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“Great East Siberian” Earthquake of February 1, 1725 ($M = 8.2$): Revision of the Main Parameters in the Light of Additional Data and Modern Requirements

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Abstract—The earthquake of February 1 (January 21 in the Julian Calendar), 1725 was for a long time considered not only the earliest precisely dated historical seismic event in eastern Siberia, but also the most powerful earthquake for the entire period of recorded seismic events in the region: M = 8.2 (*Novyi katalog*..., 1977). The epicenter location (Stanovoy Upland) and the magnitude of the event were assessed on the basis of very scanty historical data, as well as using paleoseismogeological information. The February 1, 1725 event received the name “The Great East Siberian” earthquake and served for decades as decisive evidence for the assessment of the seismic hazard and seismic zoning of the northeastern flank of the Baikal rift zone. However, the solution of the focal parameters in the (*Novyi katalog*..., 1977) has caused serious doubts. In this paper a newly elaborated version is proposed that is based on a detailed reevaluation of the initially known macroseismic information, as well as additional historical data that previously had not come to the attention of seismologists. As the result, a different solution of the focal parameters (51.8° N; 113.0° E, eastern Transbaikalia) and a significantly lower magnitude (M = 6.0) compared with the parameters given in (*Novyi katalog*..., 1977) were obtained. The presented solution makes us more attentive to the estimates of seismic hazard in east Transbaikalia based on historical data, as well as to the historical data themselves.

Keywords: “Great East Siberian” earthquake of 1725, historical earthquakes, paleoseismodeformation, macroseismic data, parametrical catalogs of earthquakes, eastern Siberia

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INTRODUCTION

The seismic history of Siberia still has a not inconsiderable number of insufficiently investigated, ambiguous points. This is because of the insufficiency and brevity of the data on perceptible earthquakes in the historical past. The written history of Siberia is much shorter than in many other regions of Russia, let alone the Mediterranean region and Europe as a whole. Many sources (books, private letters, and newspaper accounts) were published in foreign languages and outside Russia and in a number of cases over decades or even centuries have remained unclaimed by or unknown to native seismologists. So it is not to be wondered at that in the reconstruction of the seismic history of this vast region in the second half of the 20th century, the catalogs have proved to have omissions of events and uncertainty of estimates of the basic focal parameters of earthquakes, including large ones. Some efforts to remove these shortcomings have been undertaken in the recent two decades (Golenetskii, 1996a, 1996b, 1997; Nikonov, 1997, 2005, 2012; Nikonov, Fleifel, 2013; Mokrushina et al., 2010; Chipizubov, 2010; Radziminovich, Shchetnikov, 2005, 2008, 2010, 2011, 2013), but many seismic events of the early period still require special research.

The existing maps of the seismic zoning of Eastern Siberia are mostly based on the data on historical earthquakes. This makes us have to be especially attentive to those events by which the seismic potential and seismic activity of particular regions and large faults are estimated. One of the most outstanding and at the same time not particularly well-studied earthquakes, found in the catalogs of eastern Siberia, is the event of February 1, 1725 called the Great East Siberian earthquake (*Novyi katalog*..., 1977) (hereafter *New Catalog*). Its basic parameters were decided on the basis of the evidence of D.G. Messerschmidt and by the use of paleoseismologic data collected in the beginning of the 1860s. It has been recently accepted as the epicenter of the earthquake localized within the Stanovoy Upland (Fig. 1), and the event itself characterized as the strongest in Eastern Siberia in the entire history of seismological observations (*Zhivaya tektonika*..., 1966; *Novyi katalog*..., 1977; *Seismicheskoe*..., 1977). The magnitude was estimated as $M = 8.2 \pm 0.7$.

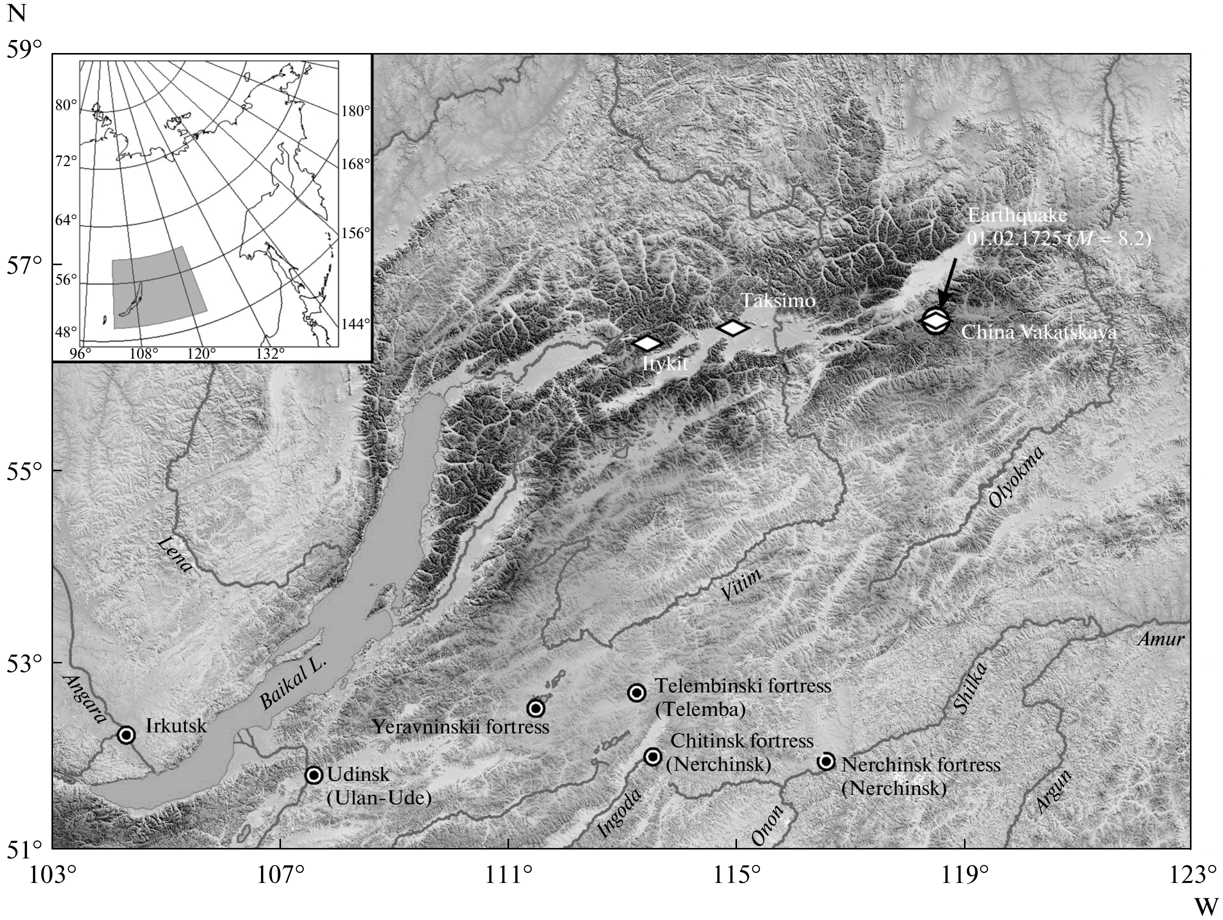

Fig. 1. Map of the study area. Settlements are denoted (in parentheses are modern names) that are relevant to the February 1, 1725 earthquake perceptibility assessment area. The inset shows the location of place of study within the eastern part of Eurasia.

Later on, doubts of the determination of the parameters arose and attempts at their redefinition were made (Ruzhich et al., 1982; Chromovskikh et al., 1993; Smekalin et al., 2010; Nikonov, 2012; Tatevosyan et al., 2012). Quite different parameters of the 1725 event have appeared, though without any explanations in the recent versions of the catalog of earthquakes of Northern Eurasia destined to provide the works of seismic zoning (Specialized..., 1995).

Since, according to the current opinion, it is the "greatest" seismic event, the problem has acquired a principal character. This work has several objects, among which are the following: 1) a careful and many-sided analysis of all facts and notions about the considered event; 2) detection of causes for appearance of mistaken solutions; and 3) an attempt at a reevaluation of the basic focus parameters of the event after clarification of the macroseismic and paleoseismogeological data.

ORIGINAL HISTORICAL DATA

The history of the February 1, 1725 earthquake investigation can be tentatively divided into two stages. In the first stage (from the eighteenth to the beginning of the 20th century), was the initial data given by D.G. Messerschmidt and their further passing from one source to another; the second stage is the second half of the 19th century, with interpretation of historical data in the seismologic aspect. Strictly speaking, the first stage cannot be taken as research, since over all this period the information was no more than repeated in publications of different kinds, including European (Perrey, 1848; Perrey, 1849; R. Mallet and J. Mallet, 1858; Milne, 1911) and Russian (Orlov, 1872; Mushketov, Orlov, 1893) catalogs of earthquakes. The historical materials were found by seismologists not earlier than the mid-1960s in preparation of a monograph devoted to the active structures and seismicity of the Stanovoy Upland (*Zhivaya tektonika*..., 1966). In its original form the macroseismic data were not given and their analysis only appeared recently (Tatevossian et al., 2013). Our study was made independently before the appearance of this publication in print, and we thought it necessary to give here all the sources with their detailed analysis.

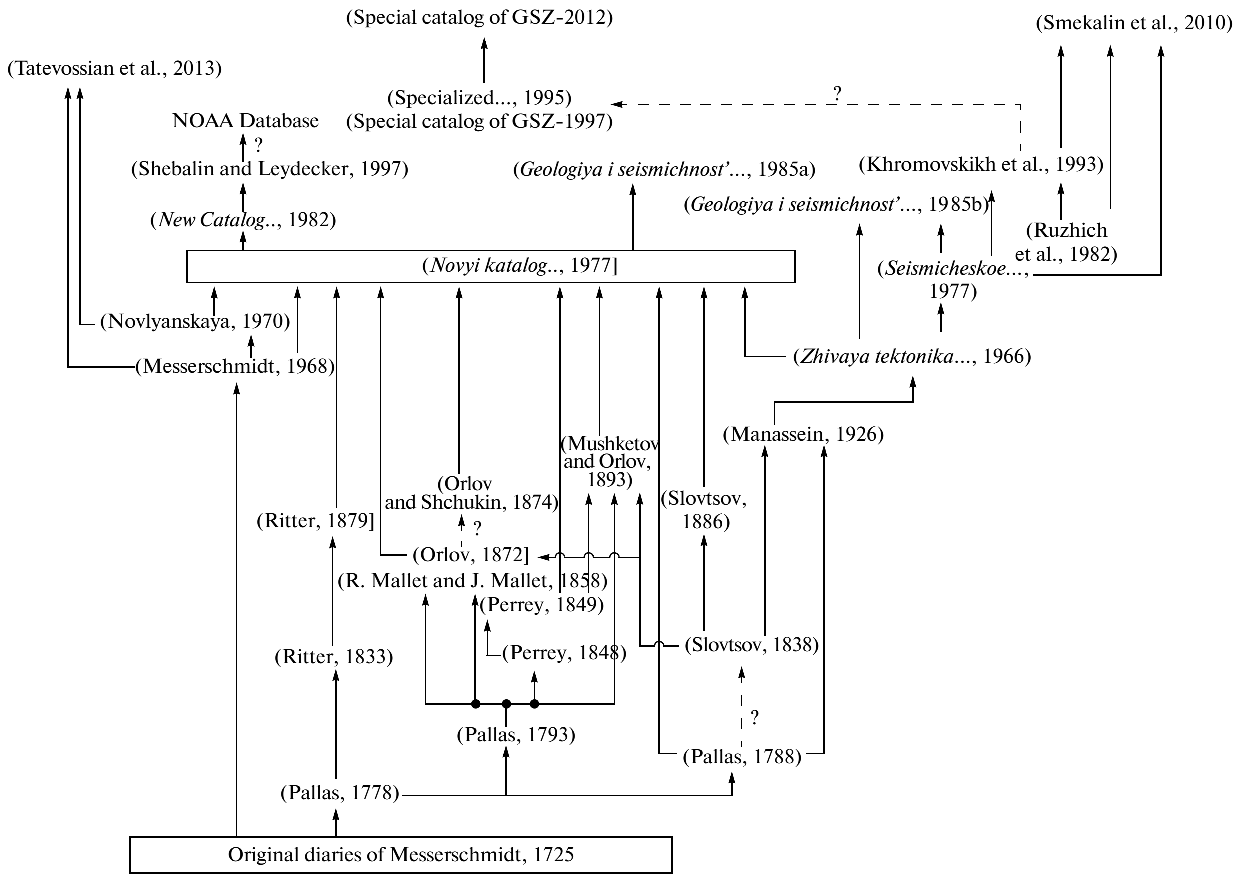

Fig. 2. Transfer of information on the February 1, 1725 event from historical sources to parametric catalogs of earthquakes.

The first and the only direct documentary account of the manifestations of the February 1, 1725 earthquake belongs to D.G. Messerschmidt, a naturalist in the service of the St. Petersburg Academy of Sciences who from 1720 to 1727 was charged with the investigation of Siberia. At the moment of the earthquake he was at the Chitinsk fortress (now city of Chita, Zabaikalskiy krai), experienced it himself and wrote his observation in the journal. The notes made by Messerschmidt were for a long time stored in archives, although they were earlier accessible to scientists taking interest in them, in particular, to P.S. Pallas. For the first time they were published not earlier than 1966–1968 in Berlin (Messerschmidt, 1968) (Fig. 2).

Some time later the data published in German were cited in fragments in the Russian translation in the monograph by M.G. Novlyanksaya devoted to the research activity of D.G. Messerschmidt in Siberia (Novlyanskaya, 1970). In this source Messerschmidt's feelings are described as follows (Novlyanskaya, 1970, pp. 101–105) (the date is given in the Julian style):

"On January 21, 1725, Messerschmidt experienced an earthquake in Chitinsk. "At 7 o'clock in evening," he writes, "in quite a calm weather a rather great earthquake began which shook the whole fortress. I was afraid that my house, which was very old, would be broken as the beams were cracking and all that was hung on the walls of the room was moving like a clock pendulum. The earliest earth vibrations took place for about a quarter of an hour, and at 7:45 everything began again to move, but slower, and for not a very long time" (III. p. 254).

Next another fragment is given which shows the area of earthquake perceptibility and some of its effects:

"Some time later, March 2, on the way to Udinsk, Messerschmidt learned that on the same day, January 21, a strong earthquake took place in Yeravnensk, Nerchinsk, and Telembinsk fortresses. Next morning the scientist examined the soil around his house and found some small splits the width of a thumb. The ice on the Chita and Ingoda rivers was heavily cracked because of the earthquake; no other traces were observed".

The macroseismic observations of Messerschmidt had been well-known long before the publication of his diaries in the second half of the 20th century. This was possible due to P.S. Pallas to whom Messerschmidt's notes had become known before and who included the fragment about the earthquake in the

Chita fortress into the description of his travel about the Russian Empire (Pallas, 1778). The works of Pallas were published first in German, later being translated also into Russian (Pallas, 1788) and French (Pallas, 1793). The text on the earthquake in the Russian publication is as follows (Pallas, 1788, p. 385):

"I was unable to find any information about previous years. Only in the diaries of late Messerschmidt I could find that in 1725, on January 21, in the evening at 7 o'clock, in Chitinsk, in the quiet period, a quake was observed, from which the both earth and ice cracked, beams crackled, and hanging things waved. In the nearest fortress on the Ingoda nothing of the kind was felt."

The earthquake was included into the Russian publication of the A. Perrey catalog with reference to the French translation of Pallas's works (Perrey, 1849):

"1725, on January 21 (Julian calendar?) at 7 o'clock in evening in Chitinsk (in the vicinity of Baikal, in Siberia) a horrible earthquake took place. Ice and soil cracked in many places. All things that were hung in homes fell, and houses cracked audibly. In the neighboring isles (Instead of "isles" one should read "fortresses"—*Authors*), situated not far from Selenga, no earthquake took place. The weather was quiet. (Pallas, voyages, vol. 4, p. 396, taken from Messerschmidt).

Then these same observations were published in A.P. Orlov's catalogs (Orlov, 1872):

"1725, on January 21, in Chita (in the Transbaikalian oblast), at 7 o'clock in evening, a terrific earthquake took place. Ice and soil cracked in many places; things that were hanging in homes fell and buildings cracked; but in the nearest fortress on the Ingoda no such thing was noted. The weather was quiet. To the west, the shaking spread even to the Selenga river (see Pallas's *Voyages*, Vol. 4, p. 396, taken from Messerschmidt). On this same day, there was an earthquake also in Irkutsk (see *Historical Review of Siberia*, by Slovtsov, Book 1, p. 539)".

Here an additional source appears, referring to the perceptibility of the earthquake in Irkutsk.

In the *Catalog of Earthquakes in the Russian Empire*, prepared for publication by I.V. Mushketov after the death of A.P. Orlov, information on the 1725 earthquake is divided into two separate notes. In the first of them information for Chita is given, in the second for Irkutsk (Mushketov, Orlov, 1893):

662. In 1725, on January 21, (Julian calendar) (February 2, according to the Gregorian calendar) at 7 o'clock in the evening, when the weather was quiet, a very strong earthquake befell Chita city in the Transbaikalia area and spread to the west to the Selenga river. Soil and ice cracked in many places, and the same thing happened to buildings; things that were hung in homes fell. At the same time, on the nearest island (Here also the word "island" should be understood as "fortress"—*Authors*) on the Ingoda river no oscillation of the terrestrial surface was observed. 663. On that same day was the earthquake in Irkutsk."

In catalogs (Orlov, 1872; Mushketov, Orlov, 1893) another, seemingly independent, source is noted—the work *Historical Review of Siberia* by P.A. Slovtsov. P.A. Slovtsov, in his short description of the seismic manifestations in Siberia, mentions an earthquake felt in Irkutsk on January 21st (Julian calendar), 1725 (Slovtsov, 1838):

"In Irkutsk there was an earthquake on January 21st, 1725 and another in May, 1742. In the latter, pipes fell from homes and an iron-tented roof fell off a church."

The Slovtsov information later had a considerable effect on the interpretation of the data about the February 1, 1725 event.

These references define the limits of the list of basic historical sources used in all solutions of the earthquake parameters.

PUBLISHED VERSIONS OF THE SOLUTIONS ON THE BASIC PARAMETERS OF THE FEBRUARY 1, 1725 EARTHQUAKE

The evaluation of seismic hazard and seismic zoning requires reliable catalogs of earthquakes covering long time periods. For the territory of the former USSR, the official source of parametric data is the basic *New Catalog* (1977). The regional section "Baikal" of this catalog includes the mention of many (but far from all) historical earthquakes of Eastern Siberia for which the compilers thought it possible to quantify the source parameters.

By the time of the preparation and issue of the *New Catalog*, the February 1, 1725 earthquake had been already thought of as one of the strongest in Eastern Siberia over the whole history of the region (*Zhivaya tektonika*..., 1966). The quantification of its basic parameters based on rather scarce information was included in the catalog (although only preliminarily, which was indicated by the compilers both in words and use of brackets) and thus received the official status. Due to the high evaluation of the magnitude, $M_{LH} = (8.2) \pm 0.7$, the parameters of the February 1, 1725 earthquake determined the seismic potential of the active structures within the Northeastern flank of the Baikal rift zone (BRZ) for a long time, and they have had a decisive effect for all works on the seismic zoning of the territory to the Northeast from lake Baikal.

At present, however, the problem of the magnitude and epicenter of the February 1, 1725 earthquake cannot be thought of as solved in the current version of the basic catalog. Since the publication of the *New Cata-*

Table 1. Resolution of the basic parameters of the February 1, 1725 earthquake in different sources

Date	Time, h	Coordinates of epicenter		h, km	M	I_0	Spatial or structural position	Source
		φ, N	λ, E					
February 2, 1725		56.5	118.5			11	Stanovoy Upland, China–Vakatskaya structure	(*Zhivaya tektonika*..., 1966)
February 1, 1725	11 ± 1	(56.5) ± 0.5	(118.5) ± 5.0	0–50	(8.2) ± 0.7	(11) ± 1	China–Vakatskaya structure	(*Novyi katalog*..., 1977 *New Catalog*..., 1982)
February 1, 1725	11	56.5	118.5		≥8.0	11–12	China–Vakatskaya structure	(*Seismicheskoe*..., 1977)
February 1, 1725		(56.5)	(118.5)		(8.2)			(*Geologiya i seismichnost'*..., 1985a)
February 1, 1725	11	56.5	118.5	0–50	8.3	11–12	China–Vakatskaya structure	(*Geologiya i seismichnost'*..., 1985b)
February 1, 1725	11	56.5	118.5	50	8.2	11		(Shebalin and Leydecker, 1997)
February 1, 1725	11	56.5	118.5	50	8.2	11		NGDC NOAA (http://www.ngdc.noaa.gov/hazard/earthqk.shtml)
1725		56.42	114.95		6.9		Taksimo structure	(Khromovskikh et al., 1993)
1725		56.27	113.45	15	6.6		Itykit structure	(Specialized..., 1995)
1725 (?)		56.42	114.97		7.4–7.9		Taksimo structure	(Smekalin et al., 2010)
February 1, 1725							Region of Chita city	(Nikonov, 2012)
February 1, 1725		52.3	114.2		6.8 ± 0.2		Eastern Transbaikalia	(Tatevossian et al., 2013)

The epicenter coordinates from the source (Tatevossian et al., 2013) are restored by illustration and are somewhat tentative.

log, new information has obtained and the possibility has appeared for essentially different solutions. The number of such variants of the solution of basic parameters includes the solution from the newest version of the *Specialized Catalog of Earthquakes*, destined for creation of maps of seismic zoning in Russia (Ulomov, 2013). The comparison of the known versions of the focus parameters of the February 1, 1725 earthquake discloses their essential difference (Table 1, Fig. 3). This situation can hardly be taken as acceptable since the lack of a solution unified and substantiated by reliable data makes it difficult or even impossible to give adequate estimates of the seismic danger of the territory of Eastern Siberia. Here we will attempt to analyze various versions of the formerly accepted placement of the epicenter of the February 1, 1725 earthquake, accentuating the chains of sources and logic schemes used by different authors.

THE BRZ NORTHEASTERN FLANK, STANOVOY UPLAND, M = 8.2

The variant of the solution of the basic focus of the February 1, 1725 earthquake in the *New Catalog* holds a special place because of the amount of information

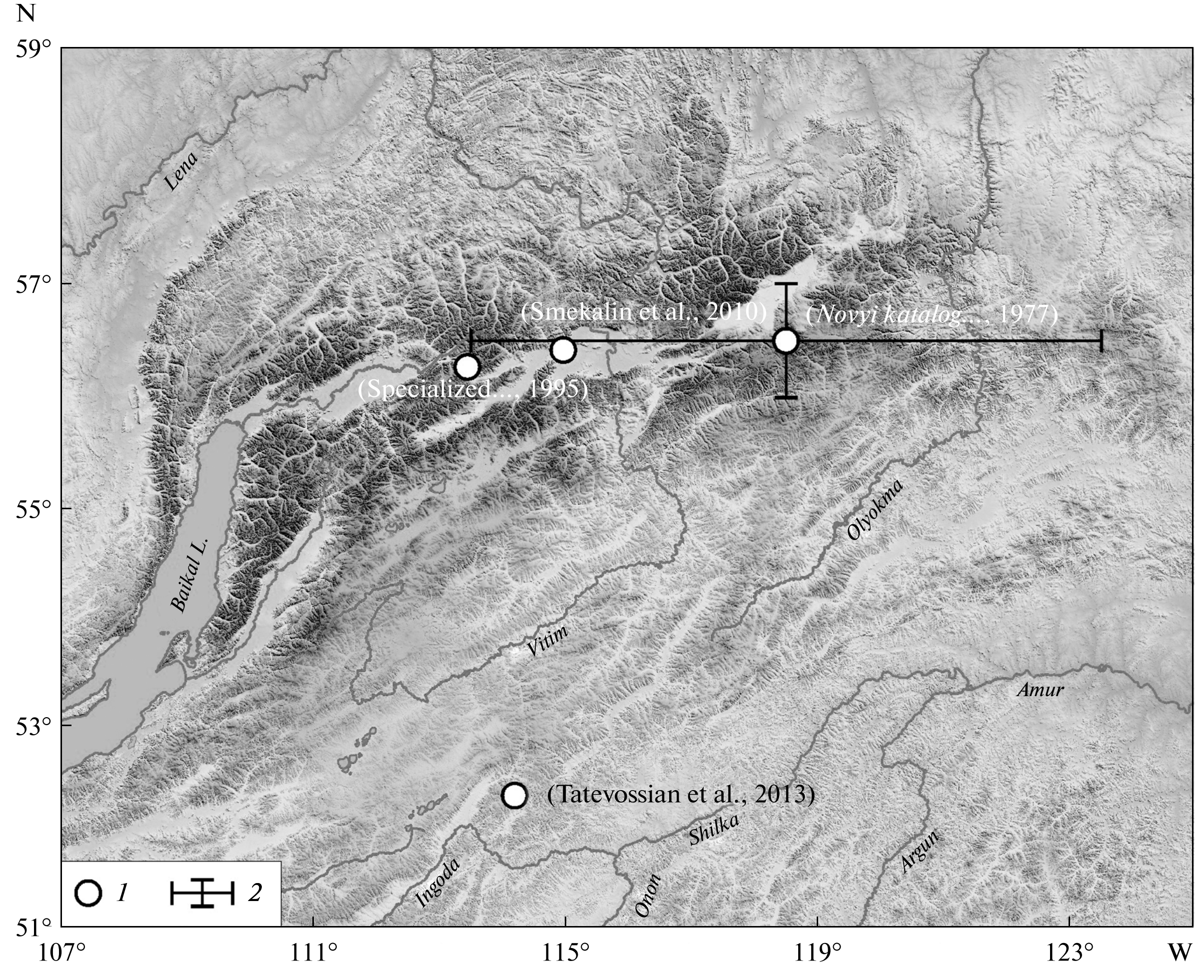

Fig. 3. Visualization of currently existing solutions of the February 1, 1725 earthquake epicenter.
(*1*) The location of the earthquake epicenter according to different solutions; (*2*) uncertainties of epicenter coordinates according to (*Novyi katalo*g..., 1977).

and because of the official status of the catalog. One of the main merits of the *New Catalog* is that each parametric line is accompanied by bibliographic references, but the uses of historical data are very dissimilar and often ambiguous. For the February 1, 1725 earthquake ten sources were noted, of which nine are historical (Pallas, 1788; Perrey, 1849; Orlov, 1872; Orlov, Shchukin, 1874; Ritter, 1879; Slovtsov, 1886; Mushketov, Orlov, 1893; Messerschmidt, 1968; Novlyanskaya, 1970) and only one of them has paleoseismologic information (*Zhivaya tektonika*..., 1966). Over two and a half centuries the data have been transferred from one source to another, making rather complicated data-transfer chains (see Fig. 2).

Both primary and secondary sources of data are given as the basis of the solution proposed in the *New Catalog*. The original diaries of Messerschmidt, published in 1968, are of the highest value being the only real primary source. Along with the original text of Messerschmidt, use is made also of the monograph of N.G. Novlyanskaya devoted to the life and research activity of Messerschmidt in Siberia and containing the Russian translation of some fragments from his memoirs (Novlyanskaya, 1970). This chain of transfer of data directly originated from the Messerschmidt notes can be thought of as the most precise one and actually devoid of distortions.

Other historical sources cannot be thought of as primary. Practically speaking, all of them go back to the work of P.S. Pallas, published in German, Russian and French (Pallas, 1778, 1788, 1793). Pallas had in his time learned of Messerschmidt's notes and borrowed some information from him, including a description of the earthquake in the Chita fortress. For example, the work by K. Ritter *Earth Science of Asia* (Ritter, 1879), cited in the *New Catalog*, is a Russian republication of the original work *Die Erdkunde im Verhältniss zur Natur und zur Geschichte des Menschen* (Ritter, 1833), which, in its turn, cites the German publication of Pallas (Pallas, 1778). The most demanded source was the latest French translation Pallas (Pallas, 1793). It is this publication that was used as source of data on the February 1, 1725 earthquake in all European and Russian descriptive summaries of the 19th century. This is seen by direct references in catalogs to the French publication of Pallas works, including the pinpoint reference to the number of page with a description of the 1725 earthquake. The data on the earthquake from the Pallas book were transferred to the catalog of Perrey (Perrey, 1848) and to its Russian translation (Perrey, 1849), to the catalog (R. Mallet and J. Mallet, 1858), and to the first Russian catalogs (Orlov, 1872; Mushketov and Orlov, 1893). Of all the above given descriptive summaries, only the catalog (R. Mallet and J. Mallet, 1858) was never used in studies of the earthquakes of Siberia. But it is of interest as it supports the broad availability of the information on the 1725 earthquake among the first European seismologists. In the beginning of the 20th century the January 21 (Julian calender), 1725 earthquake is mentioned with reference to "Chita, Transbaikalia and westwardly to the valley of the Selenga river" and estimation of the intensity, when translated into modern macroseismic scale of 6–7 degrees was "moved" from the catalog (Mushketov and Orlov, 1893) to the worldwide catalog (Milne, 1911).

The catalogs (Perrey, 1849; Orlov, 1872; Mushketov and Orlov, 1893) have been customarily thought of as reliable and authoritative sources of data and have become the backbone of the *New Catalog*. At the same time, the French translation of the Pallas contained a mistake in its description of the earthquake: instead of the Ingoda river, the Selenga river is given. Naturally, this mistake came over to the Russian descriptive catalogs (Orlov, 1872; Mushketov and Orlov, 1893) and was brought later to a considerable over-estimation of the area of strong ground shaking (Tatevossian et al., 2013). The German and French publications of the Pallas works are cited in the *New Catalog* by mediation, as direct quotation is given only for the Russian translation (Pallas, 1788). Half a century before the publication of the *New Catalog*, the Russian publication of Pallas had been used also by V.S. Manassein in compiling summary data on earthquakes in Siberia in the 17th–18th centuries. (Manassein, 1926). This publication had later influenced the parameterization of the 1725 event.

Along with the catalogs of earthquakes and works of a natural-scientific character, the *New Catalog* cites also the book of the historian and regional ethnographer P.A. Slovtsov *Historical Review of Siberia* (Slovtsov, 1886). This book, issued for the first time in 1838 (Slovtsov, 1838), mentions shortly the perceptibility of the February 1, 1725 earthquake in Irkutsk, but without a reference to the source. This arouses doubts both in the estimation of the intensity of shaking and in the very fact of the perceptibility of the earthquake in Irkutsk. R.E. Tatevossian et al. (Tatevossian et al., 2013) hypothesized as a working assumption that P.A. Slovtsov knew Pallas's work and that it was from this that he took information on the earthquake. However, a mistake was made: instead of the Chitinsk fortress, the city of Irkutsk was given. The Chitinsk fortress (now the city of Chita) was at that time a part of Irkutsk guberniya with its administrative center in Irkutsk. Speaking about the earthquake in Irkutsk, Slovtsov seems to have in mind not the city of Irkutsk but Irkutsk guberniya as a whole (Tatevossian et al., 2013). Slovtsov may have confused the geographic names, the specifics of which may have been unimportant in his view, within the general idea of the area of Irkutsk guberniya's susceptibility to earthquakes. The interpretation suggested by R.E. Tatevossian et al. (2013) seems to be quite logical and is supported by absence of any mention of the 1725 earthquake in the Irkutsk chronicles (The Irkutsk chronicle..., 1911; *Letopis'*..., 1996), as well as in lists of events in the city based on the evidences from the local residents in the works of early German travelers (Gmelin, 1751; Georgi, 1775).

On the basis of invalid data about the "earthquake" in Irkutsk, the authors of the regional section of *New Catalog* made an incorrect conclusion on the vast zone of perceptibility of the event. Additional distortions of the real picture were introduced by the estimation of the intensity of the shaking in Irkutsk. P.A. Slovtsov (1838), and then A.P. Orlov and I.V. Mushketov (Orlov, 1872; Mushketov and Orlov, 1893) indicated only the "fact," without any details, of the tangible event in Irkutsk. However, the description of the earthquake in the *New Catalog* (1977, p. 500) in relation to Irkutsk is accompanied by the epithet "strong":

"This earthquake was felt also in Irkutsk [5]: 'January 21, at 7 pm a strong earthquake.'"

The figure "5" in square brackets is a reference to republication of the book by P.A. Slovtsov (1886). The comparison of both publications (1838 and 1886) has revealed their total identity in the part of data on the earthquake. There are no indications that the earthquake in Irkutsk was "strong." Therefore, the except from P.A. Slovtsov is cited in the *New Catalog* incorrectly.

The record of a "strong" earthquake in Irkutsk exists only in the summary report (Orlov, Shchukin, 1874):

"1725. January 21, 7 pm, in Irkutsk, a strong earthquake."

The formulation is identical to the above-given quotation from the description of the earthquake in the *New Catalog*. The authorship of the report, according to the existing tradition, is attributed to A.P. Orlov and S.S. Shchukin, while in reality, as it follows from its subheading, data on the earthquake were no more than *extracted* by its anonymous compiler from the earlier publications by A.P. Orlov and S.S. Shchukin. Most probably, the data was taken from the catalog (Orlov, 1872). Since the actual author of the report is unknown, it must be defined as doubtful. In the time preceding our research, there has been no test of the veracity of the information in the report (Orlov and Shchukin, 1874), and for a long time it was thought to be as highly an authoritative independent source of data as the catalogs (Orlov, 1872; Mushketov, Orlov, 1893). In fact, the report (Orlov and Shchukin, 1874) has a double distortion of the primary information. First, Irkutsk is erroneously noted as the place of observation of the earthquake (the source of the mistake is the book by Slovtsov); second, the earthquake, absolutely groundlessly, is characterized as "strong". The source of the second mistake is unknown, but it is quite possible that the epithet "strong" in the description of the earthquake was used by the true compiler of the report, having ignored its practical meaning. In the result the authors of the regional section of the *New Catalog*, due to erroneous information, have attributed to Irkutsk a rather high intensity of shakes (not less than 4 degrees), thereby mistakenly expanding the area of perceptible shakes, which could not have existed but were used for the parameterization of the event.

The solution in the *New Catalog* (authored jointly by N.V. Shebalin and V.P. Solonenko) is closely connected with the source of the data, containing combined historical and paleoseismic data (*Zhivaya tektonika*..., 1966). The historical data from 1725 aroused interest as early as the mid 1960s when a group of researchers led by V.P. Solonenko made an analysis of the seismologic and geologic data along the Northeastern flank of BRZ. The result of these works was the monograph (*Zhivaya tektonika*..., 1966), which at that time was thought of as one of the most important publications in seismicity of the Northeast BRZ. A fragment of text with a description and interpretation of the historical data on the 1725 earthquake does not contain the name of the source, but the analysis of the list of references to the monograph allows us to conclude that it was a paper by V.S. Manassein (1926), in which, in its turn, the Russian version of the Pallas book (1788) and the book of P.A. Slovtsov (1838) are cited. References to the earthquake catalogs (Orlov, 1872; Mushketov, Orlov, 1893) are absent from the monograph; at the same time it is possible to suppose that they actually were used, although implicitly. This is seen from the following formulation in the monograph text: "From Chita down to Selenga its intensity could reach 7–8 degrees." In the V.S. Manassein work (1926) and in the Russian version of P.S. Pallas (1788) the Selenga river is not mentioned in respect to the February 1, 1725 earthquake, but in catalogs where the French publication of Pallas (1793) was used, the Selenga river is mistakenly mentioned. This important fact makes it possible to consider the monograph (*Zhivaya tektonika*..., 1966) as the source inheriting the works of Pallas, at least concerning historical data (see Fig. 2).

In monograph (*Zhivaya tektonika*..., 1966) two practically peremptory statements were made, later repeated in several following publications. The first of them is that the "epicenter of the earthquake could be found only in Stanovoy Upland," the second was that "in the territory from Chita to the Selenga river there were quakes with intensity up to 7–8 degrees." Both of these statements are not well grounded, but they have considerably influenced the conclusion about the location of the epicenter area. It was based on the then domineering ideas about the seismicity of the region and with account for the paleoseismogeological data. The earthquake epicenter was linked to the China-Vakatskaya seismic structure, shortly before that detected, described in detail in the relevant chapter of the monograph.

In the 1979 book, i.e., after publication of the *Map of Seismic Zoning of the USSR SR-79*, V.P. Solonenko repeated his statements also on the scope of the "vast territory from Nerchinsk to Irkutsk (over 1000 km from the assumed epicenter), and from Chita to the Selenga (not less than 500 km) there were noted signs of 7–8-degree macroseismic effects" and about huge sizes of the "China–Vakatskaya structure," estimating the "intensity of the earthquake" at 11–12 degrees, $M \geq 8$" (Solonenko, 1979. p. 19).

The China–Vakatskaya seismodislocation in the Stanovoi Range, discovered and studied initially by V.P. Solonenko with his team, is indeed a structure that is very expressive in a number of parameters and is characterized by rather strong seismic actions. In the 20th century no special study of this seismodislocation in view of the correct parameterization of the event generating it was performed. The following items remained unanswered:

1. Is it in fact a single, contemporary structure, or do large, visible disorders relate to different generations and were formed (renewed) by several events of different age? If the latter is true, then what are parameters of each generation of disorders?

2. What is the age of the discerned generations, how many are they and how large are the disorders of the last generation?

In the analysis of the data given in the monograph (*Zhivaya tektonika*..., 1966) first of all it is necessary to discern the fault itself and the seismodislocation in its zone. The both are expressed in the relief, but in the studies of the 1960s it could not have been documented in the required detail. This makes it difficult to parameterize seismic disorders, especially of the latest large event. "The distinct traces of recent tectonic formations" (p. 90) is quite insufficient for parameterization degree of approximation. "Parallel cracks and plates," expressed in the relief by scarps and ditches, may have different age—within the hundreds and thousands of years, which may considerably change the estimations of one-time actions or be related to the main shock and the strongest aftershocks.

The determination of the "tectonic trenches of about 6 m wide on the top, up to 3 m deep and about the first hundred meters long" is a fact of prime importance. But without knowledge of the total length of the simultaneously opened portion it is difficult to parameterize these data, the more so for an event with the maximum magnitude. If the portion length is taken as the length of the portion with the "distinct traces of recent rejuvenation," as is noted by the authors—4–5 km, then the intensity of this event could be 9, 9–10, or 10 degrees; and as for the magnitude it is far from necessary for it to be $M > 7$. Thus, the known $M = 7.6$ Muya earthquake of 1957 generated on the surface breaks of a total length of 20–22 km (on three divided parts) (Tatevossian et al., 2010).

On the "Talaya" part within the China–Vakatskaya structure with signs of a high activity, the "true normal fault amplitude in the considered period of activation, most probably does not go beyond the first dozen meters" (p. 196). As is seen, this is no more than visual, suppositional estimation, without concrete signs and evidences of the single movement. In this respect the parallel tectonic rupture with amplitude of 50 m and of 10–15 (sometimes up to 20–25) m deep, stretching "over 700 m" but vanishing on the adjacent flat swamp area (that's where its activity and subsequently age could have been clarified!) is still more questionable. In deciding on the length of the structure, the following statement of the authors: "The traces of the structure rejuvenation die out by the both northward and southward directions" (p. 198) arouses doubts. And it is still more difficult to allow the appearance of recent fractions simultaneously with the section "Talaya" on a separate section "Etyrko". The authors themselves conclude their description in quite an unequivocal manner, namely: "(facts) allow us to state in confidence that the area was recently a place of catastrophic seismic events" (p. 199) (events—in the plural!). Then: "less definitely (when compared to localization), it is possible to judge the time of the formation of the main (?) seismodislocations" (p. 200). The latter was judged by the authors according to the "exceptionally high velocity of dislocation of the products of weathering... Under these conditions the existence of tectonic ruptures on the slopes cannot last for a long time" (p. 200). Quantitative estimations are absent.

A supposition arises that in estimation of the sizes of displacements in the China–Vakatskaya structure V.P. Solonenko used the visible sizes of the fault instead of the concomitant seismodislocations and assumed all breaks to be the results of a single superpower event. From here the hypertrophic estimations of its parameters come. The catalog introduced parameters as hypothetical in the base, later they began to be taken without this qualification.

Since the 1860s the China–Vakatskaya seismogenic structure has not undergone an additional special study (judging by available publications), it is especially important to consider it along with other large seismodislocations on the eastern periphery of BRZ in the monograph (Imayev et al., 2012). However, this book (pp. 83–86) shows that no additional studies at the level of up-to-date methods has been made by the authors. At the same time, the modern vision and estimations made by the leading specialists are important. The authors say that the "China-Vakatskaya structure is a whole system of residual deformations" in the zone of a large active cognominal fault. They mean the "fragmentary uncovering of a number of linear segments (of the fault), ... two of which are the largest and well preserved (Figs. 3.10, 3.11, 3.12, 3.13, 3.14)" (pp. 83–84). On the first section, "Talaya," the length of ruptures was 300–700 m. Then multiple dislocations of the section are discussed but without indication of sizes. On the second part, i.e., "Etyrko" a tectonic wedge was found of a total length of about 3 km up to 1 km wide.

The photos by S.P. Serebryannikov placed in the book (Imayev et al., 2012. Figs. 3.10–3.14) were taken from the air and give mostly general views of the fault. In these terms, they are visual and support well its morphologic image and scale. But seismodislocations and seismodeformations differ only in two photos, and, because of their small scale and the insufficient illumination they can be characterized only approximately. No comments on them are available. Judging by the presented series of photos it becomes clear, first, that the scale of seismodislocations and seismodeformations is far smaller than that of the fault itself (in terms of its morphology), and, second, in Fig. 3.11 on the lower (closer to the reader) fault wall, on one of the spurs of the main range, three subparallel ruptures are seen as ditches within the first few hundreds of meters along.

Whatever the dislocations themselves could have been (visible in photos, both the earlier and the later), the available data are absolutely insufficient for determination of the earthquake as a single 11-degree event, which was given by the initial researchers and accepted by the present ones. It seems easier to allow two or more separable events. Besides, one could not but pay note that the seismodislocations follow the trajectory of active fault and in some places coincide with it. The renovations of forms may also proceed more slowly as a result of creeping movements.

No clear data on the age of seismodislocations (and on their simultaneity along the fault) are given. It is only said that they are post-glacial (i.e., not older than 10–12 thousand years ago) and that the products of weathering are shifting very quickly on the slopes. There is no doubt that they are large ruptures, close in size and, possibly, in age (within the Holocene), although it is impossible to know whether they belong to one event or to a series of earthquakes of different ages. In a word, a new attempt to characterize the deformation without specialized field investigations fails to complete the knowledge begun in the early works of V.P. Solonenko.

Despite the above-noted inefficiency of substantiation, the six present-day authors write without reservations about residual deformations of the China–Vakatskaya structure as "genetically relating to the most outstanding Siberian earthquake of February 1, 1725" (p. 83), and again refer to the huge territory of the quakes, though it has not only not been confirmed but not even seriously studied. We should note that in the work (Smekalin et al., 2010), the China–Vakatskaya structure was classified in the category of dislocations that need further research.

It is appropriate here to remember the attempt of placement of the prehistoric earthquakes into the Baikal area section in the *New Catalog*, whose parameters were defined exclusively by paleoseismodislocations (52 events). It was a brave and progressive action. However, 10–15 years later, after implementation of more detailed studies, including those by means of trenching and radiocarbon dating of seismodeformations, in the number of areas the list of events had to be much reduced and by a number of events to change the parameters (Khromovskikh, 1994). In the result the authors abandoned their initial solutions and withdrew this part of the catalog.

The publication of the monograph (*Zhivaya tektonika*..., 1966) is one of the key moments in the history of ideas on the February 1, 1725 earthquake. First, it is chronologically the first work where the parameters of the event are estimated on the basis of historical and paleoseismogeological data. Second, in compiling the *New Catalog* the monograph (*Zhivaya tektonika*..., 1966) was actually considered as the determining source of data on the earthquake.

Thus, of all the historical sources cited in the *New Catalog*, only two can be thought of as reliable (Messerschmidt, 1968; Novlyanskaya, 1970). The others directly or indirectly come from the works of Pallas who had borrowed the information on the earthquake from the original notes of Messerschmidt. In the result of multi-stage transfer of data from one source to the other, considerable distortions of the initial information appeared and accumulated. Despite the fact that the compilers of the *New Catalog* had at their disposal the original sources, no critical analysis of all the historical information was performed at that time. On the contrary, use was made of all possible, including mistaken, statements about the limits of earthquake perceptibility. The *New Catalog* compilers measured the earthquake with an account of maximal values of the parameters of the macroseismic field and obviously gave priority to the paleoseismogeological data, which as a result led to an unjustified parametric line (see Table 1). The parameters were given with a reservation about their tentative character and indication of error limits. The same parametrical line was transferred without changes to the English version of the *New Catalog* (1982), and after that also to the *Catalog of Earthquakes in the Area of the Former USSR* (Shebalin and Leydecker, 1997). It is possible that from these two sources the focal parameters of the February 1, 1725 earthquake were transferred to the global database of seismic events NGDC NOAA (http://www.ngdc.noaa.gov/hazard/earthqk.shtml).

The monograph (*Zhivaya tektonika*..., 1966) has become the basis for determinations of the February 1, 1725 earthquake parameters not only in the *New Catalog*, but in a number of subsequent regional publications devoted to the seismicity and seismic zoning of the Northeastern BRZ flank and of the BAM zone (*Seismicheskoe*..., 1977; Solonenko, 1979; Nikolayev et al., 1981; *Seismotektonika*..., 1982; *Geologiya i seismichnost'*..., 1985b). These publications make a separate branch in the evolution of the views on the February 1, 1725 earthquake. The description of the earthquake is reproduced almost invariably, only with some insignificant variations in the text, not changing its subject and meaning. The basic parameters of the earthquake began with time to be stated with ever-higher certainty. While the monograph (*Zhivaya tektonika*..., 1966) did not indicate the magnitude, in the works (*Seismicheskoe*..., 1977; Solonenko, 1979) its tentative value is given as $M \geq 8.0$; the estimate of the epicenter intensity is increased up to I_0 = 11–12 degrees. In the mid-1980s the monograph (*Geologiya i seismichnost'*..., 1985b) again postulates the propagation of the 7–8 degrees shakings on the vast territory without giving additional arguments, as well as again the increased magnitude value ($M = 8.3$) is given. In another book of this same series, a more careful approach to the February 1, 1725 earthquake is used, in particular, it stresses uncertainty in the estimations of the source parameters (*Geologiya i seismichnost'*..., 1985a). The authors of this publication, although they give the parametric line from the *New Catalog*, qualify these estimates as "*less reliable.*" This shows that the estimate of earthquake parameters suggested in the 1960s, despite its originally tentative character and sporadic doubts, had been rather quickly transformed to a stable stereotype.

BRZ NORTHEASTERN FLANK, TAKSIMO STRUCTURE, $M = 7.4–7.9$

The first serious doubts about the location of the epicenter of the February 1, 1725 earthquake within the Stanovoy Upland were expressed by V.V. Ruzhich (Ruzhich et al., 1982). Their attempt at relocalization of the epicenter was based on the dendrochronological dating. For the purpose of testing the method in the Northern Baikal region in the area of Taksimo seismogenic structure (see Fig. 1), six damaged old trees were selected. The study of their cross-sections made it possible to establish their dates to the range of 1724–1727. The proximity of the earthquake date and dendrochronological dating of the structure became the basis for the assumption of the relationship between them. This conclusion created the impression that the incomplete and fragmentary historical data had received independent confirmation. The macroseismic field of the February 1, 1725 earthquake, previously restored by accessible historical sources, does not contradict the proposed location of the epicenter, as many strong events in the northeastern flank of the BRZ are quite clearly felt in the territory of the Transbaikalia. Nevertheless, the new solution is left incomplete because the revaluation of the earthquake parameters was limited only to the new localization of the epicenter, while the magnitude was not reviewed, and no new interpretation of the known historical information was offered.

The data obtained by V.V. Ruzhich et al. (1982) were an impulse to appearance of a special branch in the development of visions of the February 1, 1725 earthquake. In the publication (Khromovskikh et al., 1993), a revised list of the BRZ seismogenic dislocations was presented. The age (the time of formation) of the Taksimo structure in this list is definitely 1725, the value of the earthquake magnitude is $M = 6.9$. It is noteworthy that the corresponding line of the list provides as the literary source the monograph (*Seismicheskoe*..., 1977), in which no reference to a possible relationship between the Taksimo structure and the 1725 earthquake, even as a possibility, is given. The only, extremely shaky basis for such a surmise from the monograph (*Seismicheskoe*..., 1977) is the age of the structure, tentatively defined as 150–250 years. Nor was any revision of the historical data in the publication (Chromovskikh et al., 1993) made. It is also not clear by what criteria the magnitude of the earthquake that created the Taksimo structure ($M = 6.9$) was estimated, taking into account that in earlier regional monographs the value of the magnitude is given in a range of 7.0–7.5 (*Seismicheskoe*..., 1977; *Geologiya i seismichnost'*..., 1985b).

In the recent review work (Smekalkin et al., 2010) the February 1, 1725 earthquake is again identified with the Taksimo structure. The possible earthquake magnitude estimated according to the parameters of dislocation is shown in a range of $M = 7.4–7.9$. The authors of this publication have put a question mark on the relationship of the Taksimo dislocation and the 1725 event. As the data sources on the Taksimo structure, the publications (*Seismicheskoe*..., 1977; and Ruzhich et al., 1982) are given.

BRZ NORTHEASTERN FLANK, $M = 6.6$.

This solution is given in the Specialized catalogue of earthquakes of the Northern Eurasia (1995) (hereafter *Specialized Catalog*) that was prepared in the middle 1990s under the editorship of N.V. Kondorskaya and V. I. Ulomov within the works on creation of a new map of the seismic zoning of Russia (General Seismic Zoning, GSZ–97). It does not exist in a printed format, only in the electronic format; also, it was exposed to changes and exceptions without reservation, and it was only recently that it has been again presented on the Internet with unspecified changes. The main drawback of the *Specialized Catalog* is the lack in the parametric lines of references to the sources of information and to the ways the information was processed. If a user doubts the information given, there is no way to check it. In other words, in preparation of the catalog one basic principle in the work with historical earthquakes, i.e., transparency of the whole initial information, was ignored.

The parameters of the 1725 earthquake in the *Specialized Catalog* differ essentially from those in the *New Catalog* and all subsequent summaries: in the corresponding parametric line there is no indication of the month and the day, which seems rather strange, taking into account the direct, exactly dated evidence of Messerschmidt. The coordinates of the epicenter are given with an accuracy down to the hundredths of a degree (!) (see Table 1), which is absolutely impossible due to the scarcity of macroseismic data. The magnitude is estimated as $M = 6.6$ without an indication of the limits to possible deviations. This solution arouses at least surprise, especially considering the fact that we do not know just which data were put in the basis of the interpretation and what methods of analysis were used. All this makes it impossible to think that the use of the given parameters in applied purposes, for which the *Specialized Catalog* has been created, is allowable.

The accuracy of the estimation of the epicenter coordinates down to the hundredth of degree makes it possible to assume that the compilers of the catalog have related the earthquake to a certain paleoseismic dislocation. The earthquake epicenter coordinates given in the catalog do not coincide with the coordinates of the Taksimo structure, associated with the 1725 event in the list of the seismic dislocations (Khromovskikh et al., 1993, Khromovskikh, 1994). Nevertheless, this same list includes also another structure, whose coordinates are absolutely identical

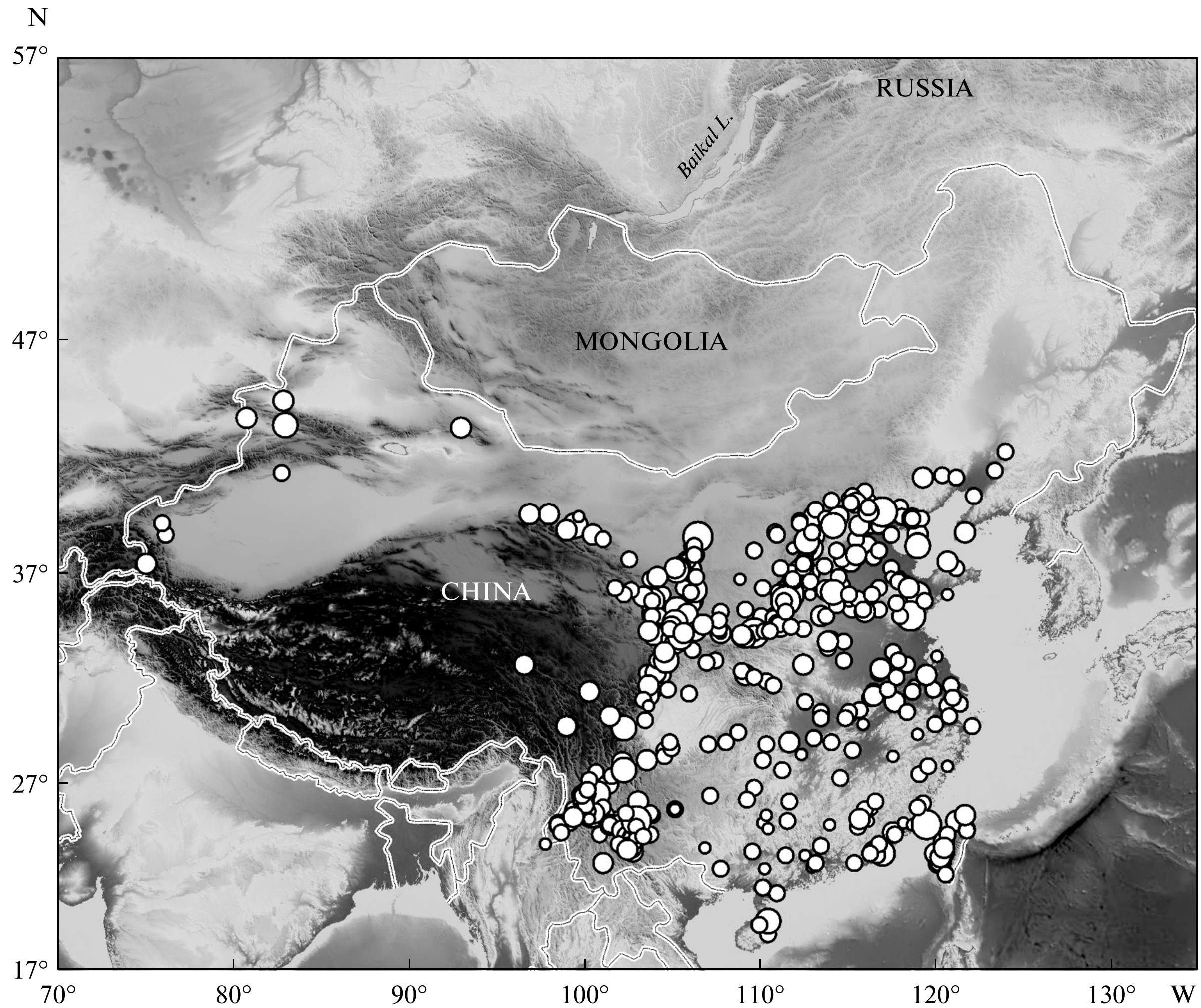

Fig. 4. Epicenters of historical earthquakes $M \geq 4.5$ in the territory of China for the period to 1900 according to data from (Lee et al., 1976).

to the coordinates of the epicenter given in the *Specialized Catalog*. This is the seismogenic structure Itykit, earlier described in detail in monographs (*Seismicheskoe…*, 1977; *Geologiya i seismichnost'…*, 1985b). Its age is estimated at 250–300 years, the earthquake magnitude that had created the structure as $M = 6.7$ (Khromovskikh et al., 1993). In a later work (Smekalin et al., 2010) two values of the magnitude are given that are calculated by the value of the vertical displacement (5 m) and by the length of dislocation (10 km), $M = 7.4$ and $M = 6.0$, respectively.

The question why in the preparation of the *Specialized Catalog* the 1725 earthquake was associated with the Itykit structure remains open. There is no serious argument whatever in favor of this statement. The list of seismic dislocations of eastern Siberia (Khromovskikh et al., 1993) was prepared, in particular, within the works on creation of the *Specialized Catalog* and on creation of the map of the general seismic zoning GSZ–97, but it does not relate the Itykit structure with the earthquake. It is possible to suppose that in the final summation of all the data a technical error took place: coordinates and magnitude of the structure Itykit were cataloged instead of data on the Taksimo structure.

The difficulty in this situation is that the *Specialized Catalog* is an official parametric catalog of earthquakes for works on seismic zoning. This is the way it is understood, as a failsafe result of seismological research. The new version of this catalog made within the works over the GSZ-2012 maps and accessible on the Internet (http://seismorus.ru/eq_cat), has the same inadequate presentation of the 1725 earthquake parameters as the 1997 catalog version.

EASTERN TRANSBAIKALIA, $M = 6.8$.

All of the above-considered versions of the basic parameters of the 01.02.1725 earthquake presupposed the location of the epicenter within the northeastern

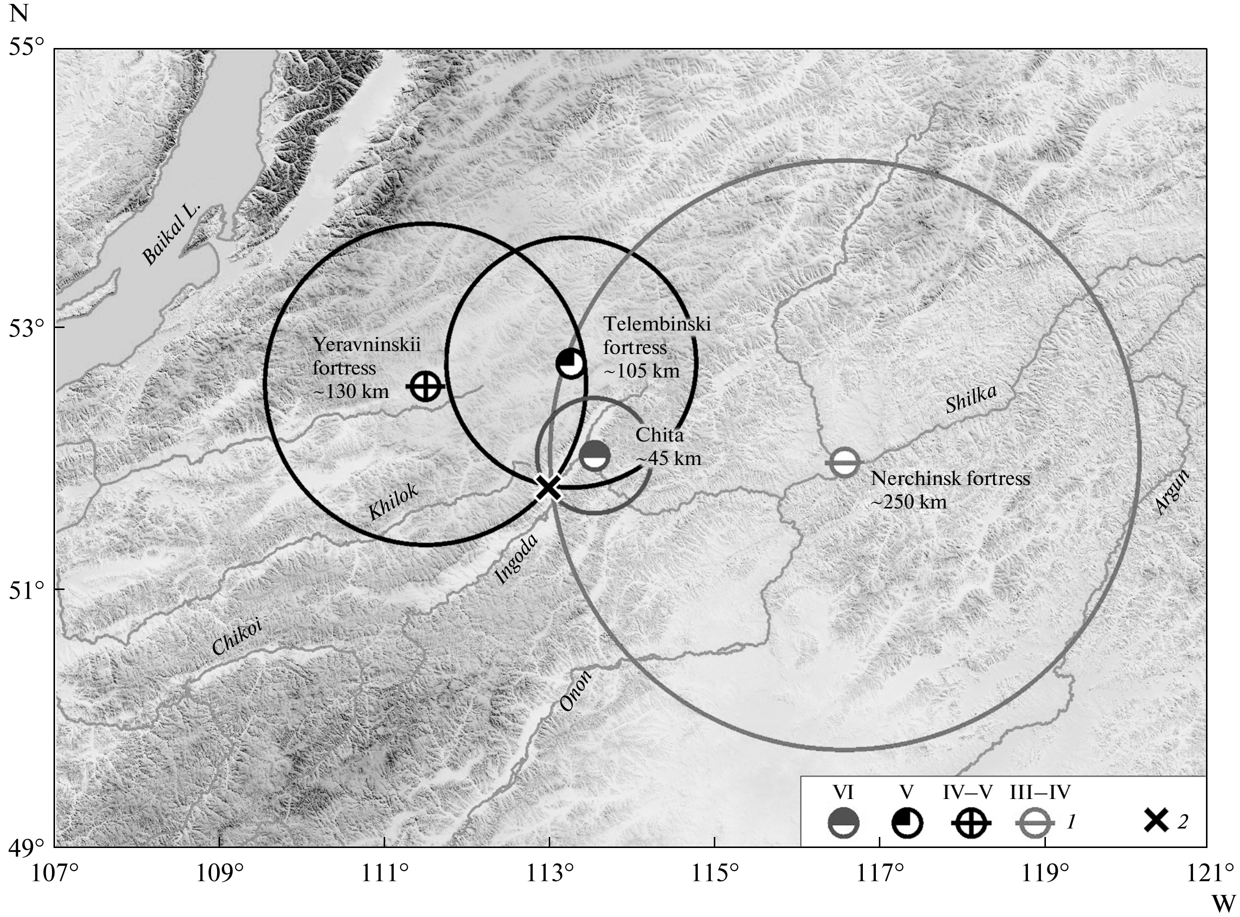

Fig. 5. The supposed location of the February 1, 1725 earthquake epicenter.
(*1*) intensity of shakes in MSK-64 degrees; (*2*) macroseismic epicenter. For other explanations see the text.

flank of the BRZ. In the estimation of the parameters priority was given to paleoseismological data, due to which the statements look like prejudged, especially so in the light of the above given critical consideration. A different approach to the estimation of the parameters of the February 1, 1725 earthquake was made first by A.A. Nikonov (2012), and then, independently, and in an expanded form by R.E. Tatevossian et al. (2013). Their statement is based only on primary macroseismic materials (Messerschmidt, 1968; Novlyanskaya, 1970), with removal of some mistakes in the macroseismic and parametric catalogs of earthquakes. The paleoseismic data in these publications are radically removed from consideration. As a result the parameters of the February 1, 1725 earthquake have been completely reconsidered.

According to the final analysis (Tatevossian et al., 2013), the epicenter area was in eastern Transbaikalia, to the northeast of the Chitinsk fortress (city of Chita). The parametric line in the generally accepted form is not given, so the coordinates of the epicenter can be tentatively reconstructed by Fig. 8 from the mentioned work (see Table 1). The estimation of the earthquake magnitude was $M = 6.8 \pm 0.2$. This far more rigorous solution still arouses some doubt, since the not-quite-substantiated assumptions have been given in the estimation of the seismic intensity at the known points of observation. Messerschmidt (1968) had given a relatively detailed description of the manifestations of the earthquake in the Chitinsk fortress, and only for this point it is possible more or less exact estimation of the seismic intensity. The information from the other points of observation (Yeravninski, Telembinski, and Nerchinski fortresses) was obtained secondhand. R.E. Tatevossian et al. (2013), directly pointing out the absence of details in the description of the earthquake in all the points, except for the Chitinsk fortress, thought it still possible to ascribe the same (6–7 degrees) to all the four points of observation. Accordingly, with the data for no more than four points (!), an intensely elongated in the sub-latitude direction 7-degree isoseismal with a mean radius of 75 km was built. The geometric center of the isoseist is interpreted as the epicenter of the earthquake. On this basis also the estimation of magnitude was made. On the other hand, in reality

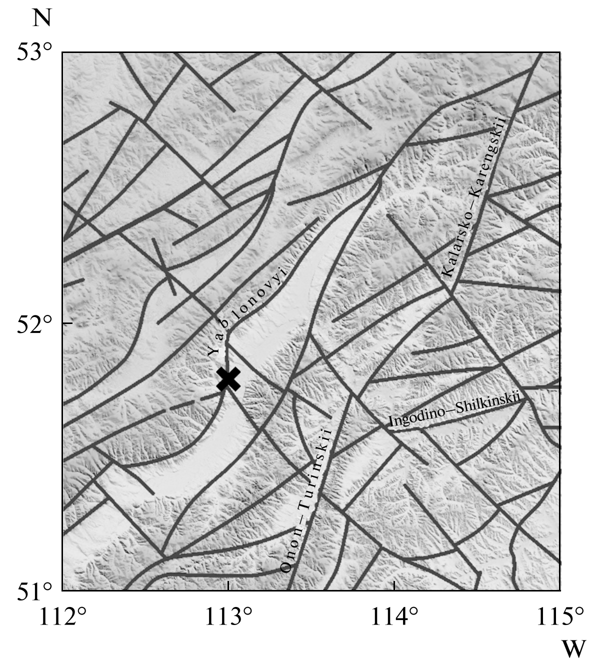

Fig. 6. Faults in the February 1, 1725 earthquake epicenter area according to (*Karta razlomov…*, 1988).

there is no reason to accept the seismic intensity in distant points of observations as significant as in the point the nearest to the presupposed epicenter. The assumption made by R.E. Tatevossian et al. (2013) on the position of the February 1, 1725 earthquake epicenter in eastern Transbaikalia actually does not contradict the known facts, but the interpretation of initial data and the proposed parameters of the event need, in our view, clarification.

Such is the evolution of solutions of the basic parameters of the 1725 event in publications and catalogs of the earthquakes in the last third of the 20th and the beginning of the 21st centuries (see Fig. 3). Most of them lack valid, rigorously given and flexibly discussed reasons.

NEW EVALUATIONS OF THE INTENSITY AND AREA OF PERCEPTIBILITY OF THE FEBRUARY 1, 1725 EARTHQUAKE

The previous estimates of the basic parameters of the February 1, 1725 earthquake are mostly based on the supposition of a vast area of perceptibility (from Nerchinsk to Irkutsk), and on the statement of the high degree shaking in the area from Chita to the Selenga river. Both statements are wrong due to the distortions introduced to the original text in the course of multiple translations and republications, and after attentive reading and comparison of the texts of the original sources they are refuted. The above-given reasoning, like also the viewpoint given in (Tatevossian et al., 2013) make us exclude the city of Irkutsk out of the places that had undergone perceptible effects. According to the original data obtained from Messerschmidt, the earthquake was felt in four points in Transbaikalia, i.e. the Chita, Nerchinsk, Yeravninsk, and Telembinsk fortresses. The latter fortresses appeared not later than 1685 and by the end of the first quarter of the 18th century had considerable populations; the Nerchinsk works began activity in 1702.

The most detailed data are available for the Chitinsk fortress, where Messerschmidt observed the earthquake in person. Turning to Messerschmidt's original text, above-cited, we can single out a few signs suitable for macroseismic estimates. Effects are described both inside the premises (crackling of beams, swinging of all the items hanging on the walls), and outside in the natural environment (soil and ice cracking 1–2 cm). It is important that the entire wooden stockade was shaking. The text does not mention any destruction or damage to buildings, even considering the fact that the house in which Messerschmidt lived was quite old. In this regard, there is no reason to assign from the observed effects 7–8 intensity in the Chitinsk fortress. But the evaluation of the intensity as 5 degrees made by A.V. Drumia and N.V. Shebalin (1985), does not meet the facts. They estimated the intensity of tremors in Chita as 5 degrees (Drumia, Shabalin, 1985, p. 105) judging by one feature: "crackled beams," but for some reason did not attach importance to such information as a concussion for the whole fortress (entirely wooden!), rocking of all things that hang on the walls, the appearance of cracks in the ground and on the ice of the river and Messerschmidt's assessment of the earthquake: "powerful." These macroseismic effects given by D.S. Messerschmidt are in the range between 5–6 and 6–7 degrees and should be considered a reasonable estimate of $I = 6$ ($\pm$ 0.5) degrees, with account that we are talking only about the wooden structures.

As to ice cracking on the rivers Chita and Ingoda, this matter is more difficult. In modern seismic scales the effects of earthquakes on ice are not considered; even specialized scales describing only the earthquake effects in the natural environment (Michetti et al., 2004, 2007) are devoid of any references to seismogenic cracks in the ice coverage of water basins. In the MMSK-92 scale, such signs as cracking and ice hummocking are assigned to 7–8 degrees, but no quantitative characteristics of the effect are described (Shebalin and Aptikayev, 2003). The appearance of seismogenic cracks in the ice coverage and their parameters is influenced by many factors, first of all by the ice thickness, existence of earlier formed defects in the ice mass, the directionality of the seismic action, etc. There are known cases of cracks appearance in the ice coverage from quakes with intensity 5–6 and 6–7 degrees (Khromovskikh, 1964, 1965; Gusev et al., 1975; Koz'min, 1999). The problem of ice reaction to

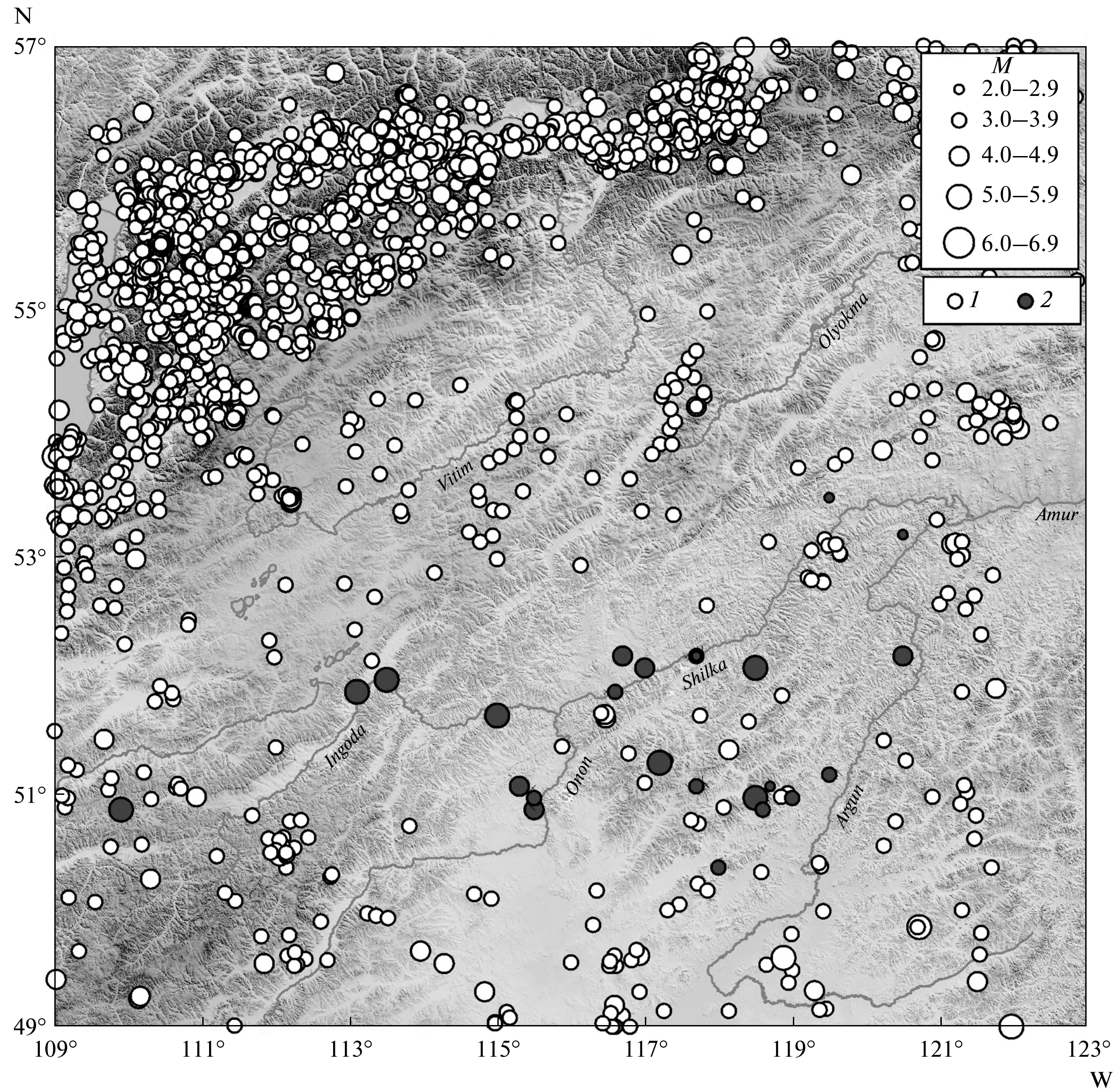

Fig. 7. Seismicity of eastern Transbaikalia and the northeastern flank of the Baikal rift zone.
(*1*) Epicenters of earthquakes that occurred within the instrumental observation period; (*2*) epicenters of historical earthquakes by the data from (*Novyi katalog*..., 1977; Chipizubov, 2010; Radziminovich and Shchetnikov, 2010).

seismic quakes requires certainly further research, but we can say with certainty that cracks in the ice coverage may appear also at the shakes of intensity less than 7 or 8 degrees. Therefore, the cracks observed by Messerschmidt on ice of the Chita and Ingoda rivers do not run counter the estimation of its intensity in Chita 1 = 6(±0.5) degrees. The ground, taking into account the cold season, was of coarse frozen and the formation of thin cracks on the ground surface at 6-degree shakes is also not surprising.

The intensity of shakes in the three other communities (Nerchinsk, Yeravninski, and Telembinski fortresses) only tentatively can be estimated by the very fact of the earthquake perceptibility and by mentioning that it was "strong" (Novlyanskaya, 1970). The data from these places were obtained by Messerschmidt from elsewhere, but it is logical to believe that the earthquake indeed was noticeable and caused alarm among the population of these fortresses. The fortresses were built by the Russian Cossacks in the middle to the second half of the seventeenth century. The settlers were engaged in business, accordingly, the connection with the Siberian tract and large settlements was constantly maintained. The estimate of intensity in these three points may vary, the interval of

3–4 to 5 degrees seems probable. In any case, there are no grounds even tentatively to ascribe to these places the same value of intensity as in the Chitinsk fortress (6–7 degrees), as is the case in (Tatevossian et al., 2013). Otherwise, it would be necessary to accept the propagation of the 6–7 degrees effects at a distance over 350 km, which, taking into account the regional regularities of attenuation, is possible only at a very high value of the magnitude ($M \sim 7.5$).

Taking into account the briefness of Messerschmidt's evidence, it seems necessary to use also all possible indirect ways to state as reasonably as possible the limits to perceptibility area, first of all, to the north and southeast of the Chitinsk fortress. All of the four above considered places are located in southern Tansbaikalia, which under our supposed estimates of the intensity of shakes do not exclude a possibility for localization of the epicenter within the northeastern flank of BRZ. According to this, the February 1, 1725 event could be considered as a close analog to the June 27, 1957 Muya earthquake with similar macroseismic manifestations in the Transbaikalia area, but, by the way, not perceptible either in Irkutsk, or in Ulan-Ude (formerly Verkhneudinsk) (Puchkov et al., 1958; Solonenko et al., 1958; Tatevossian et al., 2010). We cannot also rule out that this analogy has arisen before, in connection of the 1725 earthquake with the Taksimo seismic structure (Ruzhich et al., 1982; Khromovskikh et al., 1993). At the same time, it is well known that the shakes from events with epicenters in the northeastern flank of the BRZ propagate far to the north and northwest, to the extent of the Siberian Platform and are characterized by low attenuation in these directions. This effect is well illustrated by the case of the Muya earthquake of 1957.

All of the earlier proposed versions of the localization and value of the February 1, 1725 earthquake magnitude (*Novyi katalog*..., 1977; *Specialized*..., 1995; Smekalin et al., 2010) presupposed by default strong shakes not only to the south, but also to the west of the epicenter, in particular in the Lena river valley. No direct information about possible signs of the 1725 earthquake within the Siberian platform are available. In 1725 in the area of the upper and middle flow of the Lena river there were no naturalists or travelers who could have left documentary evidence on the perceptible earthquake, but later on, in 1736–1737, I.G. Gmelin, the head of the academic team of the second Kamchatka expedition (1733–1743) was there. I.G. Gmelin, who lived for 6 months in the Kirenski fortress, does not say anything about any shakes there during the few decades preceding, although he did take an interest in earthquakes (see below) (Gmelin, 1752). At the same time, in the case of an earthquake of $M \sim 7.5$–8.2 and epicenter on the northeastern flank of the BRZ, in Kirensk tremors with intensity up to 5–6 degrees would have been memorable for the local people.

According to the words of the local residents, I.G. Gmelin recorded an earthquake in the area between the rivers Lena and Lower Tunguska in 1725, i.e. 11 years before his trip. Although the month and season are not reported, one would surmise that this is in reference to the sought-after event in the northeast corner of the BRZ. However, this option is not likely for several reasons (Nikonov and Fleyfel, 2013). Firstly, the author points out that it spread down the flow of the river Lena "no further than Chechuisk," i.e., only 60 km northeast of Kirensk. Secondly, nowhere downstream on the Lena, i.e., closer to the source region noted in the *New Catalog*, was news on this year's event found, although a significantly earlier and a later earthquake were specified in Vitim (see below). Finally, the 1725 event in the middle of the Lena below Vitimsk could not have been missed, because in this place, closer to the supposed focus (China-Vakatskaya structure) it would have to be stronger than in the watershed of the river Lena and the lower Tunguska.

The old-timer of the Vitim settlement (now the place Vitimsk on the left bank of the river Lena opposite the mouth of the Vitim river) could report to I.G. Gmelin in 1736 only two memorable events. One of them, weak (local) took place five years before 1736, the second, a stronger one that reached by some indications 6 degrees and, seemingly, remote, took place 50 years before the day of the report, i.e., certainly before the end of the 17th century. On the way down the river Lena as far as Yakutsk and back, during his seven-month stay in the city itself, it was possible to find out that the local residents had not kept a record of any earthquakes, which is also found in I.G. Gmelin's book (Gmelin, 1752; Nikonov and Fleifel, 2013). The information obtained by I.G. Gmelin on the river Vitim is quite reliable because his interest was the history of the area, in particular, the history of discovery and production on the river of a high quality mica, traced since the end of the 17th century, which testifies to the permanent habitation of the Russian population there from this time.

A possibility of strong tremors within the Siberian platform, in particular, in the valleys of the rivers Lena (up- and downstream from the mouth of the river Vitim) and the Vitim (down to the mouth of the river Mama), in the decades preceding the expedition is absolutely excluded. The same can be concluded also about the eastern coast of the lake Baikal near the mouth of the river Barguzin. The workers on I.G. Gmelin's team that had passed by the route from the lower course of the Selenga river along Baikal coasts down to the peninsula Svyatoy Nos, the student S.P. Krasheninnikov and surveyor A. Ivanov, reported to their head, according to the local people, about a

Table 2. Basic parameters of the February 1, 1725 earthquake

Date	Time	Coordinates of the epicenter		h, km	M	I_0
		φ, N	λ, E			
February 1, 1725	11 ± 1 h	51.8 ± 0.5	113.0 ± 0.5	(20) (5–30)	6.0 ± 0.3	VIII ± 1

number of unusual events that had happened near the mouth of the Barguzin river, but no findings about a strong earthquake (that would have had here an intensity of 5–6 degrees) had been obtained. It seems impossible for any perceptible earthquake to have passed without any report in any place along the eastern coast, if any of such events had happened 11 years previously, the more so that they had managed to obtain information about other local natural events. Thus, for the February 1, 1725 earthquake the intermediate space between the extreme northeast of the BRZ and the Chita region is excluded. This conclusion is only being made now, because earlier the book of I.G. Gmelin was not being studied by seismologists and the data contained in his book were not used (Nikonov and Fleifel, 2013).

All the above said, makes it possible for us to conclude that any perceptible tremors in the first decades of the 18th century were not propagated to the this region from the extreme northeast of the BRZ. This, in its turn, does not allow us to see the version of the location of the February 1725 earthquake on the northeast of the BRZ as probable.

The epicenter of the earthquake hardly could have located on the north of China: this possibility was rejected by V.P. Solonenko as back as the middle of the 1960s because of the absence in Chinese sources of the data on the earthquakes in Manchuria. In the catalogs of earthquakes of China that have been published since that time, information on large events near the boundary with Russia in the first quarter of the 18th century is also absent (Lee et al., 1976; York et al., 1976) (Fig. 4). The materials by I.G. Gmelin, who visited southern Transbaikalia and the Argun' river region during his travel in 1735 and who wrote about seismic events in this territory (Gmelin, 1751) are very important. I.G. Gmelin made it his purpose to ask the local residents of the Argun' region about the earthquakes. In particular, the local residents remembered only one heavy event in China, in the city of Qiqihar that had occurred far from the Russian border (500 km from the Argun' river and 740 km from Nerchinck) that had not reached the Argun' region in any perceptible form and about very weak local shocks. The distance from the city of Chita to Qiqihar is about 950 km, and from there to the border with China it is 750 km. Even if the intensity of this earthquake had reached in the epicenter (near the city Qiqihar) 10 degrees, it could have been noticed in southeastern Translbaikalia (in the basin of the Argun' river) with an intensity hardly more than 4–5 degrees. A stronger event, if it had taken place on the Russian part of the Argun' area over the preceding 20–30 years, it would have been remembered by the residents and become known to I.G. Gmelin (Gmelin, 1751; Nikonov and Fleifel, 2013). Gmelin's phrase "over many years" can be understood as a period certainly more than 20 years, i.e., from the very beginning of the 18th century or, possibly, from the end of the 17th century. This is indirect evidence for the absence here of noticeable tremors or for that their intensity did not exceed 4 degrees. It follows from this that the February 1, 1725 earthquake, even if it was felt in the Argun' region, its intensity was not more than 3 or 3–4 degrees.

By limiting the possible area of perceptible shakes from Chita to the north as maximum to the Vitim upper reaches and to the Argun' region from the south-east, we obtain the only interpretation of the location of epicenter zone of the 1725 earthquake in southeast Transbaikalia near Chita. In this, our conclusions based on a wider range of information, are close to those published by R.E. Tatevossian et al. (2013).

PARAMETERIZATION OF THE FEBRUARY 1, 1725 EARTHQUAKE FROM CLARIFIED DATA

The basis for determination of the epicenter area of the February 1, 1725 earthquake is the macroseismic data with account of probable limitations to the macroseismic field. Taking into account the estimates of the intensity in four settlements of Transbaikalia and indirect data, we have performed the localization of the epicenter by use of N.V. Shebalin's (2003, p. 157) method, used many times earlier in the territory of eastern Siberia. This method, developed to be used with sparse data, is the enumeration of several values of the magnitude, for each of them a set of epicenter distances to the point with the known intensity of tremors is calculated. Next, around each point, a circle is constructed with a radius equal to the calculated distance. In the result, using the best cross-bearing of the circles, the macroseismic epicenter and optimal value of the earthquake magnitude are simultaneously determined. The N.V. Shebalin's (Shebalin, 1972) macroseismic equation with regional coefficients (*Novyi katalog*..., 1977) was used in the calculations:

$$I = bM - v\log\sqrt{\Delta^2 + h^2} + c, \qquad (1)$$

where I is the earthquake intensity; M is magnitude; Δ is epicenter distance; h is the focus depth; and b, v, and c are the coefficients for the Baikal area, equaling 1.5, 4, and 4, respectively.

The Chitinsk fortress can be considered as the base station where the intensity of shakes is fairly exactly estimated at 6 degrees. With account for the intensity value and at moderate estimation of the magnitude in a range of 5.8–6.4, the epicenter of the earthquake should be found within 40–100 km from the fortress. If, taking into account regional patterns of attenuation, the estimates for the Telembinsk fortress are taken as not more than 5 degrees, for Yeravninsk fortress not more than 4–5 degrees, and for the Nerchinck fortress not more than 4 degrees, then the best cross-bearing for the circles constructed around the fortresses, will be located to the southwest of the city of Chita (Fig. 5). The obtained basic parameters are presented in Table 2. Comparing with the existing versions of the 1725 earthquake parameters our solution is the closest to the version suggested by R.E. Tatevosyan et al. (2012), but differs by the considerably lower value of the magnitude and somewhat different location of the epicenter.

It is natural to try and estimate the correlation of the focus parameters with the geological structure and depth structure of the outlined epicenter area. The territory of eastern Transbaikalia is characterized by a complex tectonic structure and a rather dense network of disjunctive dislocations of different rank and different age of deposit. The epicenter area is found in the zone of the regional Yablonovy fault (Fig. 6). The time of its deposit is determined as Early Paleozoic, but the fault has signs of Cenozoic activation (*Karta razlomov*..., 1988). To the east of its epicenter zone, the Onon-Turinskii, Kalarsko–Karengsk and Ingodino–Shilkinsk faults intersect, which are ancient structural seams also activated in the Cenozoic. The structural pattern of the area is complicated by a number of regional and local faults. Accounting for the considerable uncertainty of the epicenter position, the structural position of the earthquake focus hardly can be established unequivocally, but it is possible to speak rather confidently about the presence in the region of the epicenter of faults able to generate strong seismic events. In any case, the validation of the modern seismic activity of the structures situated in the region of the city Chita are the February 23, 1895 ($M = 5.5$) (Radziminovich, Shchetnikov, 2010) and 11.02.1927 ($M = 5.2$) (*Novyi katalog*..., 1977) earthquakes. Proceeding from this, the minimal seismic potential of the faults in the considered region can be at present determined by the value of the magnitude $M = 5.5$, and with an account of the data on the 1725 earthquake there appear possibilities to correct it up to $M = 6.0 \pm 0.3$.

CONCLUSIONS

One of the most important principles of work with earthquakes of the historic past is the provision of maximum possible transparency of both the initial data and the logical schemes used by the researcher (Ambraseys et al., 1983; Musson, 1998; Ambraseys, 2004). Despite the approaches worked out over recent decades, the former mistaken determination of the focal parameters of historical earthquakes is still not unusual. In order to make correction it is necessary to have a clear understanding of the causes of mistakes in each case. The retrospective view of the situation makes it possible to believe that erroneous estimates of basic parameters of earthquakes were consequences, first, of insufficient attention to the primary sources, and, second, of the presence of a priori ideas of the seismicity of the region.

An attempt at the analysis of the initial historical data on the February 1, 1725 event in Eastern Siberia was undertaken as early as the compilation of the *New Catalog*, while actually the solution was made on the basis of paleoseismic information. The basic parameters of the 1725 earthquake were included into the base catalog unchanged comparing to the monograph (*Zhivaya tektonika*..., 1966). Along with this, there was distortion of the initial data by "fact" of perceptibility of the earthquake in Irkutsk and neglect of such an important primary source as the book by I.G. Gmelin (Gmelin, 1751, 1752). Due to all this, the solution that originally was of a suppositional character has with time turned into a stable stereotype circulating among the world catalogs.

Later, for a long time, there has been an a priori assumption that the appearance of strong earthquakes is possible only within the Baikal seismic belt, in particular, on the northeastern flank of the BRZ. Accordingly, the main efforts on the investigation of the earthquakes of Eastern Siberia were concentrated on the highly active rift zone. The seismicity of its neighboring territories, i.e., the Siberian platform and Transbaikalia, have remained for many decades beyond the attention of seismologists. Moreover, it was thought that the territory of southern and eastern Transbaikalia is characterized only by weak or moderate seismic activity (Fig. 7). In particular, the position of V.P. Solonenko about the absence in Transbaikalia of seismogeological preconditons for the appearance of powerful earthquakes is known (*Seismicheskoe*..., 1977). Some changes in views have taken place after the September 5, 1993 earthquake on the Vitim plateau ($M = 5.0$) (Golenetskii, 1998). The shortage of knowledge about the seismicity of Transbaikalia was able to be replenished by the data on the historical events of the 19th to the first half of the 20th century (Chipizubov, 2010; Radziminovich, Shchetnikov, 2009, 2010), as well as in the results of the detailed study of the Balei earthquake ($M_w = 4.5$) (Mel'nikova et al., 2011; Radziminovich et al., 2012).

It seems that the solution of the basic parameters of the February 1, 1725 earthquake suggested by V.P. Solonenko had appeared under fresh and bright impressions from the powerful and catastrophic earthquakes that took place in the 1950s in Siberia and Mongolia, first of all of the June 27, 1957 Muya ($M = 7.6$) and December 4, 1957 Gobi-Altai ($M = 8.1$) earthquakes. V.P. Solonenko was the initiator of the surveys of these events and took in them direct active participation. The collected data on amplitudinous seismogenic deformations of the ground surface and the huge sizes of the perceptibility areas of the both earthquakes started later be considered as a kind of the sample for further seismologic and paleoseismologic studies in eastern Siberia. It is quite natural that this would have an effect on the perception of the historical information on strong earthquakes in Siberia, and would spur attempts at making direct analogies between the earthquakes of the historical past and the events of the present time. The idea of V.P. Solonenko on the high-magnitude event in the northeast BRZ based on unreliable data of the vast area of perceptibility, as well as on insufficiently studied seismogeological information, looked ambitious, courageous, and in its own way very attractive. In the result, however, this idea was for a long time a barrier to determine the realistic parameters of the earthquake. On balance, the basic parameters of the 1725 earthquake, like the scheme of the interpretation of the original data, were in fact adopted as the only possible ones.

This situation in respect of eastern Siberia is not unique. Some cases are known where once told views of the parameters or manifestations of particular strong earthquakes acquired a character of stable stereotype. These doubts have been at different times raised in respect of the macroseismic manifestations of the Tsagan January 12, 1862 ($M = 7.5$) earthquake (Golenetskii, 1996a) and in terms of the localization of epicenters of some earthquakes in the Tunka system of basins (Golenetskii, 1998b; Radziminovich and Shchetnikov, 2013).

The result of the existing situation is the penetration of erroneously determined parameters into the general world seismologic reports. At first the data from the catalog (Mushketov and Orlov, 1983) got with a conventional evaluation of the earthquake intensity into the global catalog (Milne, 1911). Later on from the catalogs (*Novyi katalog*..., 1977; *New Catalog*..., 1982) the focus parameters of the February 1, 1725 earthquake in eastern Siberia were transferred to the global database of seismic events NGDC NOAA (http://www.ngdc.noaa.gov/hazard/earthqk.shtml), including earthquakes important according to some or other criteria (high magnitude, a large number of victims, high magnitude, considerable damages). Accordingly, any analysis of seismicity of Cental Asia relying on this database unavoidably includes the event with false, as is now clear, parameters. As an example, it is possible to mention the publications (Vergnolle et al., 2007; Mackey et al., 2010), where on the corresponding illustrations the epicenter of the 1725 earthquake is placed in Stanovoy Upland. We cannot exclude situations where the errors can lead to false estimates of the seismic regime or seismic hazard.

Over almost half of the century, the parameters of the February 1, 1725 earthquake *hypothetically* evaluated as early as in the middle 1960s were still used in estimates of the seismic potential of active structures of the northeastern flank of the Baikal rift zone and in the works on seismic zoning of the territory of eastern Siberia. Having admitted that earlier estimates were incorrect for the northeast of the Baikal rift zone and having found the missed significant earthquake in the area of the city of Chita in eastern Transbaikalia, we find ourselves obliged to make a serious correction of the established views and some hazard assessments in the official documents on the region.

The 1725 earthquake in Eastern Siberia is evidently far from the only event whose parameters in the local and world catalog need correction. The situation requires a more responsible analysis including the forgotten and not commonly used information available in books by I.G. Gmelin and I.G. Georgi (Gmelin, 1751, 1752; Georgi, 1775) on the earthquakes of eastern Siberia in the period of its initial development by the Russians (Nikonov and Fleifel, 2013).

The detection and correction of the errors and inaccuracies in the catalogs of earthquakes, including the global ones, is a task extremely important and far from easy. There seem to be two possibilities of its solution: 1) a detailed analysis of the primary data by each earthquake; 2) accidental detection of inaccuracies in the estimates of the primary data in the process of the research associated with the analysis of the seismicity as a whole. The first way requires a high cost of time and efforts, the latter is ineffective. Only one is clear: the purposeful search for mistakes and inaccuracies in parametrical catalogs is possible only through careful and consistent consideration of all the primary and secondary sources of data, through tracing the history of the development of concepts about the particular earthquake. This, like also the compliance with the principle of transparency of estimates, is required by the general logic of research in the field of the history of earthquakes.

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