliable grounds for gathering information, its tectonophysical analysis, and development of other cartographic projects, which will allow peculiar features of the seismo-tectonic process in southeastern Siberia to be better understood.

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