Journal of Asian Earth Sciences 62 (2013) 134–145

Contents lists available at SciVerse ScienceDirect

Journal of Asian Earth Sciences

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

Historical earthquakes studies in Eastern Siberia: State-of-the-art and plans for future

Ya.B. Radziminovich *, A.A. Shchetnikov

Institute of the Earth's Crust, Siberian Branch of Russian Academy of Sciences, Lermontov Street 128, 664033 Irkutsk, Russia

ARTICLE INFO

Article history:
Received 30 November 2010
Received in revised form 25 April 2012
Accepted 19 September 2012
Available online 4 October 2012

Keywords:
East Siberia
Lake Baikal
Historical seismicity
Earthquake
Earthquake catalogue

ABSTRACT

Many problems in investigating historical seismicity of East Siberia remain unsolved. A list of these problems may refer particularly to the quality and reliability of data sources, completeness of parametric earthquake catalogues, and precision and transparency of estimates for the main parameters of historical earthquakes. The main purpose of this paper is to highlight the current status of the studies of historical seismicity in Eastern Siberia, as well as analysis of existing macroseismic and parametric earthquake catalogues. We also made an attempt to identify the main shortcomings of existing catalogues and to clarify the reasons for their appearance in the light of the history of seismic observations in Eastern Siberia. Contentious issues in the catalogues of earthquakes are considered by the example of three strong historical earthquakes, important for assessing seismic hazard in the region. In particular, it was found that due to technical error the parameters of large $M = 7.7$ earthquakes of 1742 were transferred from the regional catalogue to the worldwide database with incorrect epicenter coordinates. The way some stereotypes concerning active tectonics influences on the localization of the epicenter is shown by the example of a strong $M = 6.4$ earthquake of 1814. Effect of insufficient use of the primary data source on completeness of earthquake catalogues is illustrated by the example of a strong $M = 7.0$ event of 1859. Analysis of the state-of-the-art of historical earthquakes studies in Eastern Siberia allows us to propose the following activities in the near future: (1) database compilation including initial descriptions of macroseismic effects with reference to their place and time of occurrence; (2) parameterization of the maximum possible (magnitude-unlimited) number of historical earthquakes on the basis of all the data available; (3) compilation of an improved version of the parametric historical earthquake catalogue for East Siberia with detailed consideration of each event and distinct logic schemes for data interpretation. Thus, we can make the conclusion regarding the necessity of a large-scale revision in historical earthquakes catalogues for the area of study.

1. Introduction

In the last few decades, considerable efforts have been made to reconstruct seismic history in many regions of the Earth using methodical approaches on disciplines ranging from instrumental observations to paleoseismological studies (Guidoboni, 2002; Caputo and Helly, 2008). Particular emphasis has been placed on the analysis of documentary historical evidence for the past earthquakes. The use of historical data significantly (sometimes by one order of magnitude) extends the timeframe for our concept of seismicity as compared to the instrumental records whose duration is at best only a little over a century. The historical materials often provide a detailed description of macroseismic manifestations, which is why large historical earthquakes may be taken into account in seismic hazard assessment. These problems are also important for East Siberia whose seismicity is mainly due to the intracontinental Baikal rift zone (BRZ) (Fig. 1). A high-level activity of the BRZ is evidenced by both historical events (e.g. the 1862 Tsagan earthquake, $M = 7.5$) and instrumentally recorded earthquakes, e.g. the 1957 Muya earthquake, $M_{LH} = 7.6$ (Kurushin and Mel'nikova, 2008).

It is agreed that the period of instrumental seismological observations in East Siberia began in 1960 with deployment of the regional seismic network (Golenetsky, 1990) though the first instrumental observations in the region formally started in December 1901 after the "Irkutsk" station had been put into operation. The observations made in the first half of the XXth century should not be considered reliable because no more than three seismic stations could be working simultaneously at that time that provided neither preliminary earthquake records nor precise earthquake parameter estimations. Nevertheless, the date when the "Irkutsk" station started operation (1901) may be considered as the upper limit of the historical period. The lower limit is determined by

* Corresponding author.
E-mail address: ian@crust.irk.ru (Ya.B. Radziminovich).

1367-9120/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jseaes.2012.09.017

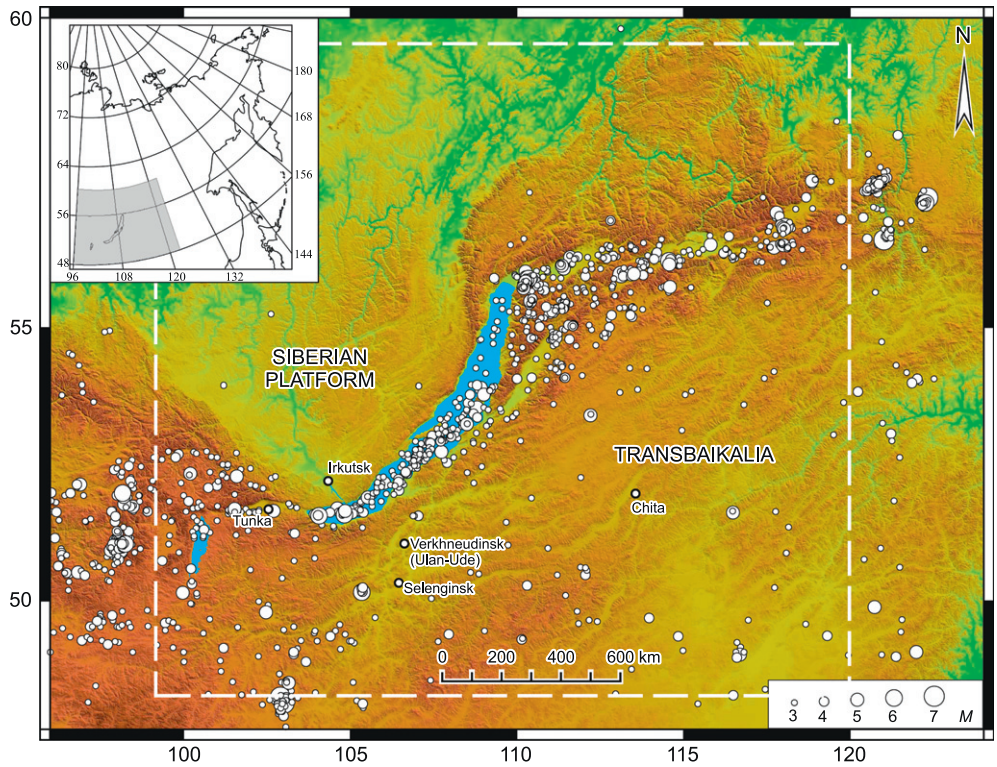

Fig. 1. Digital elevation model and seismicity of East Siberia. A white dashed contour line indicates the investigation area – "Baikal region" (48–60°N, 99–120°E) in accordance with zoning accepted in the «New catalogue...» (Kondorskaya and Shebalin, 1982). The epicenters of earthquakes presented here were recorded instrumentally between 1960 and 2008 by the Baikal Division of Geophysical Survey of Siberian Branch of Russian Academy of Sciences. Some settlements shown in Fig. 1 are important in terms of research on historical seismology in East Siberia as some of the oldest administrative centers of Siberia from which regular macroseismic information arrived.

the history of multidisciplinary explorations and investigations in Siberia, the most important of which are primarily written accounts. The duration of historical period in the seismic studies of East Siberia lasted from the late XVIIth century to the early XXth century. During this period, the number of reports of felt earthquakes gradually increased. The increase in number of reports is associated with the development of postal service in Siberia, as well as with the appearance of regional periodicals in the middle of the XIXth century. Since the beginning of the XXth century the surveys of strong earthquakes in Eastern Siberia were carried out with the mailing of questionnaires.

One of the most acute problems in the analysis of historical seismicity of East Siberia is the lack of reliability and quality of information sources. The historical part of the parametric catalogues available is generally based on information from various dissimilar sources. However, borrowing materials from one source and publishing them in another one, particularly in a foreign one, often leads to the distortion of the primary data and accumulation of errors that may have a profound impact on the analysis of results – estimation for the major source parameters of a historical earthquake. This necessitates making thorough search and revision for the original *primary sources* of the historical–seismological data.

For East Siberia, the studies of historical seismicity were made by Nikonov (1997), Golenetskii (1996a, 1996b), Chipizubov (1988, 1997, 2010) and Radziminovich and Shchetnikov (2005). Nevertheless, these studies are not sufficient to characterize historical seismicity of the region and many problems remain unsolved.

This paper provides a historical review of macroseismic information in East Siberia and presents the major data sources. The paper deals with the analysis and use of the available earthquake catalogues, related problems and probable solutions.

2. Brief history of earthquake studies in East Siberia

2.1. A period of "random" information

Seismic activity of the Lake Baikal area is known since at least the end of the XVIIth century. In the XVIIIth – the first quarter of the XIXth centuries, Siberia was rather poorly developed and sparsely populated. The settlements were generally located on the banks of large rivers. The houses that were for the most part made of wood adequately resisted earthquake motions. Stony buildings remained the exception rather than the norm for a long time.

Most of the information on earthquakes arrived occasionally from the settlements of administrative or trading importance, among them the town of Irkutsk. Founded as fortification in 1661, Irkutsk acquired the status of a town in 1686 and became an administrative center of a vast area and, therefore, a center for collection of diverse information.

Some random evidence was provided by I. Ides, a head of the diplomatic mission sent to China by Russian tsar Peter I. Ides who stayed in transit at the town of Udinsk (now Ulan-Ude) in Late March–Early April of 1693 witnessed a rather large earthquake and cited brief data about this earthquake in his travel description. This earthquake is the first rather precisely dated seismic event in East Siberia, though it is still not included in macroseismic catalogues.

In the XVIIIth – first half of the XIXth centuries, the earthquakes of Lake Baikal region were of particular interest to scientists specializing in natural environment of Siberia. Valuable materials are found in the works of Messerschmidt (1966), Georgi (1775), Gmelin (1767), Pallas (1778) and Erman (1850), and others. Their direct observations as well as purposely collected data on earlier events were used in the European and Russian macroseismic