Geoscience Frontiers 5 (2014) 605–619

Contents lists available at ScienceDirect

China University of Geosciences (Beijing)

Geoscience Frontiers

journal homepage: www.elsevier.com/locate/gsf

Focus paper

Southern East Siberia Pliocene–Quaternary faults: Database, analysis and inference

Oksana V. Lunina [a,*], Riccardo Caputo [b], Anton A. Gladkov [a], Andrey S. Gladkov [a]

[a] Institute of the Earth's Crust, Siberian Branch of Russian Academy of Sciences, Lermontova Street 128, 664033 Irkutsk, Russia
[b] University of Ferrara, Department of Physics and Earth Sciences, Via Saragat 1, 44122 Ferrara, Italy

ARTICLE INFO

Article history:
Received 26 April 2013
Received in revised form
3 December 2013
Accepted 16 December 2013
Available online 17 January 2014

Keywords:
Pliocene–Quaternary faults
Database
Seismic hazard
Tectonics
Southern East Siberia

ABSTRACT

This paper presents the first release of an Informational System (IS) devoted to the systematic collection of all available data relating to Pliocene–Quaternary faults in southern East Siberia, their critical analysis and their seismotectonic parameterization. The final goal of this project is to form a new base for improving the assessment of seismic hazard and other natural processes associated with crustal deformation. The presented IS has been exploited to create a relational database of active and conditionally active faults in southern East Siberia (between 100°–114° E and 50°–57° N) whose central sector is characterized by the highly seismic Baikal rift zone. The information within the database for each fault segment is organized as distinct but intercorrelated sections (tables, texts and pictures, etc.) and can be easily visualized as HTML pages in offline browsing. The preliminary version of the database distributed free on disk already highlights the general fault pattern showing that the Holocene and historical activity is quite uniform and dominated by NE–SW and nearly E–W trending faults; the former with a prevailing dip-slip normal kinematics, while the latter structures are left-lateral strike-slip and oblique-slip (with different proportion of left-lateral and normal fault slip components). These faults are mainly concentrated along the borders of the rift basins and are the main sources of moderate-to-strong ($M \geq 5.5$) earthquakes on the southern sectors of East Siberia in recent times. As a whole, based on analyzing the diverse fault kinematics and their variable spatial distribution with respect to the overall pattern of the tectonic structures formed and/or activated during the late Pliocene–Quaternary, we conclude they were generated under a regional stress field mainly characterized by a relatively uniform NW–SE tension, but strongly influenced by the irregular hard boundary of the old Siberian craton. The obtained inferences are in an agreement with the existing models of the development of the Baikal region.

1. Introduction

The study of Pliocene–Quaternary faults is crucial for a better assessment of the seismic hazard and other natural processes associated with crustal deformation. Moreover, a better knowledge about faults promotes the development of geodynamic conceptions on the general formation mechanisms and the evolution of specific structural elements in mobile belts. In order to effectively use this knowledge, specific databases containing active or conditionally active faults have been created in several countries (Valensise and Pantosti, 2001; GNS Science Ltd, 2004; U.S.G.S, 2006; A.I.S.T, 2007; Basili et al., 2008, 2009, 2013; Caputo et al., 2012, 2013; Yu et al., 2012). In Russia, the first experience devoted to the elaboration of a digital map and a database of active faults was carried out by Ioffe et al. (1993), Trifonov and Machette (1993), Ioffe and Kozhurin (1996), Trifonov (1997, 2004), Trifonov et al. (2002).

It is worth to note that an active fault is defined as one which has moved in recent geological time and is considered likely to move again in the future (GNS Science Ltd, 2004). Although there are different opinion on the definition of "recent geological time" (Allen, 1975; Vita-Finzi, 1986; Nikonov, 1995; Trifonov, 2004), we believe it is corresponding to the Quaternary period followed by the

* Corresponding author. Tel.: +7 3952 424759; fax: +7 3952 426900.
E-mail addresses: lounina@crust.irk.ru, lounina@inbox.ru (O.V. Lunina).

Peer-review under responsibility of China University of Geosciences (Beijing)

Production and hosting by Elsevier

1674-9871/$ – see front matter
http://dx.doi.org/10.1016/j.gsf.2013.12.006

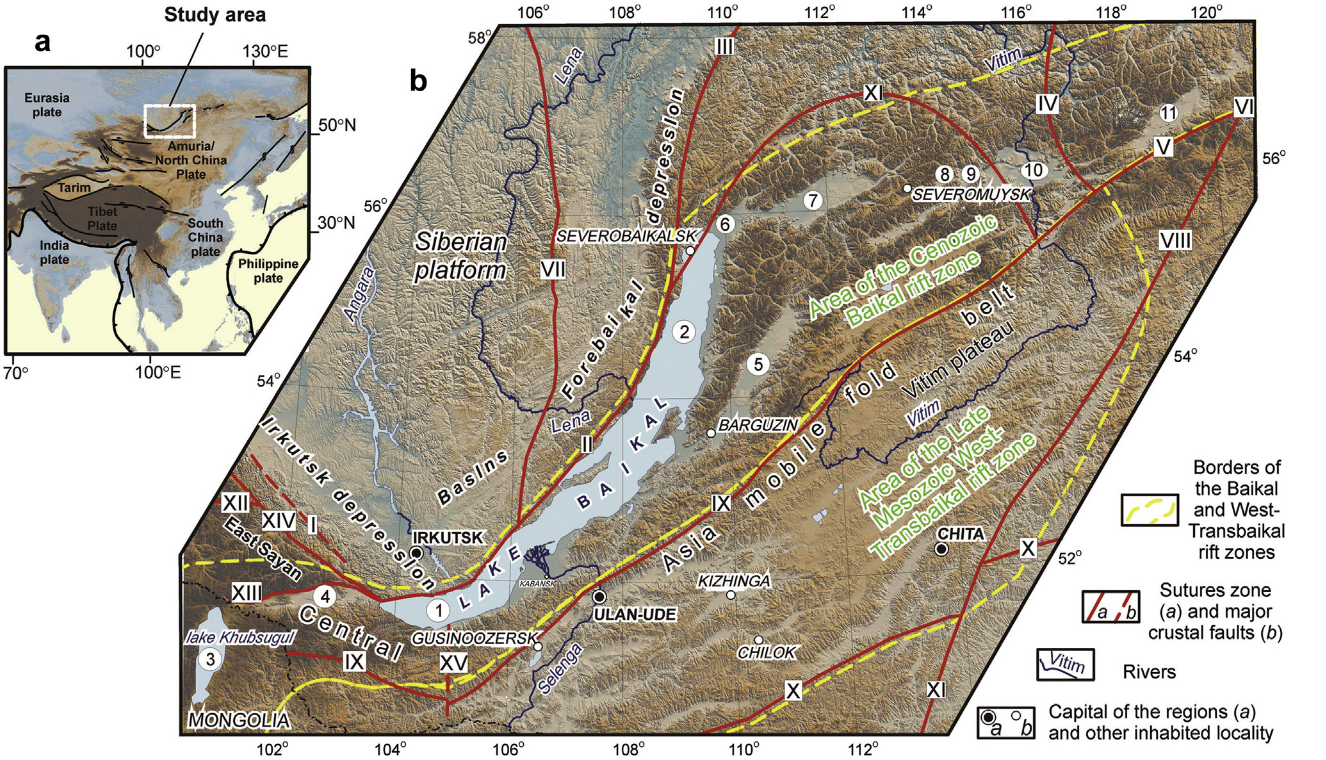

Figure 1. Topography and principal tectonic elements of the Asia (**a** – faults after Petit and Deverchere, 2006) and southern sector of East Siberia (**b** – faults after Khrenov, 1982). Roman numbers refer to the segments of marginal suture zones of the Siberian platform (I: Main Sayan, II: Pribaikalsky, III: Akitkan-Dzherbin, IV: Zhuin, V: Kalar, VI: Stanovoy), other structural sutures (VII: Baikal-Taymyr, VIII: Kalarsk-Karengsky, IX: Dzhida-Vitim, X: Mongol-Okhotsk, XI: Baikal-Muya, XII: Sayan-Tuva, XIII: Tunkinsko-Khamar-Daban) and major crustal faults (XIV: Prisayan-Enisey, XV: Torey). Numbers in circle refer to the major basins within the Baikal rift zone (1: South Baikal, 2: North Baikal, 3: Khubsugul, 4: Tunka, 5: Barguzin, 6: Kichera, 7: Upper Angara, 8: Muyakan, 9: Ulan-Makit, 10: Muya, 11: Chara).

Research Group for Active Faults of Japan (1992). Some Quaternary faults with an obscure displacement history and pre-Quaternary faults which can reasonably have attributes consistent with the current tectonic regime refer to conditionally active faults (Fraser, 2001).

According to a nowadays well established approach to seismic hazard assessment (SHA), mainly based on the construction of specific databases, the collection of geological information, its critical analysis and the intercorrelation of all data by means of a dedicated software have become a standard (Haller and Basili, 2011). Indeed, SHA analyses are impelling especially in densely inhabited zones like the southern sector of East Siberia, whose central part is characterized by the highly seismic Baikal rift zone. A huge amount of geological and geophysical data on Pliocene–Quaternary faults and recent earthquakes, which represent the core information for seismotectonic and geodynamic analyses, has been collected in the past years by many researchers (Sherman et al., 1973, 2004; Solonenko, 1981; Khrenov, 1982; Solonenko et al., 1985; McCalpin and Khromovskikh, 1995; Levi et al., 1996, 1997; Delouis et al., 2002; Lunina and Gladkov, 2002, 2004, 2007, 2008; Lunina et al., 2009; Smekalin et al., 2010; references therein). However, the problem for their representation as well as for a systematic analysis was not solved. A relational database allowing to keep the information in several sections intercorrelated with field data, keywords or identifiers could certainly represent a step forward. Eventually a relational database gives the possibility of a simple and quick access using structured query language (SQL) reports and provides an increased reliability and integrity of data whose analysis could allow to get new results.

The aim of this paper is to present the first version of an Informational System devoted to the systematic collection of all available data relative to Pliocene–Quaternary faults, their critical analysis and their seismotectonic parameterization of the included structures. The IS has been exploited to create a first regional database of neotectonic faults in southern East Siberia and therefore includes both active (late Quaternary, 10 ka, 130 ka, 0.5–2 Ma by different authors) and conditionally active (up to late Pliocene) faults. This IS represents the first such attempt for the whole Russia and it could represent an important scientific tool for many researchers as well as for improving seismic hazard maps of the region.

2. Geological background

The southern sector of East Siberia includes two large structural elements: the Siberian platform and the central Asia mobile fold-belt containing both Caledonian and Baikalian folding and thrusting phases (Solonenko, 1981; Belichenko et al., 2003). In this region, the West-Transbaikal and Baikal rift zones (Fig. 1) formed during the late Mesozoic and Cenozoic, respectively. This polyphased crustal deformation is the principal cause of the complex and quite heterogenous geological setting of southern East Siberia, which includes pre-Cambrian, Paleozoic, Mesozoic and Cenozoic rocks from different geodynamic environments and undergoing different deformational events (Malich, 1999).

The late Mesozoic West-Transbaikal rift zone (Yarmoluk et al., 1995) consists of NE–SW trending basins bounded by normal faults and controlling the volcanic fields during the late Mesozoic and Cenozoic. The general extent of the zone from the head of the Selenga River to the Vitim plateau is ca. 1000 km while its width is 200 km. The first grabens started forming at the end of the early Jurassic, but the main rifting stage occurred 130–140 Ma. At