DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN FILE REPORT 02-500

Composite Regional Catalogs of Earthquakes in the Former Soviet Union

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DECEMBER 2002

CONTENTS

frontispiece: Photograph of the compound of the Garm Seismological Expedition, near the village of Garm in Tadjikistan. The expedition was established following the devastating Khait earthquake and rock avalanche of 1949, and is considered to be the birthplace of Soviet regional seismology.

1. INTRODUCTION

Seismological study of the territory of the former Soviet Union developed in the 20th century with the approach of maintaining constant observations with standard instrumentation and methods of data processing, determining standardized parameters describing the seismic sources, and producing regular summary publications. For most of the century, event data were published only in Russian and were generally unavailable to the Western scientific community. Yet for many regions of this vast territory, earthquakes with magnitudes less than 2 were routinely located and characterized, especially since the early 1960s. A great volume of data on the seismicity of the Eurasian land mass is therefore available, although to date only in scattered publications and for incomplete periods of time.

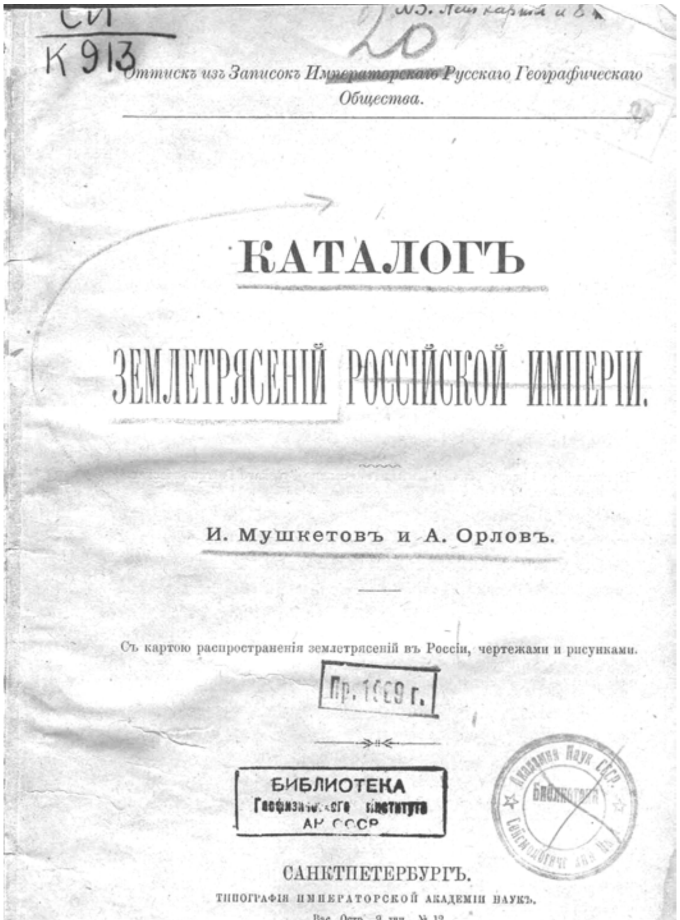
To address this problem, we have undertaken a comprehensive compilation, documentation and evaluation of catalogs of seismicity of the former Soviet Union. These include four principal, Soviet-published catalog sources, supplemented by other publications. We view this as the first step in compiling a complete catalog of all known seismic events in this large and important region. Completion of this work will require digitizing the remaining catalogs of the various regional seismological institutes.

To make these data more useful for regional seismic investigations, as well as to be consistent with their provenance, we have prepared composite regional catalogs, dividing the territory of the former Soviet Union into 24 regions. For each of these regions, all the data available from the basic catalog sources (see below) have been combined and evaluated. Note that, for regions with low seismicity, the historical (non-instrumental, macro-seismic) data are of increased importance. Such information, if not included in any summary, were taken from various publications and marked as "historical".

1.1 A Brief History of Seismological Study in Russia and the Former Soviet Union

The first substantial summary of earthquakes in Russia and adjacent territories was the catalog of I.V. Mushketov and A.P. Orlov [1893; **Figure 1**], which was based solely on macroseismic data. The beginning of regular seismic observations in Russia was marked by the issuance of a noteworthy publication --the *Bulletin of the Permanent Central Seismological Commission* (or *PCSK* [2]), published from 1902-1908 and from 1911-1915 under the direction of G.V. Levitskaya. Being aware of imperfections in the seismic instrumentation used at that time, the compilers of the *PCSK Bulletin* did everything possible to preserve the main quantitative characteristics of these records –the amplitude and duration of vibrations– in the most complete form. Macroseismic data were collected under the direction of the PCSK, and were combined with instrumental data in a separate publication, in order to simplify the use of the materials in the *PCSK Bulletin*.

After the 1917 revolution and civil war, periods and amplitudes were again published from 1923-1925 in the first Soviet summary bulletins of the individual seismic stations [3]. Because of the high quality of seismogram analysis, reflected in the individual bulletins of the best seismic stations (e.g., Pulkovo and the independent stations of Anapa, Grozniy, Pyatigorsk, Samarkand and others), it is still possible to calculate accurate earthquake magnitudes for events in this time period. Beginning in 1923, the bulletins of the individual seismic stations were published in Moscow by the Institute of Physics of the Earth(IPE).



Оттискъ изъ Записокъ Императорскаго Русскаго Географическаго Общества.

КАТАЛОГЪ

ЗЕМЛЕТРЯСЕНІЙ РОССІЙСКОЙ ИМПЕРІИ.

И. Мушкетовъ и А. Орловъ.

Съ картою распространенія землетрясеній въ Россіи, чертежами и рисунками.

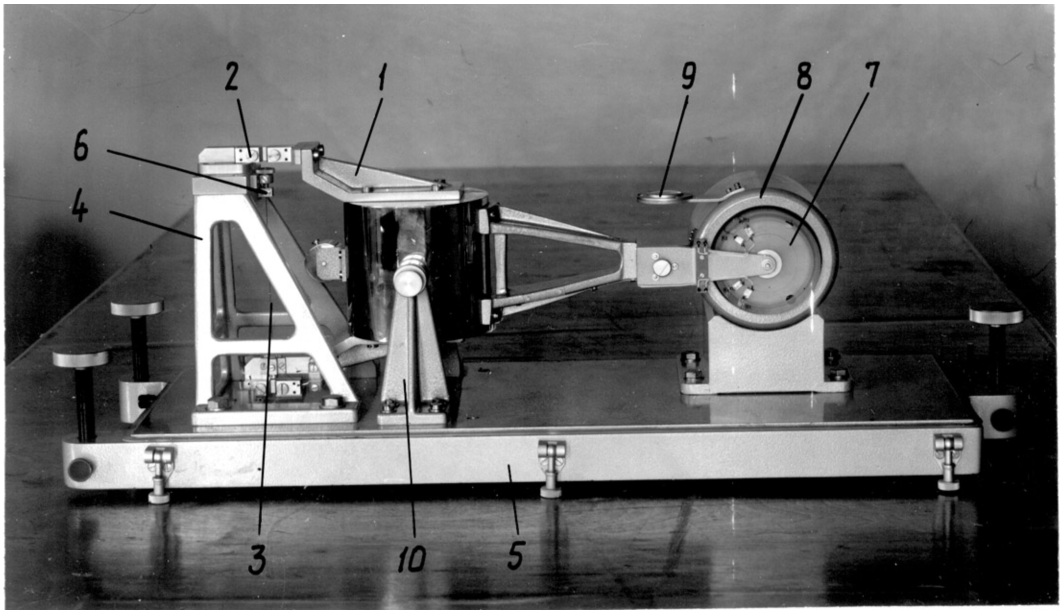
САНКТПЕТЕРБУРГЪ.
ТИПОГРАФІЯ ИМПЕРАТОРСКОЙ АКАДЕМІИ НАУКЪ.
Вас. Остр., 9 лин., № 12.

Figure 1. Cover of the first comprehensive catalog of earthquakes in Russia (Mushketov and Orlov, 1893, "*Catalog of the Earthquakes of the Russian Empire*").

By 1911, macroseismic observations were being separated from instrumental data, and their publication in the bulletins became of secondary importance. Macroseismic data were collected and analyzed, but published independently, without cross-reference. Eventually, however, the boom in construction brought to the forefront the problem of seismic risk, and aroused new interest in historic strong earthquakes. In these early years, the Caucasian seismologist, Eu.I. Bius, compiled an exceptionally detailed and complete catalog of *Earthquakes In Transcaucasia* [4], and a number of other data collections were published [5-8]. Changes were also made to the summaries of instrumental data. For example, the inability to accurately calculate true ground displacement was considered sufficient reason to remove the dynamic characteristics of waves from event summaries.

A landmark publication was the 1962 *Atlas of Earthquakes in the U.S.S.R* [9], a compilation and presentation of earthquakes that occurred in the period of 1911-1957. This volume, which included a catalog of seismicity and detailed maps, served to summarize this early period in the development of Soviet observational seismology.

After the 1948 devastating Ashkabad earthquake, the expansion of the seismic network was undertaken, as well as the replacement of the seismographs of the *Nikiforov* system with what were then the advanced broadband seismographs of the *Kirnos* system (CK) [**Figure 2**]. This created a new foundation for improving the analysis of observations. Substantially more precise calculation of amplitude of ground displacement soon made it possible to incorporate the earthquake magnitude into seismological practice. After 1956, the sensitivity of seismic stations was further increased and the dynamic and frequency ranges of the recorded signals were widened. Short-period seismographs of high sensitivity were installed at the network stations, as well as long-period instruments and seismographs for recording strong ground motions. In the 1970s, the sensitivity of the equipment increased again, with the dynamic range of instruments increasing to 100 dB. An increase in the number of stations was accompanied by unification and standardization of seismic observations. With a few exceptions, the instrumental and macroseismic data were not cross-correlated or jointly analyzed.



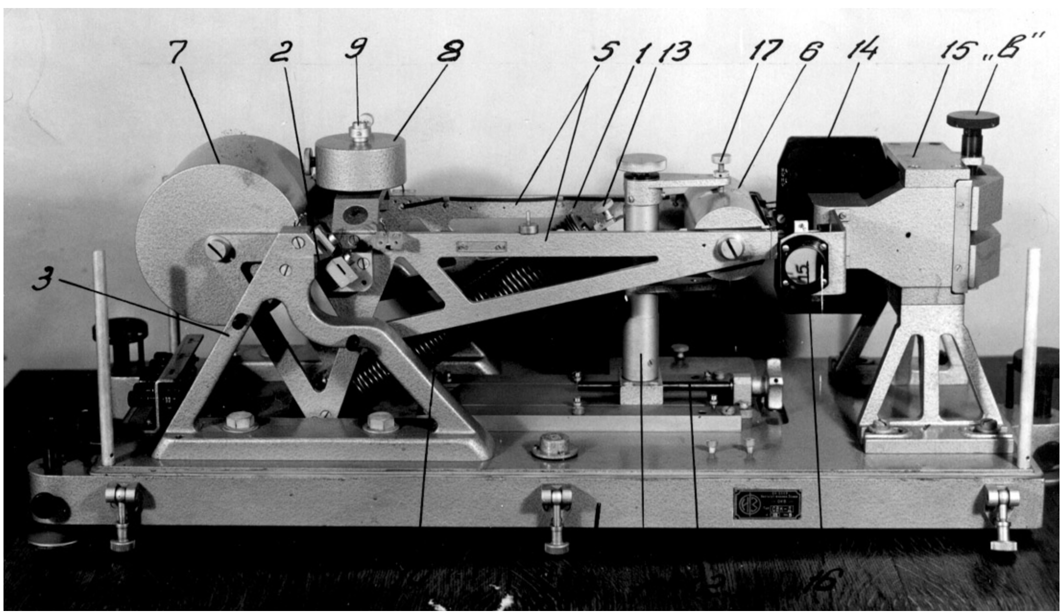


Figure 2. Standard Soviet seismometers. Top: Short-period horizontal SKM-3 (To = 1.2 – 2.0 sec.); Bottom: Intermediate-period vertical SK (To = 10 – 12 sec).

2. PRINCIPAL CATALOG SOURCES

By the end of the 20th century, four principal earthquake catalogs had been compiled and published (one electronically):

1) *The Obninsk Bulletin*, issued every 10-days in the period from 1955 through 1999;

2) The Annual series, "*Earthquakes in the USSR*" (since 1992, "*Earthquakes in Northern Eurasia"*), consisting of the regional catalogs of the *ESSN,* from the Russian abbreviation for *Unified System of Seismic Observation*. Published annually in Russian since 1962, the most recent issue, published in 2000, was for earthquakes in 1994.

3) The "*New Catalog of Strong Earthquakes in the USSR*," compiled by N.V. Shebalin and N.V. Kondorskaya [1974].

4) The *"General Catalog of Earthquakes in North Eurasia"*, compiled by the Institute of Physics of the Earth under the direction of W. Ulomov, including and extending the "*New Catalog*".

Additional event data were taken from the catalog published by *SevMorGeo* [Avetisov, 1996, see ref. 10], the book, *"The Seismic Regionalization of USSR Territory*" [11], and various other publications. Some non-instrumental data were taken from a collection of felt earthquakes by Nikonov and Ananin (still being compiled). At present, not all of the available data are in electronic format. For some of the most seismically active regions, such as Kopetdag, Central Asia and the Far East, the smallest earthquakes (M < 3.5) are unfortunately not yet included.

A diagram illustrating the provenance and publication histories of the various catalogs is shown in **Figure 3**, and summarized in **Table 1.** A comparison of the number of events per year in the principal catalog sources and in the regional catalogs is shown in **Figure 4.**

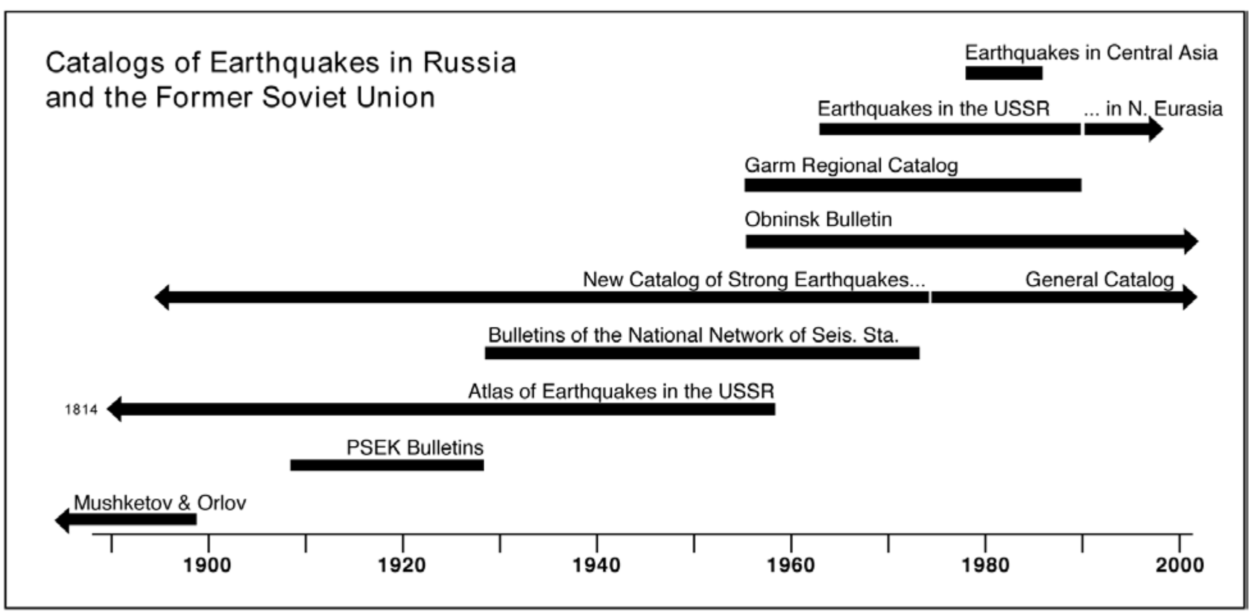


Figure 3. Publication date ranges for the principal Russian and Soviet catalogs of seismicity.

Table 1. Summary of the principal catalogs of seismic events in the former USSR.

Short Name	**Full Name** (in translation)	**Abbrev.**	**Date Range Avail.**
Obninsk Bulletin	Bulletin of the Central Experimental-Methodical Expedition of the Geophysical Survey (CEME GS RAS)	OBN	1955-present
The Annuals	Earthquakes in the USSR; Earthquakes in Northern Eurasia	ESSN	1962-1994
The New Catalog	New Catalog of Strong Earthquakes in the USSR [1973]	NEW	historic through 1973.
The General Catalog	General Catalog of Earthquakes in Northern Eurasia (digital)	GNRL	historic through 1999

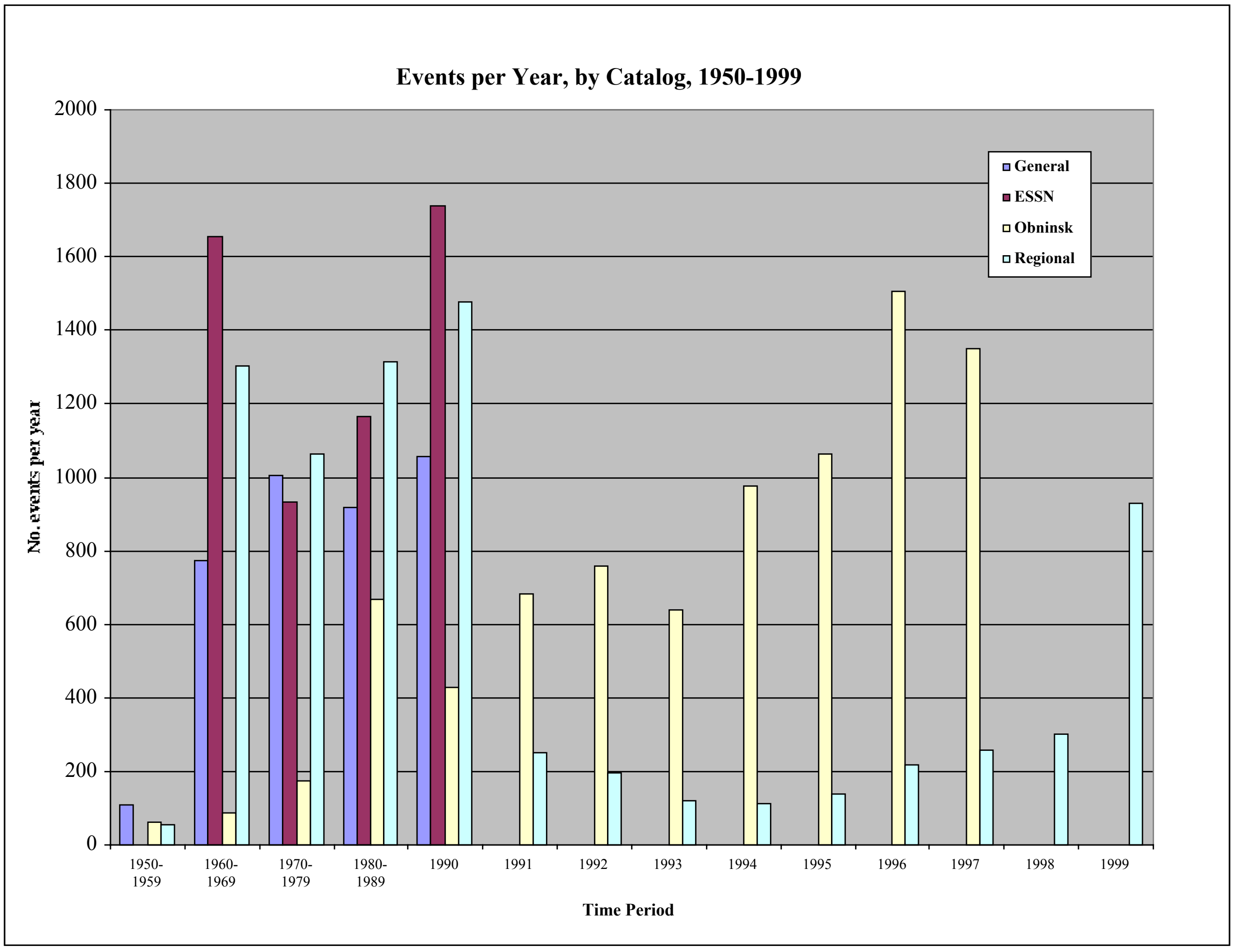
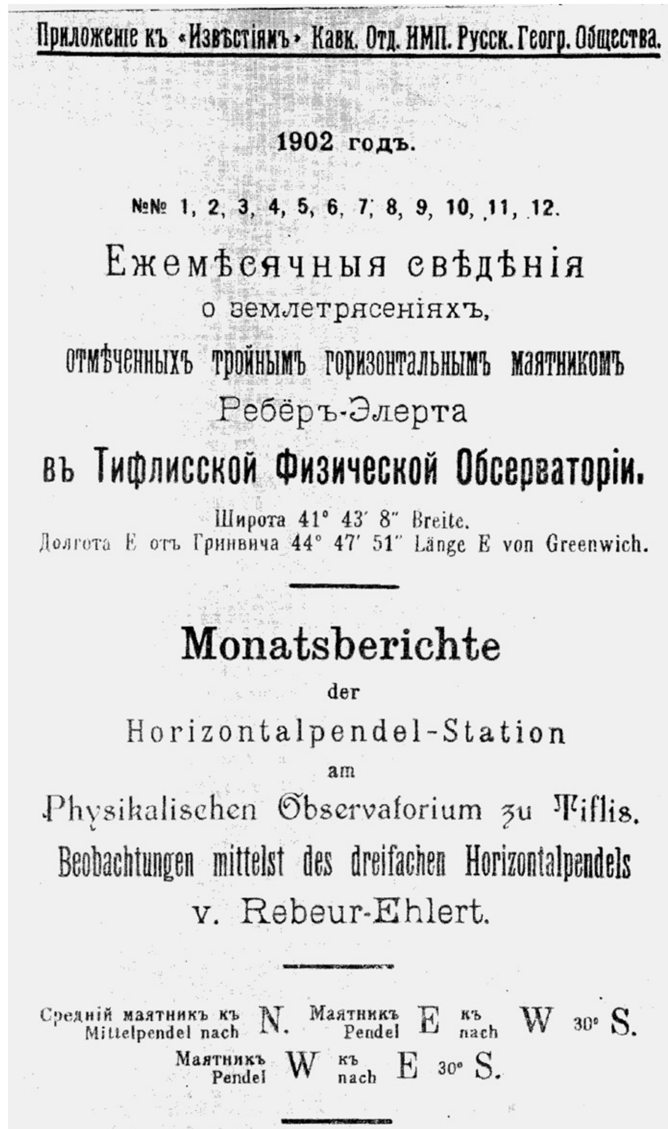


Figure 4. Graph showing the number of events per unit time period, in each of the principal catalog sources and in the composite regional catalogs. Prior to 1990, the time period is decade; from 1990, the time period is one year.

2.1 The Obninsk Bulletin

The “decadal” (10-day) catalog was first issued by the Moscow Institute of Physics of the Earth, beginning in 1955. This catalog was compiled by the Seismological Expedition of Geophysical Survey of the Russian Academy of Sciences (SEME GS RAS). Its publication was delayed only a few months, issued in about 50 paper copies, and sent to all the seismological centers of the former USSR. The Obninsk Observatory later became responsible for preparing the publication (now referred to as the *Obninsk Bulletin*), and it is now available in electronic format in its entirety.

The Bulletin includes the earthquakes recorded by numerous seismic stations (45, as of Dec. 2000) belonging to the Geophysical Survey of the Russian Academy of Sciences. At present, these stations include: 19 digital broadband stations; 2 micro-arrays; and 24 analog, three-component stations equipped with short-period, middle-period and long-period seismometers with analog galvanometer recording on photo paper. The broadband digital stations include 12 stations of the Global Seismic Network (see www.iris.washington.edu/GSN)) and seven stations of Russian manufacture, known as the *Seismic Digital Acquisition Station* (or *SDAS*). The analog stations of the network are equipped with short period (SKM) and long period (SK and SKD) instruments. The data from the teleseismic network of analog stations are transferred to the Obninsk processing center in the form of station summaries in alert and operation modes by regular telephone and teletype lines. The quality of digital station operations are monitored continually, but only periodically for the analog stations. No seismic event parameters are automatically determined.


Приложенiе къ «Извѣстiямъ» Кавк. Отд. ИМП. Русск. Геогр. Общества.

1902 годъ.

№№ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.

Ежемѣсячныя свѣдѣнiя
о землетрясенiяхъ,
отмѣченныхъ тройнымъ горизонтальнымъ маятникомъ
Ребёръ-Элерта
въ Тифлисской Физической Обсерваторiи.

Широта 41° 43′ 8″ Breite.
Долгота E отъ Гринвича 44° 47′ 51″ Länge E von Greenwich.

Monatsberichte
der
Horizontalpendel-Station
am
Physikalischen Observatorium zu Tiflis.
Beobachtungen mittelst des dreifachen Horizontalpendels
v. Rebeur-Ehlert.

Среднiй маятникъ къ Mittelpendel nach N. Маятникъ Pendel E къ nach W 30° S.
Маятникъ Pendel W къ nach E 30° S.

Figure 5. Cover page of the Bulletin of Earthquakes of the Tiflis (Tbilisi, Georgia) Physical Observatory for 1902, recorded on the Rebeur-Ehlert horizontal pendulum.

For the digital recordings, the processing and analysis are done at the Obninsk processing center (CEME GS RAS). For analog seismograms, the analysis is done by the operator of the station(s) with subsequent transfer of results to Obninsk. The decadal catalog (Russian for 10-days) is available after a delay of about 30 days. It includes earthquakes in Russia with M > ~4.5; for the whole of Northern Eurasia, M > ~5.0; and for the globe, with M > ~5,5. The *Bulletin* is sent throughout Russia and to foreign data centers (e.g., in the USA, the USGS National Earthquake Information Center (NEIC), and in the U.K., the International Seismological Center (ISC)). Currently, the Obninsk Bulletin (through 1999) consists of about 41,550 earthquakes, worldwide. About 16,600 events are in the region roughly from 34-90N and 00-195E, including the former USSR and surrounding areas. A comparison of the number of earthquakes in the Obninsk Bulletin in this region during three five-year periods is as follows:

Years	Events
1955-1959	**258**
1975-1979	**1,011**
1995-1999	**6,055**

The Obninsk Bulletin reports origin times, coordinates, depth and magnitudes. Three magnitudes are traditionally reported: a surface wave magnitude *MLH*; a P- wave magnitude from short-period instruments (*Mpsp*; earlier called *MPVA*) and a long-period P-wave (*Mplp*, earlier called *MPVB*). Most events have no magnitudes; these are usually at about 4 < M < 4.5. The intensity data published in the Obninsk Bulletin are taken only from seismic stations as “alert” information, and not included in our composite regional catalogs.

2.2 The Annual "Earthquakes In The USSR"

By 1962, the creation and development of regional seismic surveys led to a tremendous increase in the number of earthquakes detected in northern Eurasia (see **Figure 3**). Subsequently, the Institute of Physics of the Earth began publication of a new yearly summary, "Earthquakes in USSR" (*Zemletriasenniia v SSSR)*, which was a collection of bulletin data from the regional seismological institutes, along with articles on the seismicity of the various geographic regions of the USSR.

Increased coverage, as a result of using regional and local stations, resulted in catalogs that had lower detection thresholds and higher epicentral location accuracies than that of the global catalogs (such as the ISC and USGS), which were based only on teleseismic observations. The much greater resolution of the Annuals is evident from the comparison of these data with the ISC Bulletin made by *Simpson and Lerner-Lam, 1992* [18] for the years 1962-1986, which showed that the annuals have about five times as many events as the ISC Bulletin in that time period.

The data in the Annuals is based on observations solely from stations located within the former USSR. Coverage therefore decreases to the south and southeast. Epicenters are also reported only to the nearest 0.1 or 0.01 degree (11 or 1.1 km), resulting in a gridded pattern on maps of high-seismicity areas when viewed at large scales. Another problem with the catalog is the lack of resolution in depth determinations, which is especially prominent near the boundaries of regions covered by the regional networks. Many events are given zero or no depth (i.e., blank).

2.2.1 Recent Contributors to the Annuals

In Russia, there are currently nine regional surveys operated under the management of Obninsk:

- Geophysical Survey Russian Academy of Sciences (GS RAS); director: Starovoit Oleg E.; E-mail: ostar@gsras.ru; deputy director Golubyatnikov Vyacheslav L.; E-mail: gloria@gsras.ru; 249035, Russia, Kaluga reg., Obninsk, Lenin av., 189, ph. (084) 393-1441, (095) 912-6872, fax: (095) 334-2002.
- Central Experimental-Methodical Expedition of Geophysical Survey Russian Academy of Sciences (CEME GS RAS), director Starovoit Oleg E.; E- mail: ostar@gsras.ru; deputy director Mekhrushev Dmitry Y., E-mail: dima@gsras.ru; 249035, Russia, Kaluga reg., Obninsk, Lenin av. 189, ph. (084)- 393-1441, (095) 912-6872, 334-2002, fax: (095) 334-2002.
- Kamchatka Experimental-Methodical Seismological Department Geophysical Survey Russian Academy of Sciences (KEMSD GS RAS), director Gordeev Evgeniy I.; E- mail: gord@emsd.iks.ru, 683006, Russia, Petropavlovsk-Kamchatskiy, Piip av. 9, ph. (41522) 5-95-31, 595-21, fax: (41522) 5-89-19, 5-95-23.
- Sakhalin Experimental-Methodical Seismological Department Geophysical Survey Russian Academy of Sciences (SEMSD GS RAS), director Kuznetsov Dmitry P.; E-mail: somsp_im@sakhmail.sakhalin.ru; 693010, Russia,

Yuzshno-Sakhalinsk, Tikhookeanskaya st., 2-a, ph. (42422) 3-90-13, fax: (42422) 3-90-13.

- Magadan Experimental-Methodical Seismological Department Geophysical Survey Russian Academy of Sciences (MEMSD GS RAS), director Gunbina Larisa V.; E- mail: glv@gate.emsd.magadan.su; 685024, Russia, Magadan, Skuridin st., 6-b; ph. (41322) 2-23-77, fax. (41322) 2-23-77.
- Dagestan Experimental-Methodical Seismological Department Geophysical Survey Russian Academy of Sciences (DEMSD GS RAS), director Daniyalov Marat G.; E-mail: uuball12@ball12.dagestan.su, 367008, Russia, Dagestan Republic, Makhachkala, Belinskiy st., 16, ph. (8722) 67-02-73, fax. (8722) 67-60-04.
- Kola Regional Seismological Center Geophysical Survey Russian Academy of Sciences (KRSC GS RAS); director Kuzmin Igor A.; E-mail: kuzmin@krsc.ru, admin@krsc.ru; 184200, Russia, Apatity, Murmansk reg., Fersman st. 14; ph. (81555) 7-96-63, fax. (81555) 7-64-25.
- Siberian Geophysical Survey, Branch of Russian Academy of Sciences (GS SB RAS); director GS SB RAS Seleznev Victor S.; E-mail: sels@gs.uiggm.nsc.ru, nata@gs.uiggm.nsc.ru; 630060, Russia, Novosibirsk, Zoologicheskaya st. 8; ph. (3832) 33-20-21.
- Baikal Experimental-Methodical Seismological Expedition Geophysical Survey Siberian Branch Russian Academy of Sciences (BEMSE GS SB RAS); director Masalskiy Oleg K.; E-mail: bomse@irk.ru; 664033, Russia, Irkutsk, Lermontov st., 128; ph. (3952) 46-47-82.
- Yakutiya Experimental-Methodical Seismological Department Geophysical Survey Siberian Branch Russian Academy of Sciences (YaEMSD GS SB RAS); director - Larionov Alexander G.,; E-mail: a.g.larionov@sci.yakutia.ru; 677982, Russia, Yakutsk, Lenin av. 39; ph. (4112) 44-51-88.
- Altai-Sayans Experimental-Methodical Seismological Expedition Geophysical Survey Siberian Branch Russian Academy of Sciences (AS EMSE GS SB RAS); director Emanov Alexander F.; E-mail: emanov@gs.nsc.ru; 630090, Russia, Novosibirsk-90, University av., 3; ph. (3832) 33-27-08, 33-22-15. Seismic network of GS RAS.
- North Caucasus = Obninsk, Central Experimental-Methodical Expedition of Geophysical Survey Russian Academy of Sciences (CEME GS RAS), director Starovoit Oleg E..

The contributors from outside Russia are:

- Carpathian Institute of Geophysics of the Ukranian Academy of Sciences;
- Crimea Institute of Geophysics of the Ukranian Academy of Sciences;
- Kopetdag Institute of Seismology of the Academy of Sciences of Turkmenistan;
- Central Asian Institute of Seismology of the Academy of Sciences of Kyrgyzstan;
- Institute of Seismology of the Academy of Sciences of Kazakstan;
- Institute of Seismology of the Academy of Sciences of Uzbekistan
- North Tien Shan Institute of Seismology of the Academy of Sciences of Kazakstan;
- *Gruziya* Institute of Geophysics of the Academy of Sciences of Georgia;
- Institute of Geophysics and Engineering Seismology of the Academy of Sciences of Armenia;
- Institute of Geology of the Azerbaijan Republic.

2.2.2 The Structure of the Annual

The catalogs completed by each regional survey are only a part of the Annual volume. It includes as well papers describing the seismicity of each zone or region, special papers with detail studies of macroseismic data of strong earthquakes with isoseismal maps, separate papers on large (M>6) earthquakes around the world, tables of fault plane solutions and the spectral content of large earthquakes. As an example of the typical content of the annual "*Earthquakes in the USSR*," the contents of the 1990 volume are duplicated in English in Appendix I.

2.2.3 The Number of Earthquakes in the Annual

Because the monitored regions differ both in terms of in their seismic activity and their areal extent, the yearly number of earthquakes in the various regional catalogs range from a few tens of events to thousands of events. The following table compares the number of earthquakes listed in each zone in 1990 and 1993:

Zone	1990	1993
Carpathians	50	37
Crimea	100	11
Caucasus	300	330
Kopetdag	270	263
Central Asia and Kazakhstan	970	617
North Tien Shan	330	475
Altai and Sayan	110	117
Baikal	230	263
Primorie	320	136
Sakhalin	40	24
Kuril-Okhotsk	630	667
Kamchatka & Komandorskaya Isl.	550	880
North-East	70	40
Yakutia	260	255
Baltic Shield and Arctic	53	2
Large earthquakes in the World	113	100
Yearly total, about…	4,400	4,200

These numbers vary in time not only because of variations in seismicity and changes in the number of operating stations, but also because of changes in a cutoff value of the lower magnitude (or "Energy Class"[1], *K* [12,13]) for earthquakes that were included in Annual Catalog. In 1967, a decision was made to raise the lower energy class limit of earthquakes from 7 to 9, in order to make the Annual catalogs "representative" (comparable) at all geographic zones. While the small events were still characterized at the regional seismic centers, they were not reported in this publication.

For example, in 1990, the Annual Catalog for the Altai & Sayan zone listed 110 earthquakes with Energy Class (K) of 8.5 or larger, while that year about 870 small earthquakes (5 <= K <= 8) were characterized but not published. In the Caucasus, about 1300 small earthquakes (K=5-8) were processed but not included in that year's Annual publication. In the relatively small area monitored by Garm expedition (100 by 150 km), more than 80,000 earthquakes were compiled in the expedition catalog for the time period from 1955 to 1990 (over 2200 per year), but only a small fraction of these events were included in the Annual catalog for Central Asia: for example, in 1964, only 84 earthquakes were reported, with energy class, K > 9.

[1] From the Russian, "Klass".

2.2.4 The Parameters Reported in the ANNUAL Regional Catalogs

As a rule, the following parameters are included in the Regional Catalogs:

- Origin date and time t_o (GMT)
- Coordinates of epicenter
- Depth (in km)
- Energy Class, a measure of energy, where K = log E (in joules)

The Energy Class (from the Russian, *Klass*) determination is standard in most geographic zones (Carpathians, Caucasus, Kopetdag, Central Asia, Kazakstan, Altai-Sayans, Baikal, Yakutia, and North East), but differs slightly in the catalogs for the Crimean region [14]. In the Far East, regional versions of K were created; these are K_{FS} (after S. Fedotov, Kamchatka) and K_C (for Sakhalin, after *Soloviev & Solovieva* [15]).

Unfortunately, when comparing these scales with the more widely used K (sometimes K_R, for K *after Rautian*) via teleseismic magnitudes, the regional versions were found to have a systematical discrepancy:

$K_R = K_{FS} + 0.7$

$K_R = K_C + 1.6$

In 1980, a new movement appeared in the regional seismological surveys, which begin to create their own versions of P-wave magnitude scales for regional distances. The MPVA scale was extended to local and regional distances (tens to hundreds of km), and the surveys begin to include values of these magnitudes in Annual Catalogs. Unfortunately, these regional scales MPVA have the same name as was for the classic teleseismic scale in the Obninsk Bulletin. This would be not bad if the values of regional MPVA were in good accordance with the traditional teleseismic MPVA, but preliminary study shows that they are not. In contrast, the K scale, which is based on the maximum phase of P and S (mainly the Lg wave), is much more stable. The regional variation of amplitude- distance relation is small and negligible. To avoid confusion the name MPVA now means regional P-wave scale. The teleseismic P wave scales are named Mpsp and Mplp (short- and long-period Mp). MPVA are not included in the Composite Regional Catalogs. The main scale used in the Annuals was taken to be *K*, with its Far East and Crimean modifications [15,16]. Energy Class, *K,* was estimated for nearly 100% of the earthquakes in the regional catalogs. For deep Carpathian earthquakes, the MSH scale was used, based on the maximum amplitudes of the S wave (on the horizontal, short-period instrument). The magnitudes of deep Hindu Kush earthquakes were also determined by *K*.

2.3 The "New Catalog Of Strong Earthquakes"

The *New Catalog of Strong Earthquakes in the USSR* (Shebalin and Kondorskaya, 1974), was the first attempt to collect all the data for strong earthquakes together, both for seismological and macroseismic observations. In 1984, data through 1977 were added and the New Catalog was translated into English [16].

The *New Catalog* comprises a huge volume of data, carefully collected and critically analyzed. The macroseismic and instrumental data were made compatible by the development of methods to estimate the epicenter, depth and magnitudes from macroseismic data. The methodological details are explained in the New Catalog.

Note that the *New Catalog* was used in an abbreviated form in the *General Catalog*. All earthquakes were included and the format was nearly the same. However, not all the data from the New Catalog were included in the General Catalog. Specifically, no comments, references or information on macroseismic effects were included, and only some maximum intensity (I_o) determinations.

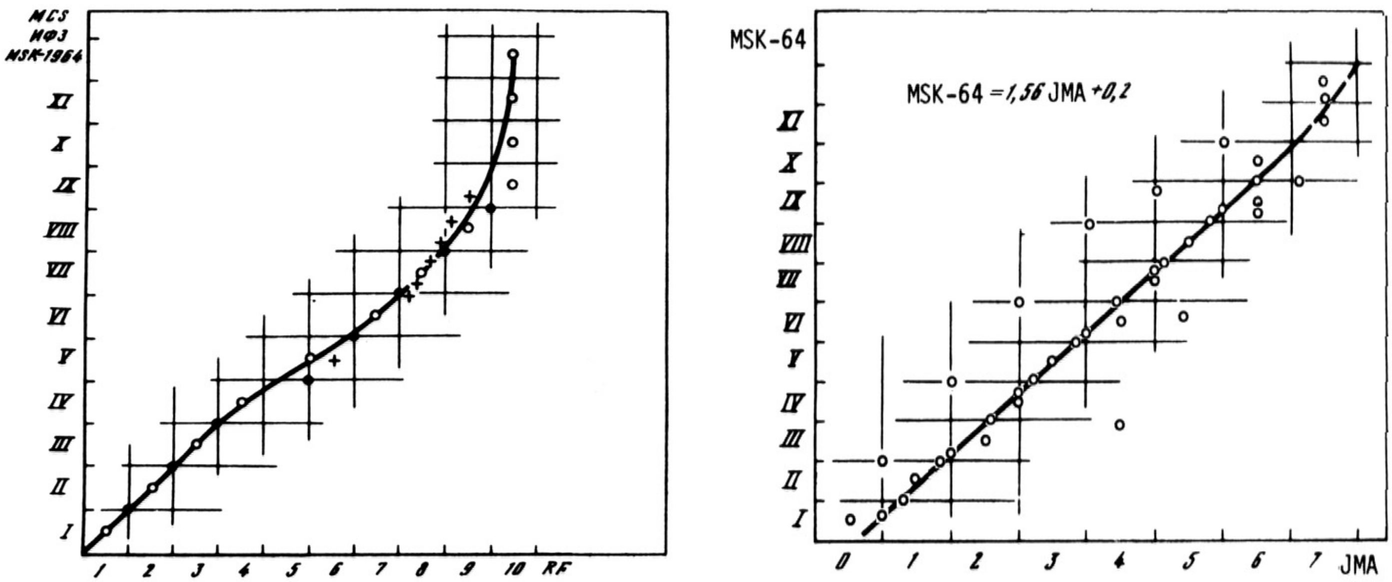


Figure 6. Curves used to convert Rossi-Forel (left) and JMA (right) intensity estimates to the MSK-64 scale (from Shebalin, 1974).

2.3.1 Sources of Data for the New Catalog

The main principles used in preparing the *New Catalog* were to use all available information for each earthquake, and to estimate the most probable values for each of the basic focal parameters. The compilers did not limit themselves to using basic, well-known sources. Attempts were made to seek additional information, through research done in archives and elsewhere. Even for the period 1911- 1957, covered by the "Atlas of Earthquakes In the USSR", many “new” earthquakes were found. The list of references used as a sources of data comprises 20 pages of the published Russian text, and about 30 pages of foreign-language versions.

To compile a chronological foundation for the New Catalog, data were taken from:

- "Atlas of Earthquakes in the U.S.S.R."
- Bulletins of the National Network of Seismic Stations for (1902-12) and (1928-73);
- International Seismological Service (ISS);
- Bulletins of the BCIS and the Preliminary Determination of Epicenters of the USGS;
- Publications of the ISC;
- Individual bulletins of domestic stations (1911-27) and foreign stations (1900-70);
- numerous summaries of macroseismic data, beginning with the catalogs of A. Perrey and A.P. Orlov (both published and in manuscript form).

In addition, a great number of papers and investigations dealing with individual earthquakes were reviewed, along with archive materials, reports of seismic correspondents, extracts from geographic descriptions by travelers and regional specialists, reports in the Soviet and foreign newspapers, and so on. One specific task of the work with the various sources was the elimination of errors --mainly in dating the events, since every error in date, particularly in early sources, is then repeated in subsequent summaries making one earthquake appear as two events.

2.3.2 Processing of Events With Macroseismic Data

In using historic and archival data, the help of historians was particularly important in evaluating the sources and separating true information from anachronisms and fabrications caused by emotional, political, and other factors. Special control of determination of basic parameters from macroseismic data was used. Analysis of the earthquake was made first on the basis on macroseismic data only. The results were then compared with the basic parameters of the earthquake determined from instrumental data. This analysis showed that the procedure for treatment of macroseismic data does make it possible to determine the basic parameters of the focus with adequate reliability. A clearly defined formalism in choosing the parameters and estimating their errors is most important for macroseismic data in the pre-instrumental period. The formalism was described in detail in the New Catalog. The following general principles were used in selecting the final values for the basic parameters and in estimating their precision:

1) Each parameter was determined in several ways where possible;
2) The value of each parameter was chosen to eliminate or minimize contradictions with the raw data;
3) If estimates coincided, the value obtained for the parameter was taken as final, and its error was taken as the minimum of the errors determined by different methods;
4) If estimates differ and the ranges of error overlapped, the final value was chosen in the common range of errors and the value of the error was taken as the minimum;
5) If estimates differ and the ranges of error did not overlap, the one with the least error was taken as the final value and the spread of the determinations was taken as the error;
6) If direct calculation of a parameter was not possible, the seismologically reasonable extreme values were taken as limits, and the final value of the parameter was chosen as the mean of the interval;
7) All errors were rounded upward in a given system of gradations.

Intensity was estimated based on the European *MSK-64* scale. If the data were originally given in the Rossi-Forel or JMA scale and the observational data were unavailable, *a priori* redetermination of intensity was impossible. In such cases, the values of intensity were converted into the MSK-64 scale by graphic relations compiled by N.V. Shebalin (see **Figure 6**). The range of error in intensity was assigned based on the quality and quantity of initial macroseismic data.

Origin Time. Using the macro-seismic data, origin times were assigned based on the individual reports. Dates were converted to modern format (accounting for differences from century to century), and dates according to the Muslim calendar were translated to the European chronology. Times were converted to Greenwich Mean Time. In this process, local time was taken to be that of the local time zone, which is not always accurate. Before the end of the 19th century, the time in nearby major cities was used as local time, with an error generally not more than 30 minutes.

Because the quality of time estimates for older earthquakes were low, we ignored this difference. After the introduction of daylight-savings time in 1931, the corresponding 1-hour corrections were incorporated.

The epicenter, depth (H) and magnitude (M) of earthquake estimation was calculated from intensity (I) using the so called “equation of the macroseismic field”:

$$I = B*M - A \operatorname{Log} R + C;$$

where R is hypocentral distance ($R = (H^2 + D^2)^{1/2}$, where D is epicentral distance), with the empirical parameters A, B and C. These parameters were initially estimated as B = 1.5, A = 3.5, and C = 3.0.

The epicenter of large earthquakes having abundant data was taken as the center of first isoseismal, with an error equal to its average radius. For poor data, or if there was no macroseismic data near the epicenter (due to the earthquake being located at sea or in an uninhabited area, etc), the Golenetski method was used. The equation:

$$I_i - I_k = a \operatorname{Log} (R_{i2}/R_k^2),$$

describes a circle as the locus of the possible position of epicenter. If the coefficient *a* is known, the epicenter can be found with the Wadati method as intersection of loci for several pairs of points. The error of epicenter estimated by this way was taken from 0.2° to 0.5°, depending on magnitude. For earthquakes found from paleoseismic data the epicenter was taken as the center of the paleoseismically-identified fault that presumably generated the earthquake, with an error of half the fault length.

The focal depth was determined by two methods: from the decrease of intensity with distance (using a nomograph), and/or from magnitude and intensity "Io" at the epicenter. The magnitude was determined from the intensity at the epicenter. If the depth could not be estimated, the magnitude was determined from the intensity far from the epicenter, where epicentral and hypocentral distances do not differ. In this manner, the parameters time, location, depth and magnitude were calculated and "non- instrumental" earthquakes became compatible with instrumental ones.

The *New Catalog* includes the radii of isoseismals and in some cases comments about destructive effects, such as landslides, collapse of ancient buildings (churches, fortress) and human loss, if these were mentioned in original sources. There are also comments about the reliability and errors in the referenced sources (the latter were not included in the *General* Catalog, see below).

2.4 The “General” Catalog

The “*General Catalog of Earthquakes in North Eurasia*” is an extension of the previous "New Catalog" by Shebalin and Kondorskaya (1974). It was compiled by the Institute of Physics of the Earth under the direction of W. Ulomov, but never published, and exists only in electronic form. As a source in our Composite Regional Catalogs, it is referred to as "General" (or shortened to "Gnrl").

The GENERAL Catalog provides data for 31,821 events that occurred during the time period from 1900 to 1990 in the region of Eurasia from 30°-90° N and 0°-190° E. Earthquakes that occurred before 1955, when Obninsk began to issue its Bulletin, are mostly taken from the New Catalog, supplemented by macroseismic information and from some local station Bulletins (the sources of data are not documented in the catalog).

The GENERAL Catalog contains a seismic magnitude M, which has been calculated from various kinds of data, as follows:

- the Soviet surface wave magnitude *MLH*, (later renamed to Ms, but really not identical to western Ms), which is determined not from amplitude A but from A/T; both A and T correspond to maximum A on surface wave records (and not necessarily to 20-second period waves).
- The P-wave magnitude, *MPVA* (taken from SKM instrumentation, periods To-1.5-2 sec records) and *MPVB* (taken from SD instrumentation, To=15-20 sec) were used for calculation of M.

The magnitudes of the smaller events were initially characterized by Energy Class (K), as determined by the local surveys. This makes the number of earthquakes in the GENERAL catalog more than twice that of the Obninsk Bulletin; further, *all* events in the GENERAL catalog have a value of M.

The GENERAL catalog has been divided into regions, corresponding to those of the OBNINSK catalog (see the following table). The table below shows the distribution of events versus regions and the magnitude range of earthquakes in each region. Note that the total number of events in the all the regions listed below (N=23,467) are less than in the whole General Catalog, since no data are listed below for Central Asia and Turkmenia , which are highly active.

Region	N	Lat	Lon	M
Aldan	249	52-60	122-142	6.6-3.3
Altai	474	43-60	80- 90	8.0-3.5
Arctic*	334	70-90	0-170	6.8-3.5
Baikal	1967	50-60	102-122	7.6-3.3
Baltic	12	52-60	20- 30	4.7-3.5
Caucasus-East	1074	38-45	44- 51	6.9-3.3
Caucasus-West	317	40-45	37- 44	6.8-3.3
Central Asia	7662	35-44	65- 80	8.3-3.2
Chukotka	37	59-70	165-190	5.8-3.5
Crimea	45	44-46	28- 37	6.8-3.5
Kamchatka	6767	50-60	155-165	8.5-3.5
Kazakstan NE	15	45-60	65- 80	5.8-3.6
Kuriles Is.	1954	45-51	145-164	--N/A--
Primorie-E	649	42-52	131-142	7.8-3.2
Primorie-W	6	48-52	127-131	6.0-3.6
Russia (Central)	3	52-60	30- 54	4.8-3.5
Russia North	13	60-70	30- 54	4.9-3.0
Russia South	12	45-52	37- 54	5.4-3.5
Sakhalin	660	46-55	142-146	7.0-3.3
Sayans	924	50-60	90-102	7.0-3.5
Siberia East	240	59-72	115-165	7.1-3.3
Siberia West	0	60-72	66-115	--N/A--
Ukraine	45	46-52	20-37	5.5-3.4
Urals	15	45-70	54- 66	5.5-3.2

*including the Laptev Sea

2.4.1 Sources of Data for the General Catalog

The General Catalog was converted to electronic format in the 1990s. The compilers at IPE combined data from the *New Catalog*, the Obninsk Bulletin and the annuals (ESSN data), with the goal of making the catalog as homogeneous as possible in terms of seismic magnitude. If two of three sources reported the same event, was only one version was included, as decided by the compiler. The origin time and coordinates were taken from these sources, choosing the most reliable version, or after revising the data. The compilers converted all of the various magnitude scales and energy classes, as well as macroseismic data, into a unified magnitude *M*. The available information on errors were included for all the parameters.

2.4.2 Parameters Reported for All Earthquakes

The parameters reported in General Catalog are:

t_o, the origin time:
Year, Mon, day, hour, min, sec;

Er-t
error in time, along with units of measurement for that error (sec, min, etc.)

Latitude and Longitude
coordinates of epicenter, in degrees;

Er-ep:
error in the epicenter, in degrees;

Dep:
depth of origin, in km;

Er-D:
Error in depth, described as a fraction of the depth, as follows:

(1) - 0.05 Dep,(5%)
(2) - 0.1 Dep,
(3) - 0.2 Dep,
(4) - 0.5 Dep,
(5) - Dep
(6) - 2 Dep (200%)

Meth:
method of depth determination, as follows:

(0) - instrumental
(1) - macroseismic
(2) - assumed

2.4.3 Parameters Based on Macroseismic Data

For events that occurred in the pre-instrumental period, depths were estimated using all available data, and based on the experience of the compilers.

The following additional parameters based on macroseismic data are reported:

M	unified magnitude, determined as identical to M_{LH}, M_{Io}, MD (calculated from the duration of oscillation), or M(K) (defined below).
Er-M	error in the magnitude determination
M(_)	the type of magnitude selected as *M*. If for a particular earthquake, M was taken from instrumentally-estimated MLH, no value is given.
I_o	intensity at the epicenter, observed or calculated
Er-I_o	error in I_o.
Azim	azimuth of fault, if known, or of long diameter of the first isoseismal.

2.4.4 Earthquake Energy and Magnitude Determinations from Instrumental Data

The equations used to calculate the magnitude, M , varied as follows:

I. Large earthquakes (M=>6) if depth is less than 70km

$M = 1.59\ Mplp - 3.97;$

$M = 1.59\ Mpsp - 3.67;$

If the ISC magnitudes were available,

$M = 0.82\ Ms + 1.19$;
$M = 2.13\ mb - 5.85$;

Variations, for some regions, are as follows:

$M = 1.64\ mb - 3.55$;	(Europe)
$M = Ms$;	(Europe)
$M = 1.14\ M_{SH} - 0.9\ Log\ Dep$	(Kurily-Okhotsk);
$M = 0.97\ Mplp + 0.28$	(Moldova);
$M = JMA$	(Japan)
$M = 0.97\ LogMo - 11.49$	(Kamchatka)

II. For moderate earthquakes ($M < 6$), if depth is less than 70 km:

$M = Ms$;	
$M = MSH - 0.5\ Log\ Dep\ (km)$	(Kurily-Okhotsk);
$M = 0.92\ MT + 0.51$	(Moldova);
$M = 0.86\ MT + 0.71$	(Tadjikistan);
$M = 2.13\ mb - 5.85$;	
$M = (K - 4)/1.8$;	
$M = (KFS - 4.6)/1.5$	Kamchatka;
$M = (Kf) - 4.6)/1.65$	Kamchatka, Kurile;
$M = (Kc- 1.2)/2$	Kurily, Okhotsk;

III. For deep earthquakes (depth more than 70 km):

$M = M_{LH} + 0.8$	Hindu Kush, Carpathian;
$M = 2\ Mpv - 7$	Carpathians
$M = 0.49\ K-2.2$	Carpathians

For large ($Mplp > 6$) earthquakes of Kamchatka, depending on depth:

$M = 1.77\ Mplp - 5.5$	Depth < 390 km
$M = 1.77\ Mpsp - 5.2$	Depth < 390 km
$M = 1.85\ Mplp - 5.2$	Depth > 400 km
$M = 1.85\ Mpsp - 4.9$	Depth > 400 km
$M = 0.97\ Log\ Mo$	

For earthquakes in Kurily and Okhotsk Region

$M = M_{SH} - 0.5\ Log\ Dep(km)$	$M_{SH} < 6$
$M = 1.14\ M_{SH} - 0.9\ Log\ Dep$	$M_{SH} > 6$
$M = (K_{FS} - 4.6)/1.5$	
$M = (K_C - 1.2)/2.0$	

IV. Magnitude priority:

If more than one estimate of magnitude is available, the following order of priority was established:

1) The magnitude, obtained from surface waves (the correction for depth added),
2) The magnitude from seismic moment,
3) The magnitude from P-waves,
4) The magnitude from S-waves.

3. COMPOSITE REGIONAL CATALOGS

As described above, the compilers of the four principal source catalogs (*New, Obninsk, ESSN, General*) took different approaches in the compilation of their data, which are reflected in the content and scope of their products. For example, the *New Catalog* attempted to make instrumental and non-instrumental data mutually compatible, and the events therein are described with the same language. Macroseismic data are a significant part the New Catalog, since it was constructed as as source of information on strong earthquakes.

The *Obninsk Bulletin* can be considered to be “conservative”, in that only teleseismic data were used for characterizing events. The *Bulletin* therefore contains only moderate and large earthquakes and only instrumentally-determined magnitudes. While growth in the number of stations over the second half of the 20th century greatly increased the number of earthquakes cataloged by Obninsk, it did not break the principle of stability and conservatism.

In contrast, the Regional (ESSN) surveys worked to characterize as many earthquakes as possible, with the goal of elucidating the detailed spatial distribution of regional seismicity and its relation with regional geological structure.

The *General* catalog was undertaken with the goal of merging all data into a single complete catalog. A “unified magnitude” was adopted and a standard lower cutoff of M=3.5 was imposed.

3.1 Approach

Our principal goal in compiling the Composite Regional Catalogs is to archive as much of the available information as possible, *with no lower magnitude cutoff and no “standardization” of magnitudes*. When integrating the data from the various “ancestral” catalogs, the following approach was taken:

1. If, for particular seismic event, two (or three) source catalogs report identical origin time and coordinates, the event occupies a single record in the database. In the column "Source" these two or three initial catalogs are pointed in "chronological order" of publication (*OBN, ESSN, NEW/GNRL*). Other parameters, from different surveys are placed in the same record, in different fields. They are:

   from *ESSN:* K = energy class

   M(K) = magnitude calculated from K : M(K)=(K-4)/1.8]

   from *OBN:* MLH, Mpsp, and Mplp magnitudes

   from *GNRL:* M = the "unified magnitude"

   M(_) = the magnitude type used to calculate M

   Io = intensity at the epicenter

   Azim = azimuth

2. If the times and/or coordinates are different in initial catalogs (estimated independently), two events are reported, with each source data in a separate record.

3. Events are assigned to a geographic region. The “regionalization” of the Catalog does not precisely coincide with the zones for which each of the separate regional surveys are or were responsible. For example, the Baikal Survey processed and included in its catalog some events with longitudes less than 100°; they were incorporated into the Sayan Regional Catalog. Another example is the situation for Siberia, where the Yakutsk survey is responsible for the huge area, including the Aldan, East Siberia and Chukotka.

4. For several regions (Turkmenia, Central Asia, Primorie & Priamurie, Sakhalin, Kurile, Kamchatka), ESSN data are not yet available in digital form, so only the Obninsk and General catalogs were used in the compilations to date.

The catalogs can be divided into two time periods: “historical” (prior to 1962) and “modern” (from 1962 through 1999). The first period includes the available data on errors, as estimated or assumed by the compilers of the *New* and *General* catalogs. In the so-called “modern observation period,” the errors are smaller then in the historical period. Note also that error estimates were not included in all of the regional catalogs, and when they were reported, they were mostly assumed values. For example, the density of seismic stations was generally not sufficient to discriminate a depth of 5, 10, or even from 15 km. Therefore, the depths of many events are presumed. The accuracy of these determinations can be evaluated by comparing separate analyses of the data for events that were recorded and processed by neighboring surveys, by regional and independent (e.g., Obninsk) determinations, or by comparing with the revised estimations by authors of the *General Catalog* or other special studies. For these reasons, the data about accuracy are not included in 1962-99 catalogs.

3.2 Parameters Included in the Composite Regional Catalogs.

The catalogs for the early time periods have nearly the same parameters as those in the *General* catalog, and are included in the same format. But there is a difference: because the Obninsk Bulletin begins in 1955, the magnitudes MLH were included in it. Therefore an additional column "MLH" was included in the Composite Regional Catalogs.

For recent years, the catalogs report origin time, coordinates, depth, energy class K (from ESSN), M(K) (calculated by us for consistency), M and M(_) (from the General Catalog), three classical magnitudes (MLH, Mpsp and Mplp, from the Obninsk Bulletin), maximum intensity, Io and azimuth (from the General Catalog. The data from the Annuals are marked in the Composite Regional Catalogs as "ESSN" (from the Russian abbreviation for "Unified Survey of Seismic Observation"; the identifier "ESSN" was used for all the regional data published in the annual publication, “Earthquakes in the USSR” (described above), without mention of which regional center provided the data).

3.3 The regionalization

The system of regional networks, and the responsibilities of the regional seismological centers for monitoring the seismicity and characterizing events in their regions, was established mainly for political and administrative reasons. Some broad territories, like Central Russia and the Urals, were designated as regions, even though they had no regional network or survey.

The boundaries between the various Soviet/Russian administrative regions were important for regional surveys, defining their areas of responsibility. However, these politically based geographic divisions are not particularly useful to Earth scientists (“earthquakes know only natural boundaries”). Therefore, in the Composite Regional Catalogs, we have defined regions based not only on historical reporting responsibilities, network distributions and basic geographic features, but also on the spatial distribution of seismicity and tectonic features.

The entire territory of the former Soviet Union has been divided into contiguous regions (see **Table 2**). Some low-seismicity regions are poorly represented in the available catalog sources and appear as “blank spots” on seismicity maps. Also, Russia, the Urals, West Siberia, and North Kazakhstan have a low and poorly studied seismicity, but known intensive blasting. Most of the available information for events in these regions are for non-instrumentally recorded earthquakes. The following Table lists the latitude-longitude boundaries of the regions for which composite regional catalogs are being constructed.

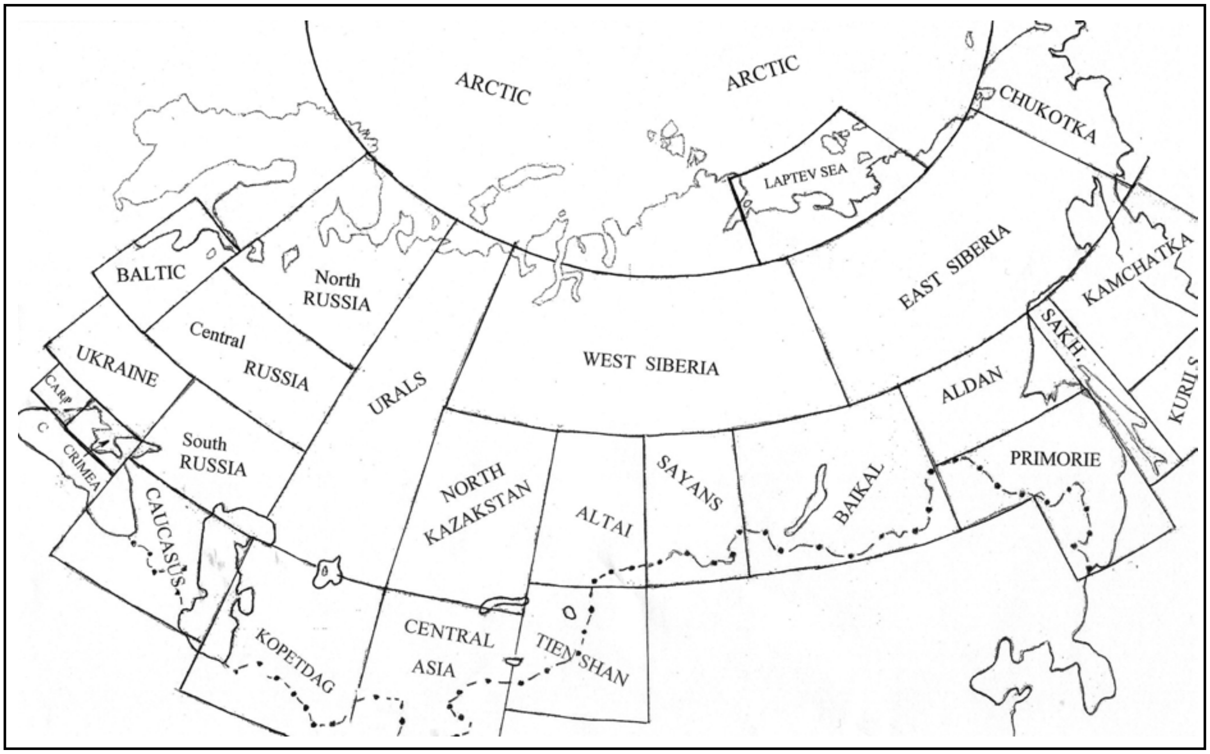


Figure 7. Map of the former Soviet Union, showing the regions used in constructing the composite regional catalogs

TABLE 2. GEOGRAPHIC REGIONALIZATION

Region	**Latitude N**	**Longitude E**	**Region**	**Latitude N**	**Longitude E**
ALDAN	52-58	122-142	KURILES	45-51	145-165
ALTAI	43-58	80- 87	PRIMORIE	48-52	122-141.5
ARCTIC	70-90	00-150	and	43-48	130-141.5
ASIA Central	35-45	65- 82	RUSSIA North	58-70	28- 52
BALTIC	52-60	20- 30	RUSSIA Central	52-58	30- 52
BAIKAL	50-58	100-122	RUSSIA South	46.5-52	37- 52
CAUCASUS	38-44	37- 52	SAYANS	46-58	87-100
CRIMEA	43.5-46.5	30- 37	SAKHALIN	45-58	142-145
CARPATHIA	45-46.5	22- 30	SIBERIA East	58-70	110-165
CHUKOTKA	58-72	165-195	SIBERIA West	58-70	70-110
KAMCHATKA	51-58	154-170	CENTRAL ASIA	36-45	65- 82
KAZAKSTAN North	45-58	52- 80	UKRAINE	46.5-52	22- 37
KOPETDAG	35-45	52- 65	URALS	45-70	52- 65

A map of the epicenters of events in the General and composite regional catalogs is shown in **Figure 8.** In this presentation, the epicenters of events in the regional catalogs overlay the epicenters of events in the general catalog. This emphasizes the spatial distribution of events in the regional catalogs. **Appendix 2** provides detailed comments on the construction and content of the composite regional catalog for each of the regions.

SUMMARY

We have made substantial progress toward the goal of completing uniform regional catalogs of seismicity of Russian and the former Soviet Union, using and documenting all available major catalog sources, with no standardization of magnitudes and no lower magnitude cutoff. These catalogs therefore contain the best available representation of the seismicity of the former Soviet Union, particularly at low magnitudes. Completion of this work will require digitizing the remaining catalogs of the various regional seismological institutes. A prototype web site for the distribution of these data is available through the U.S. Geological Survey, at: http://geology.er.usgs.gov/gmapeast/kaz/.

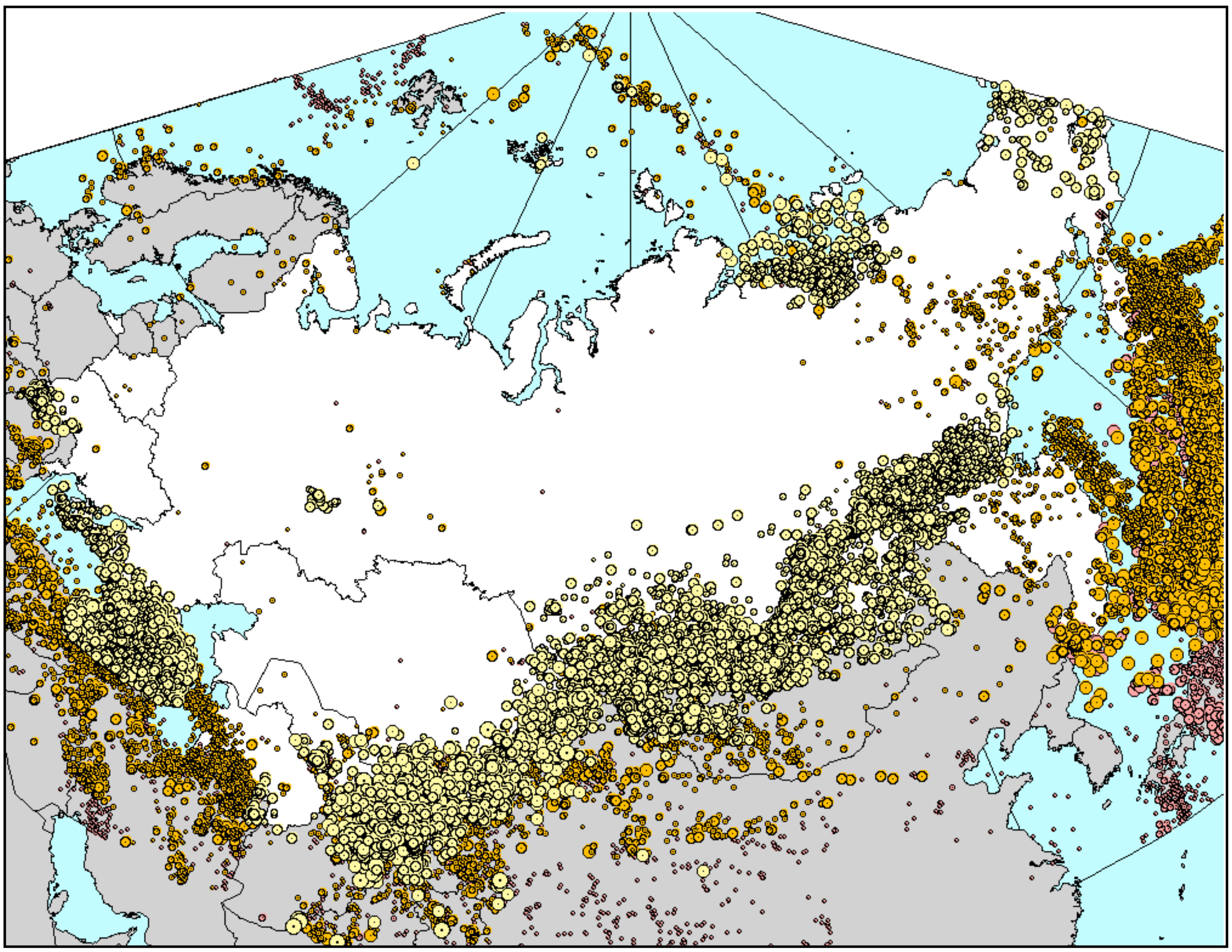


Figure 8. Map of epicenters in the Obninsk Bulletin (pink), overlain by those of the General Catalog (orange), overlain by epicenters of events in the Annual catalogs (yellow). Maps epicenter of events in the Composite Regional Catalogs are shown in Figures A1-A9.

Acknowledgements

We gratefully acknowledge support from the U.S. Geological Survey and the U.S. Department of State. This work benefited greatly from the expertise, contributions and reviews of Vitaliy Khalturin, and from reviews by James Dewey, Shane Detweiler, Masha Krasnova and Irina Artimeva. We also thank Danielle Denenny, Kim Buttleman, Fred Riggle and Steve Schindler, for assistance in building and maintaining the web site.

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APPENDIX I: CONTENTS OF THE ANNUAL PUBLICATION, "EARTHQUAKES IN THE USSR IN 1990"

continues

REGIONAL CATALOGS

APPENDIX 2: NOTES ON THE REGIONAL CATALOGS

ALDAN REGION

This region is named after the Aldan river, a tributary of the great Lena River. In language here is of the Turkish family, and "Aldan" or "Altyn" means "gold" --gold mining was the first industry to develop after the Russians arrived there. In the early years, the local people were mostly hunters, so historical information about earthquakes is very poor and begins from only 1776.

In defining this region, the western boundary between the Aldan and Baikal Regions was chosen at 122E. This is the longitude, where the Yablonovy ridge in the Baikal Region, extending in a NE direction, is sharply crossed by Stanovoy ridge, running here in a SE direction. Another significant ridge, called the Dzgugdzhur, curves slightly along the coast of the Sea of Okhotsk. Together, these two ridges form an arc of about 140 degrees, extending from 122E to 132E, with a geometrical center at East Siberia.

In main source catalogs, the numbers of earthquakes and their magnitude ranges are as follows:

Gnrl	before 1962	17	M:	4.2-6.0	(17)
Gnrl	1962-1990	286	M:	3.3-6.6	(286)
Obn	before 1962	1	MLH:	6.3	(1)
	1955-1999	33	Mpsp:	4.0-6.2	(20)
			Mplp:	4.8-6.3	(8)
			MLH:	4.0-6.6	(19)
ESSN	1962-1990	2851	K:	7.0-16.5	(2849)
	with K converted into		M(K):	1.1-6.9	(2849)

The number of earthquakes in the Aldan region listed in the ESSN (local catalog) increased along with the development of seismic network here:

Range of Years	Number per year
1962-1965	19
1966-1969	11
1970-1974	128
1975-1979	113
1980-1984	98
1985-1989	144
1990	211

Before 1980, the lowest reported value of K was 8 (M(K)=2.2); becoming 7.5 (M(K)=2.0), from 1980 onwards.

The local seismic surveys in this region previously did not include depth among the parameters reported in their catalogs. The Obninsk Bulletin mostly gives a depth of 3 or 33 km; this simply reflects which travel-time table was used. The General catalog mostly gives depths of 15 km, assuming that this value is typical. It is therefore assumed that only values that are different from 3, 15 or 33 km are not default values, but are actually the results of determinations.

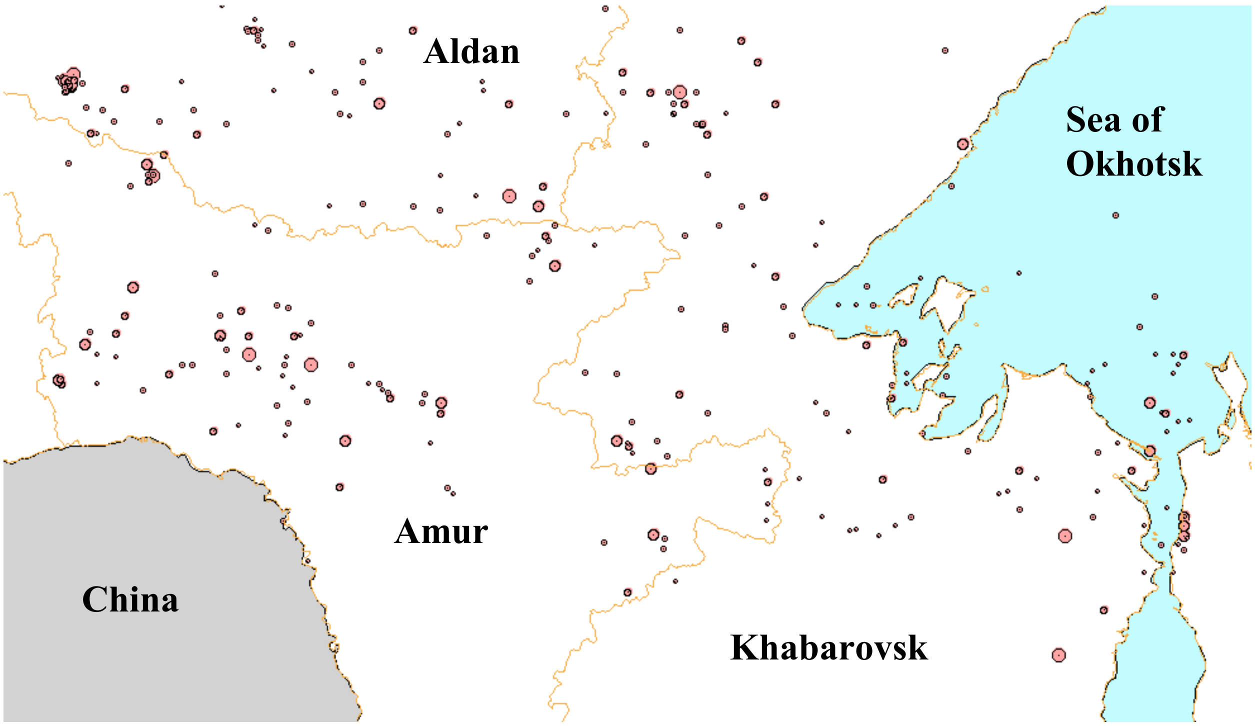

Figure A1. Map of epicenters in the Composite Regional Catalog for the Aldan Region.

ALTAI REGION

Altai, a "Russification" of Turkish word *Alatau* or *Alatoo*, means "mottled mountain" ——whitish-blue snow on top, gray rocks, golden and dark green forests with numerous bright-red tulips—— they really are mottled. There are many coal mines and quarries in the region, which are important for producing iron for factories in the Ural Mountain region. Seismic events from blasting activities make up about half of the events recorded here.

The first earthquake documented here was in the year 1716, and the 31 catalog events that are known from before 1900 were characterized by macroseismic data. Of the 80 earthquakes documented between 1900 and 1961, only 7 were listed in the Obninsk Bulletin (1955-61). Until 1921, the origin times are quite imprecise, with errors ranging from hours to years. Later, from 1927 till 1960, errors in t_o became less, ranging from 3-5 sec. to 20 sec.

Local seismic stations began operating in 1962. Some of the earthquakes that are included in the Obninsk Catalog are therefore not present in the Annual catalog.

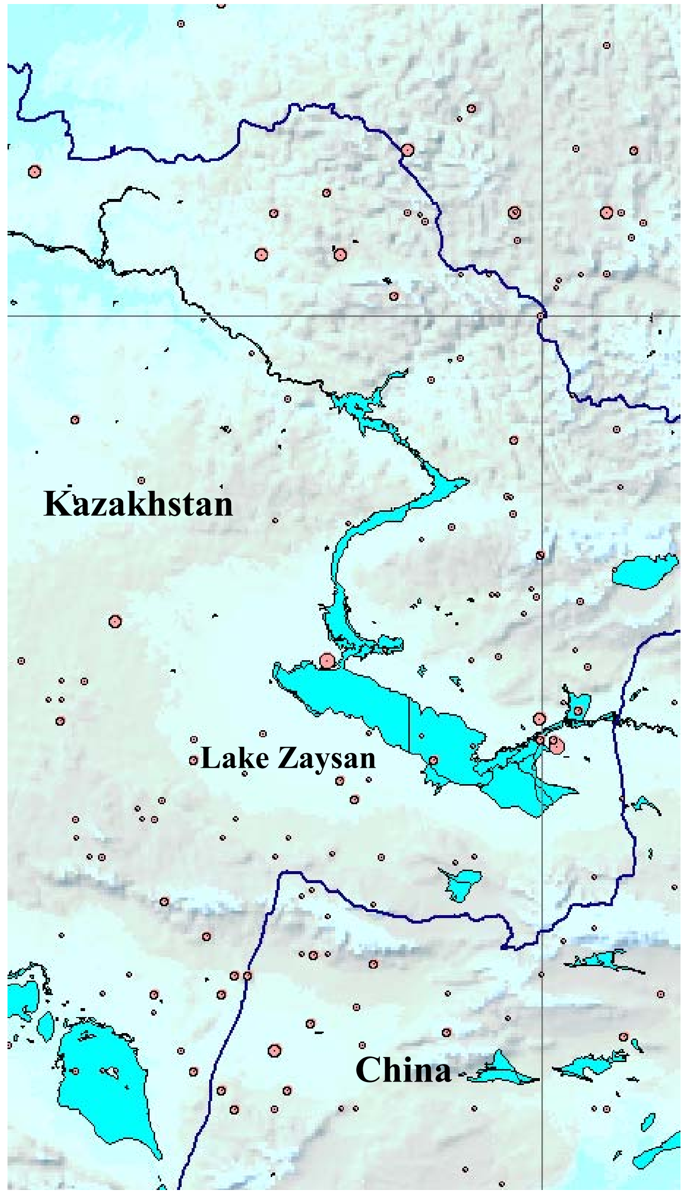

Figure A2. Map of epicenters in the Composite Regional Catalog for the Altai Region.

The number of earthquakes in the source catalogs are as follows:

Gnrl	1716-1900	31	M:	4.2-6.0	(17)
	1901-1930	18	M:	3.7-6.5	
	1931-1961	65	M:	3.5-7.1	
Obn	1955-1961	7	M:	5.0-6.5	

Almost all of these were doubled in the General Eurasian Catalog:

Gnrl	1962-1990	225	M:	3.5-6.9	(225)
Obn	1961-1999	91	Mpsp:	4.2-6.1	(51)
			Mplp:	4.9-6.3	(8)
			MLH:	3.7-6.3	(41)
			no magnitude		(26)
Annuals	1962-1990	646	K:	6.0-14.5	(645)
	or, if converted into		M(K):	1.1-5.9	(645)

After 1961, the estimates of error that were included in the General Catalog were excluded from the Altai Regional Catalog. Only beginning about 1980 did origin time errors became as small as 1-2 sec., while from 1962 through the 1970s they range from 1-2 sec. to 10 sec.

The local surveys contributing to the Annual usually did not estimate the depth at all, reasonably believing that errors are too serious to say more than that all of the events are inside the upper part of the crust. The depth values in the General Catalog are mostly just assumed (e.g., 3, 15 or 33 km). The value of 15 km was assumed as "typical". Values of 3 or 33 were taken from the Obninsk Bulletin, and mean no more than to indicate the kind Travel Time Table used in the determination. Depth values different from these three are probably based on the seismological recordings when the nearest station was close to epicenter.

The Altai region has numerous quarries with active blasting. The Local seismological survey generally tried to identify these events as distinct from natural earthquakes and exclude then from the Catalogs. The time distribution of events 1962-1990, after this “cleaning," appears as follows:

GMT	N	GMT	N	GMT	N
00-01	40	08-09	37	16-17	48
01-02	37	09-10	56	17-18	33
02-03	30	10-11	47	18-19	45
03-04	29	11-12	47	19-20	51
04-05	33	12-13	51	20-21	37
05-06	45	13-14	35	21-22	42
06-07	42	14-15	35	22-23	34
07-08	31	15-16	47	23-24	30

Local time is usually GMT +7 hours. It appears that the maximum seismic activity is from 05-07h GMT (i.e., 12:00-14:00 local time, corresponding roughly to the lunch break), with a second peak of activity falling at 09-13 GMT (16:00-20:00 local time, the end of workday), a typical time to prepare the quarry for the next day. Although these daily maxima are not pronounced, we estimate that many tens of mine blast events escaped the “filtering” process, were linked into the Annual bulletins, and are therefore still included in the Altai Composite Regional catalog.

ARCTIC REGION

Seismic observation in Arctic began in 1906, with the opening of the Swedish station at *Abisco*. Subsequently, other countries (Greenland, Canada, Scandinavia), opened stations in the Arctic region.

Year range	Grnlnd		Canada		Alaska		Scand		Spits.		Russia		Total
Before 1950	1	-	-	-	-	-	1	-	1	1	-	1	2-3
1950 - 1960	2	-	1	-	-	-	3	1	1	-	3	-	11-12
1961 - 1970	4	3	4	1	1	-	2	1	1	-	3	1	20-26
1971 - 1980	2	2	3	-	8	2	-	-	1	1	-	-	29-34
1981 - 1990	-	-	2	1	2	-	3	-	3	-	4	-	43-44

The locations of Arctic earthquakes in the New and General Catalogs were based on the data from all of these international seismic stations. Of the 41 earthquakes that make up the Regional Arctic Catalog before 1962, eight of them were taken from the Obninsk Bulletin. The magnitude range is 4.5-6.8. Later, with the installation of the seismic stations *Kheis* (on Franz-Joseph Land), *Barenzburg* and *Piramida* (Spitsbergen), along with stations in Siberia, arctic earthquakes could be located with Soviet stations alone, and they appeared in the Obninsk Bulletin and the Annual Catalogs.

In 1968, *SevMorGeo* (Inst. of Geology of the North Sea) began observations using temporary seismic stations (see Table, below). The instrumentation was with the system *"VEGIK"*, with a flat frequency response from 0.8-10 Hz and magnification about 30k-40k.

Temp. Station	Coordinates		Period of work
Arcticheskaya	80.8	46.8	1968 Jul 28 - 1970
"Temporary"	75.45	137.46	1972 Aug 01 - Sep 30
			1973 Jun 11 - Aug 09
Kigilakh	73.22	139.52	1973 Jun 30 - Sep 12
			1974 Mar 20 - Apr.23
Dymnoe	73.14	142.24	1974 Mar 18 - Apr.22
Bunge Land	74.50	142.35	1975 Apr 15 - Jun 14
New Siberia	75.03	147.00	1975 Apr 16 - Jun 15
Udzha	71.15	117.10	1975 Aug 27 - Sep 19
Khalganakh	71.50	114.20	1975 Jul 21 - Aug 10
Chochurdakh	72.50	116.15	1975 Aug 13 - Sep 21
P.Khvoinova	74.15	140.53	1976 Apr 18 - Jun 24
P.Herpichy	75.50	143 20	1976 Apr 25 - Jun 27
p.Diring-Ayan	75.57	139.55	1976 May 28 - Jun 23

Between 1985 and 1988, observations were made in the delta of the Lena River. During a period of 9 months, 140 earthquakes were recorded, 121 of which were located and characterized. These data are not listed in the Annual Catalog, but were taken from Avetisov [10]. In the Arctic composite regional catalog, the magnitude *mb* is used, either as estimated by the Seismic Center in Apatity or as taken from the ISC.

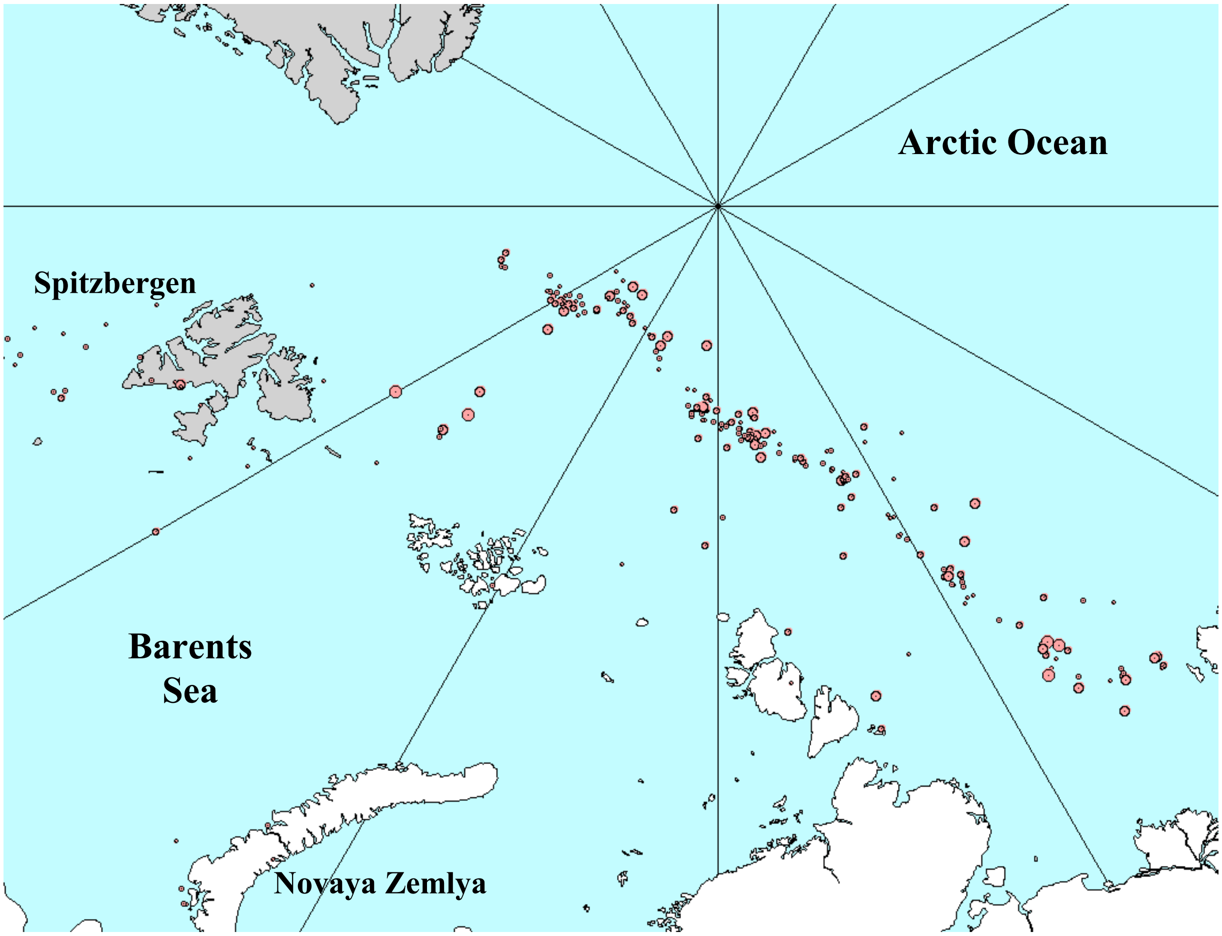

Figure A3. Map of epicenters in the Composite Regional Catalog for the Arctic Region.

BAIKAL REGION

The Baikal region (48-58N; 100-122E) can be divided into three areas of differing seismicity: Baikal Lake, itself, including branches of secondary rift zones with high levels of seismicity; Southeast of Lake Baikal, where the seismicity appears scattered, having no clear structure; and Northwest of Lake Baikal, where there were very few earthquakes recorded by the network, although there are a number of events from industrial blasting in quarries.

Careful paleoseismic study in this region has resulted in the identification of 30 earthquakes in the period from the year 200 until the end of the nineteenth century. Historical information was found for more than 250 earthquakes, and their time, location and magnitudes were estimated. The General Catalog includes 558 earthquakes for the time period before 1961. Since 1955, the Obninsk Bulletin contains 17 earthquakes; 8 of these have identical parameters in the General Catalog.

In the first few years of the operation of the local network, the lower limit of event size for inclusion in the catalog was about Energy Class K=7; nevertheless, about 100 earthquakes with 5 < K < 6 were reported. The number of events reported during the five-year period from 1962-1966 is 5,394 —more than a thousand per year. In 1967, the lower limit of Energy Class for publication was raised, to K=9. During the 23 years from 1967 until 1990, the average number of earthquakes in catalog decreased by two-thirds, to an average of about 300 per year.

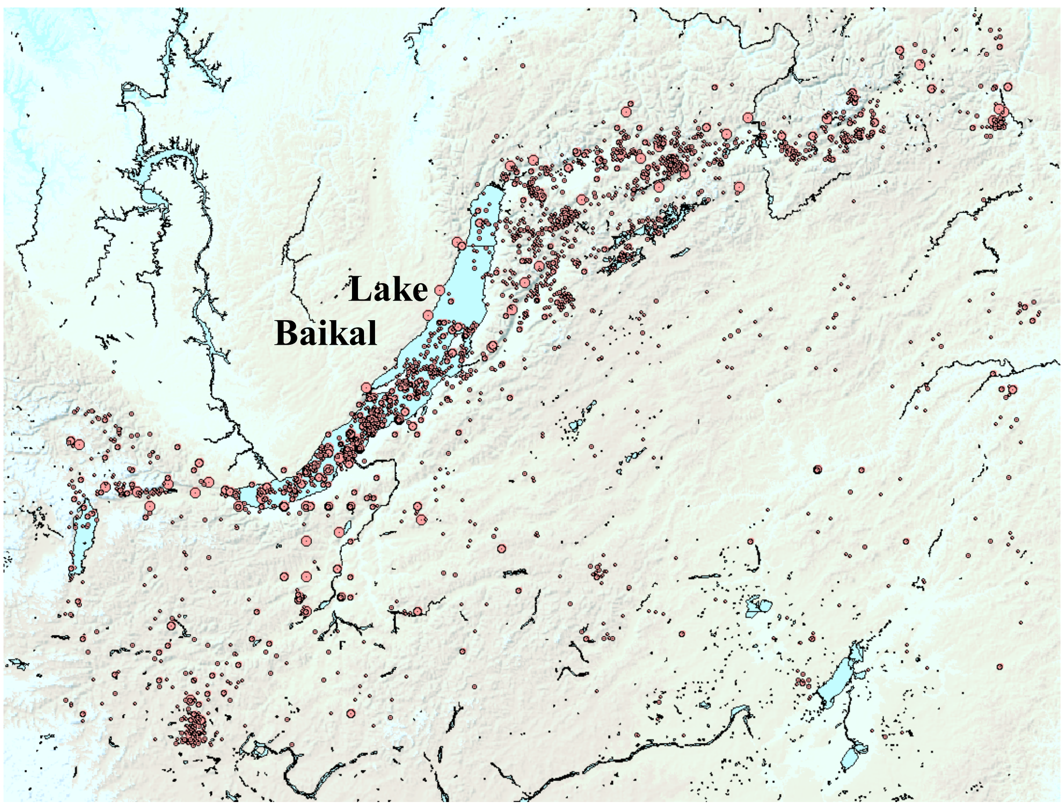

Figure A4. Map of epicenters in the Composite Regional Catalog for the Baykal Region.

BALTIC and BELORUSSIA REGIONS

(52-60N; 20-30E)

This region includes territories of Estonia, Latvia, Lithuania and Belorussia. The region has a low seismicity, but studies have found 16 historical earthquakes. Seven earthquakes occurred in the recent (instrumental) period; among them an Estonian earthquake with M=4.7. The detailed study of Byelorussia near Soligorsk ("Salt mountain") station, began in 1983. This station is located at approximately at 52.9N 27.8E.

At Soligorsk, instrumentation was installed in a mine, 600 m deep. The result supports the existence of seismicity here, connected with a fault system. During the years 1983-1986, 146 small earthquakes were recorded with energy class (K) from 6.0 to 9.5. For most of them, recorded by single station, no epicenter was estimated. All are in the vicinity of Soligorsk. The S-P times vary from 2 to 5 sec; a very few events reach 8-10 of S-P time. Almost all these events are, therefore, located inside the area of 40-50 km radius around the Soligorsk; approximately 52.5-53.5N; 26.5-28E.

Some earthquakes are at distances sufficiently large that they do not originate from mining activity but are of "normal tectonic nature". Only one event coincides with the collapse of a mine roof. The calculated energy of rocks falling is about 100 times less than the seismic energy of the event. So the collapse could hardly have been the source of the observed seismic waves (although perhaps it could have triggered the event). It seems to be more probable that event in mine was a result of earthquake.

While there are a lot of explosions in the region, the few known earthquake epicenters were mostly located by western seismic surveys, especially that of Finland. The clusters of epicenters are located at the places of active quarry blasting, especially along the Gulf of Finland. They have a classic "daytime" distribution. No Russian survey has collected or processed the data it recorded.

CARPATHIAN REGION

Because this region includes a territory of ancient high civilization, historical information for large earthquakes was found as early as about 500 years BC. In the General Catalog, 90 earthquakes were reported for the period before 1990, with magnitudes between 5.8 and 8.0; 363 more events are reported from the early instrumental period, 1900-1961. Among these, only 24 (about 5%) have estimated depths of 50 km or more. This contrasts sharply with the 495 deep earthquakes, of a total of 637, in the 1962-1999 period. This discrepancy may be because the deeper events produced smaller macroseismic effects and were, therefore, rarely noted in historical records.

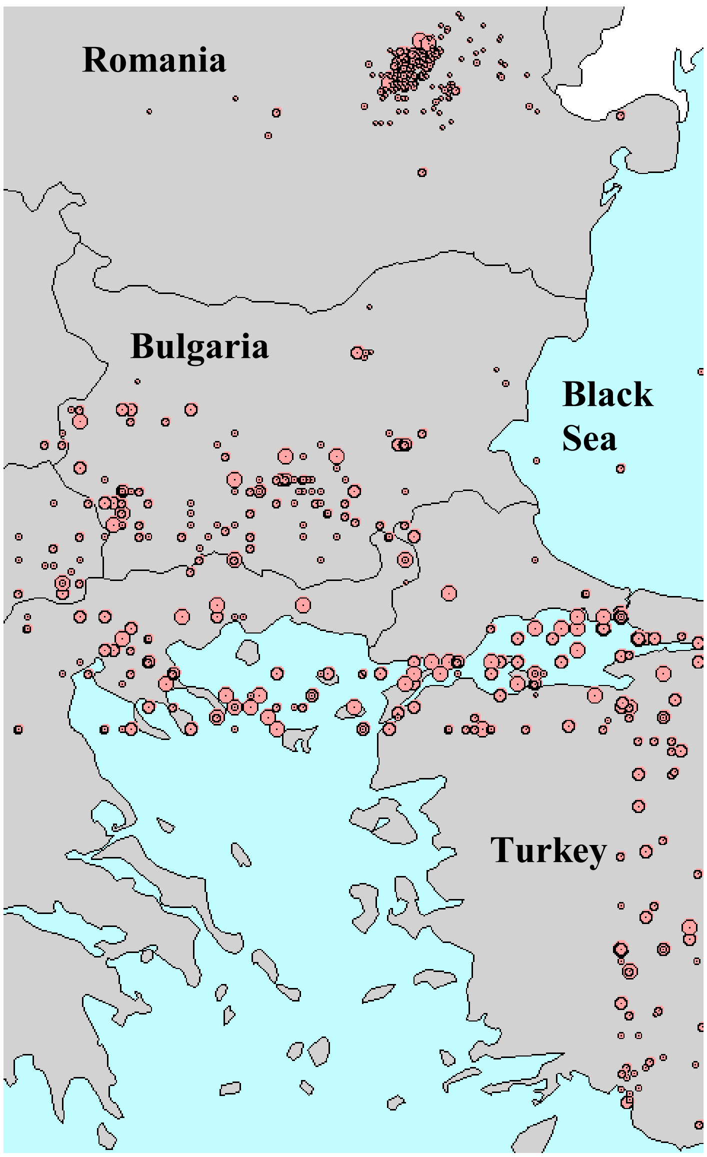

Figure A5. Map of epicenters in the Composite Regional Catalog for the Carpathian Region.

CAUCASUS REGION

The territory of the Caucasus Region (38-46.5N; 37-52E) includes Azerbaijan, Georgia, Armenia and the Russian North Caucasus. Six large events here are known from the period BC; twenty in the first millennium, and 292 in the years between 1000 and 1990. In the early instrumental period (1900-1961), 483 events were reported, or about 700 per year. Between 1962 and 1966, the minimum published energy class, K, was 6-7, and during this time 3484 earthquakes were included in the catalog. Beginning from 1967 the minimum level of K was increased to 9, with the goal of making the catalog more representative geographically as discussed above. As a result, during the 23 years from 1967 to 1990, the average number of events per year was halved. Note that several earthquakes about 100 km deep were reported beneath the Main Caucasian Ridge.

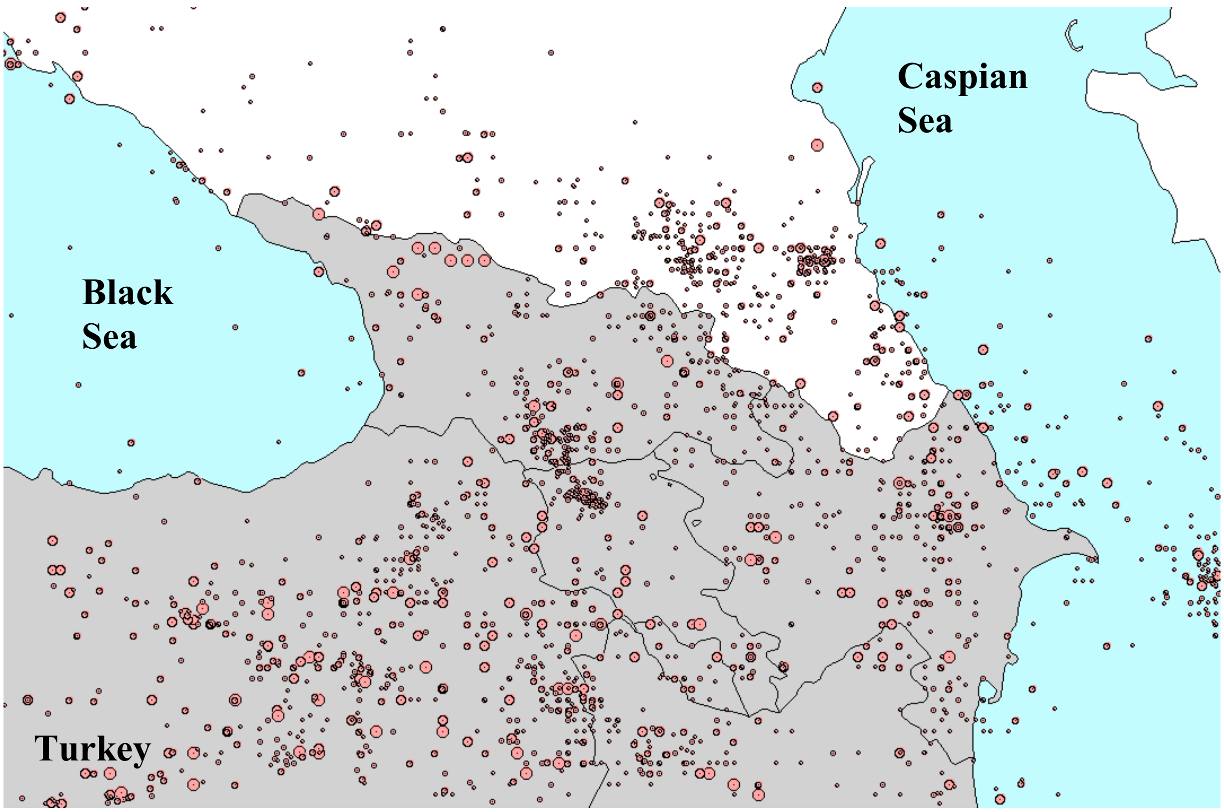

Figure A6. Map of epicenters in the Composite Regional Catalog for the Caucasus Region.

CENTRAL ASIA REGION

Central Asia is one of the most highly seismic zones in Central Eurasia. This Region includes the Hindu Kush zone, where a large number of deep earthquakes occur. Earthquakes from the Hindu Kush are routinely felt in Tadjikistan and Kirgyzstan. Local networks in Tadjikistan, Kyrgyzia, and Uzbekistan consist of many closely-spaced stations, and the epicentral locations in this region are of high accuracy. In the relatively small area (100x150 km) where the Garm Expedition worked from 1955 till 1992, more than 80,000 earthquakes were listed.

The Central Asian Regional Catalog (35-45N; 65-82E) includes 74 historical earthquakes from the year 250 BCE to 1899, with magnitudes ranging from 5 to 8.3. In the early instrumental period (1900-1961), the General Catalog contains 1068 earthquakes, compared to about 200 in the Obninsk Bulletin. About half of them have identical parameters in the two Catalogs.

During the period from 1962 to 1999, 6549 Central Asian earthquakes were taken from the General Catalog, and 1964 from Obninsk catalog. Only 123 of them have identical parameters in both sources; many more differ in origin time or/and coordinates.

A significant fraction of the earthquakes are deep, with depths 50 to 300 km or more. There are 329 deep earthquakes reported for the period before 1962 and about 3,000 from 1962-1999.

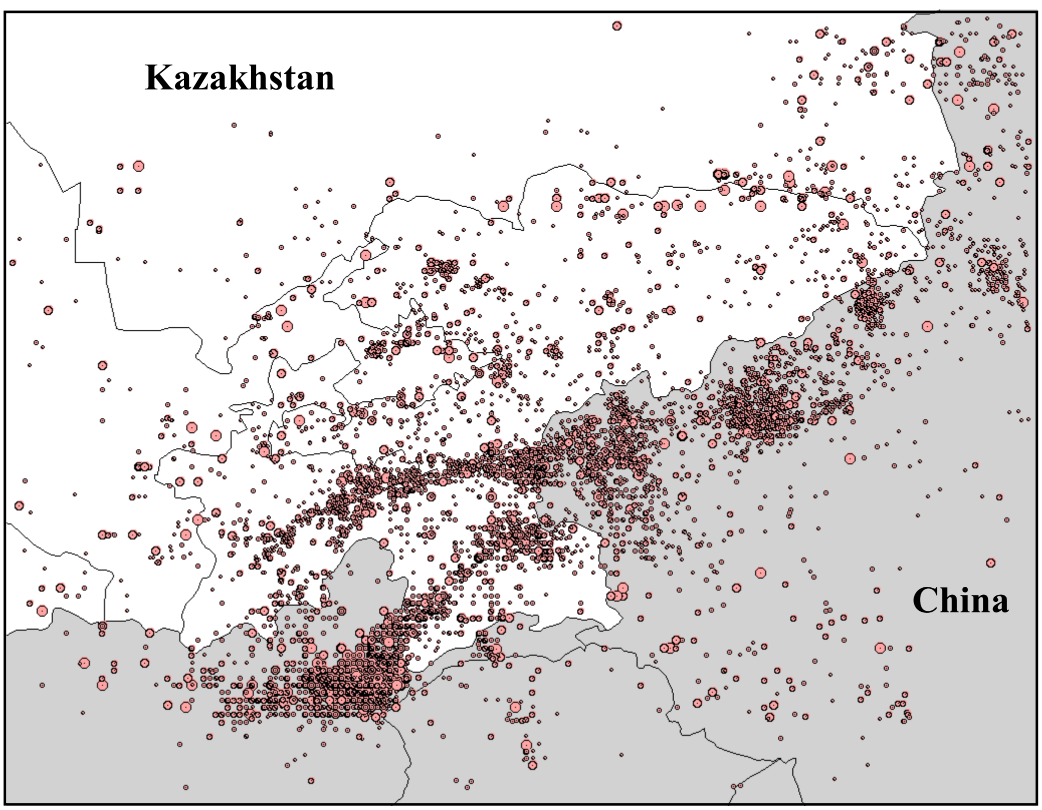

Figure A7. Map of epicenters in the Composite Regional Catalog for the Central Asian Region.

CHUKOTKA REGION

In the Chukotka region, the earthquakes located in the Western hemisphere are signed in longitude greater than 180 East (up to 195 East) as a convenience for database processing. Only two earthquakes were known before the installation of the seismic station *Iultin* (now closed). Since 1970, many small earthquake were located, with 7 < K < 9.

To check for explosions in Annual catalog, the time-of-day distribution was made for small events, (K • 10), as follows:

GMT	N	GMT	N	GMT	N
00-01	15	08-09	16	16-17	09
01-02	21	09-10	16	17-18	11
02-03	23	10-11	08	18-19	12
03-04	34	11-12	12	19-20	14
04-05	18	12-13	17	20-21	18
05-06	11	13-14	16	21-22	12
06-07	11	14-15	10	22-23	24
07-08	14	15-16	09	23-24	15

Two peaks are seen, corresponding to GMT from 1 to 4 and about 21-23. Local time here is about 10 hours later. So the first clear peak corresponds to 12-14 pm (lunch break), and the second one to 7-8 am (morning). This suggests that about fifty events (of a total of 379 small events in the ESSN catalog) are industrial blasts.   The total number of earthquakes in the Composite Regional Catalog for Chukotka during 1962-1999 is, therefore, as little as about 450. Nevertheless, 38 earthquakes have occurred with at least one of the three Obninsk magnitudes (MLH, Msps, Mlpl) of 5.0 or more, and six with M • 6.

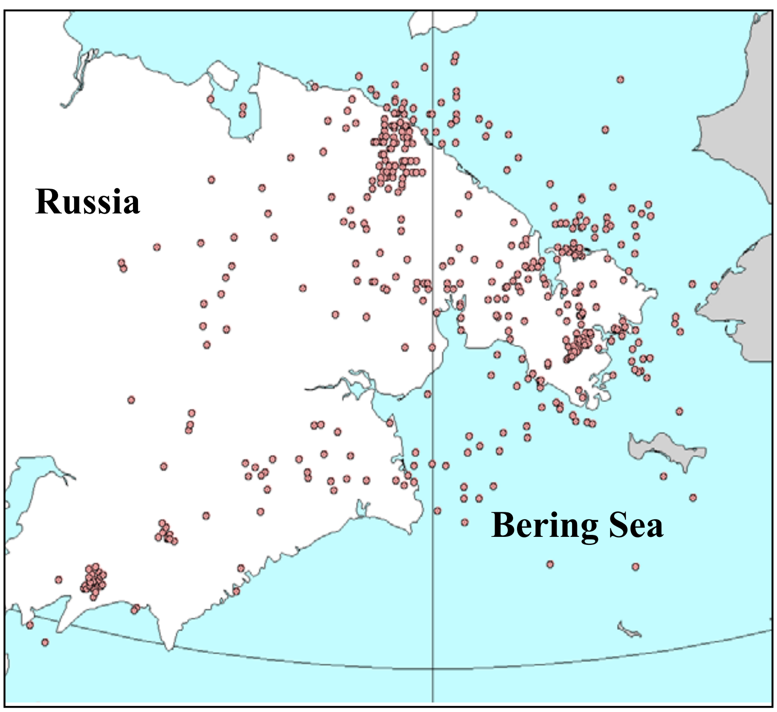

Figure A8. Map of epicenters in the Composite Regional Catalog for the Chukotia Region.

CRIMEAN REGION

The seismic observations in Crimea begin in 1927, driven by the magnitude 6 earthquake that occurred on June 26th. The Crimean Peninsula looks like a small continent, with its own tiny Benioff zone and epicenters reaching depths of 40-50 km. These are located mostly in the local Black Sea, an area of oceanic crust. There is even volcanism here: a mud volcano located in the Northern part of the region.

The seismicity is low here, with no earthquakes with M > 5.5 occurring since the damaging magnitude ~6 event of June 6, 1927. However, during the last 2000 years, there are historical data pointing to a large event in 63 BC, with M=6.8. Six earthquakes with M=>6 are known before 1616. Up until 1961, twenty four events with M=>5.0 are included in the General catalog for this region. The last such earthquake (M=5.5) occurred in 1957.

EAST SIBERIA REGION

(58-70 N; 115-165E)

This broad region begins from the Laptev Sea and extends to the North-West. To the South, it contacts with the seismically-active Aldan region; to the South East it touches the neck of the Kamchatka peninsula. Some researchers believe that the Kamchatka seismic belt is the Western boundary of the North American plate, and even a rift zone, called “Mom Rift”. Some believe it to be the extension of the Middle Arctic Ocean rift.

However, the character of the seismicity here (which is significantly scattered) and dominant fault plane solutions (many of them are of thrust-type) shows that the tectonic situation is more complicated. Only 13 earthquakes are known from 1735 to 1899; three of these have magnitudes from 5.7 to 6.5. In the early instrumental period, 1900-1961, thirty-three earthquakes are listed in the General Catalog.

After local stations began operation, many earthquakes were recorded. In the Annual bulletins, there are 3254 earthquakes with M from 1.5 to 6.5. Of these,134 are identically duplicated in the General Catalog; five event characterizations are identical in the Obninsk catalog. Many listings for events are nearly the same in the Obninsk and General catalogs, but do have not identical coordinates and origin times.

KAMCHATKA REGION

(51-58N; 145-170E)

Note that this region includes the Okhotsk Sea, where the deep earthquake epicenters are located in the Kamchatka Benioff zone.

Kamchatka is one of the most active seismic regions of Russia. The Kamchatka Regional Catalog includes 6,696 earthquakes from the General Catalog and 1939 from the Obninsk Bulletin. The fifty events from the Obninsk Bulletin are duplicated in the General Catalog. Many other earthquakes in the General Catalog have origin times and coordinates differing from Obninsk. ESSN data for this region were not available yet in electronic format and therefore data for small events are not represented in the Composite Regional Catalog. Only the energy class values (KFS after S. Fedotov, which is not identical to K after Rautian), were indicated as used to calculate magnitude M in the General Catalog.

Events from historical data are known from 1737. During the period from 1737 to 1900, many large events are known, and spread over a range of depths as follows:

Magnitude Ranges

Periods	**5-5.9**	**6-6.9**	**7-7.9**	**>8**	**total**
1737-1899	4	12	8	3	30
1900-1961	50	119	28	3	277
1962-1979	235	38	9	1	4,317
1980-1999	102	20	4	-	2,378

Depth Ranges

Years	**50-100**	**101-300**	**301-500**	**>500**
<1900				1
1900-1961	47	21	9	6
1962-1979	475	340	56	12
1980-1999	676	383	69	21

KOPETDAG REGION

(35-45N; 52-65E)

Kopetdag is a seismically unique region within the territory of the former Soviet Union. It is in several ways analogous to the San Andreas fault zone in California, marked by the right-lateral strike-slip faulting. The structure of the crust differs sharply on the opposite sides of fault, and seismicity is practically absent northeast of this fault. Earthquakes in Kopetdag typically have low-frequency spectra. Only the Balkhan massif plays the role of a barrier, resisting slippage: high-frequency earthquakes occur there.

The region is also the site of ancient agriculture and civilization. V.Trifonov (personal communication, T. Rautian) studied the ancient irrigation system here. It consists of underground channels (to prevent evaporation in the hot dry climate), transporting water from the mountain rivers to the plants. Trifonov found that the few, old (about 5 thousand years ago) disruptions to channels were due to right-lateral strike-slip, with displacements up to a half-meter. These disruptions were repaired, and the curved channels keep working. These events are not yet listed in the General Catalog as ancient large earthquakes.

The General Catalog begins with an earthquake from approximately 2,000 BC. In the period before 1962, the General Catalog lists 265 earthquakes. Three of these are of M = 7-7.3, four have M = 6.0-6.9, and 43 events lie in a magnitude 5-5.9 range. In one case, the estimation of depth is 160 km. It is probably not within the Kopetdag itself, but marked the North-West extension of Hindu Kush deep earthquake zone.

After the local network began operation, the number of reported earthquakes increased. In the General Catalog, 1294 events are listed between 1962-1990; in the Obninsk Bulletin, 378 events. Among them, 106 events fall in the period 1991-1999; 14 of these are duplicated in the General Catalog.

Four aftershocks of the Gazli (M=7) earthquakes, two of them in 1976 and two in 1984, have a "normal" depth in the Obninsk Bulletin, but are estimated as deep as 60 and 160 km in General. These deeper depths are not well constrained. To get more reliable results the lateral differences in the structure of crust have to be taken into account carefully. The temporary seismic station from Garm (the *ChISS*, frequency band passed filtered, station), deployed near the epicenter did not record any aftershocks with S-P times corresponding to depths of 160 (or even 50) km, only those corresponding to about 5-10 km.

The western end of the Kopetdag extends as the Main Caucasian Ridge into the Caspian Sea. The depths of many earthquakes in the Caspian Sea are estimated to be about 50-60 km. Some indirect evidence supports such estimations. But if we take into account the strong lateral differences in the crustal structure (i.e., tens of km of soft sediments on the North-East side of Kopetdag fault and crystalline rocks on the surface at West-South side), the previous depth estimations would be significantly changed.

KURILE ISLANDS REGION

(45-51N; 145-165E)

The *Kurily* (in Russian, "smoking") Islands region is of high seismicity. In the General Catalog, one can see many large events, beginning in 1737.

	Magnitude					
Period	**M=>8**	**7-7.9**	**6-6.9**	**5-5.9**	**4-4.9**	**total**
1737-1861	**2**	**33**	**174**	**68**	**13**	**271**
1962-1990	**-**	**10**	**127**	**782**	**629**	**1666**

Earthquakes as deep as 100-500 km, and occasionally even more then 600 km are found in the Regional Catalog. For example, in the General Catalog there are:

	Depth				
Period	**>600**	**500-599**	**300-499**	**100-299**	**50-99**
1737-1961	**-**	**15**	**15**	**56**	**89**
1962-1990	**8**	**25**	**70**	**330**	**387**

The local catalog data for this Region are still unavailable in digital format and are not included in the Composite Regional Catalog. However, the energy class, *KFS* (after Fedotov) or *Kc* (after Soloviev & Solovieva), were the source for the magnitude (M) calculation that was included in the General Catalog.

LAPTEV SEA REGION

(70-76N; 110-150)

The Laptev Sea zone is where the Middle Arctic Ocean seismic belt abuts the continental shelf of Siberia. In the beginning of the XX century, several earthquakes as large as M=5.5-6.8 occurred here. The very poor seismic network here makes the seismicity badly known. In 1968, the *SevMorGeo* Institute (Geology of the North Sea) began seismological observations here, using a few temporary seismic stations. Observation was possible only in the summers. The instrumentation was VEGIK, with a flat frequency response 0.8-10 Hz and magnification about 30-40X.

Station	Coordinates	Period of work
Temp	**75.45 137.46**	**1972 Aug 01 - Sep 30**
		1973 Jun 11 - Aug 09
Kigilakh	**73.22 139.52**	**1973 Jun 30 - Sep 12**
		1974 Mar 20 - Apr.23
Dymnoe	**73.14 142.24**	**1974 Mar 18 - Apr.22**
Bunge Land	**74.50 142.35**	**1975 Apr 15 - Jun 14**
New Siberia	**75.03 147.00**	**1975 Apr 16 - Jun 15**
Udzha	**71.15 117.10**	**1975 Aug 27 - Sep 19**
Khalganakh	**71.50 114.20**	**1975 Jul 21 - Aug 10**
Chochurdakh	**72.50 116.15**	**1975 Aug 13 - Sep 21**
P.Khvoinova	**74.15 140.53**	**1976 Apr 18 - Jun 24**
P.Herpichy	**75.50 143 20**	**1976 Apr 25 - Jun 27**
p.Diring-Ayan	**75.57 139.55**	**1976 May 28 - Jun 23**

During 1985-1988, the observations were done in the delta of Lena River. During this period (9 months) 140 earthquakes were recorded, and 121 of them were located. Nevertheless, the time of observation was so short, that the data obtained becomes important for understanding this zone, where the mid-oceanic ridge transforms into scattered continental seismicity.

NORTH KAZAKSTAN REGION

(45-58 N; 65-80 E)

Kazakhstan is a marginal zone with low- and poorly-studied seismicity. The official northern boundary of the North-Tien Shan seismic survey is 45N. The territory northwest of 45N does not belong to any seismic survey. Its south-east corner is effected by the high activity of the Dzhungaria zone.

Along the Eastern boundary of Kazakhstan, there is a band of epicenters, which geographically and geologically belongs to the West side of the Altai seismic zone. Some of them are located in close proximity to Semipalatinsk Test Site (49.5 N; 77-79 E). The two earthquakes that have occurred in the North-West part of the region are a part of the seismicity of the Ural Region.

Historically, the Zerenda seismic station recorded many explosions at distances of a few hundred kilometers, but these records never were processed.

Some events are believed to be earthquakes because:

1. They occurred at night;
2. They are present in Soviet-era catalogs (large explosions were usually excluded);
3. The magnitudes are M=4 or more, considered too big for normal blasting.

For example, the event of Aug. 1st, 1994 is located in the vicinity of several quarries or mines (48 N, 67 E). Nevertheless, it is believed to be an earthquake because of its magnitude, MLH=4.6 and MPVA=4.8, and early origin time.

PRIMORIE & PRIAMURIE REGIONS

(48-52N; 122-141.5E and 43-48N; 130-141.5E)

The name *Priamore* means "Land Near-Sea " and *Priamurie*, "Land Near Amur River ". The local seismicity in the crust is not highly active, but deep earthquakes are observed. More than a half of the large earthquakes here (M=6 and more) are deep --some as deep as 600 km. Small events (M=3.5-4.5) are mostly shallow.

A dozen earthquakes are known to have occurred before 1900, and about fifty were recorded between 1900 and 1961. The recent record has about 500 earthquakes. All of them are from the General Catalog and the Obninsk Bulletin. At present, no local data are available from the Annual (ESSN) Catalogs.

CENTRAL RUSSIA REGION

(52-58N; 30-52E)

Most seismological data about this region are historical, beginning from 1467. Half of the 18 historical earthquakes occurred before 1900, the other half occurred from 1900 to 1956. Four events are duplicated in the various source catalogs, but their parameters (such as time, intensity (Io) and magnitude (M)) are not identical. Four events are listed in the General Catalog, while the other ones (marked as Historical, "Hist") were taken from the compilations by Nikonov and Anayin (published in various reports).

Only one event was found in the Obninsk Bulletin, and no local seismic survey existed here. Between the years 1968-1989, Western seismological surveys (ISC and NOAA) recorded eight events in this region. They were apparently missed by the Russian seismological stations. So this region is almost a "blank spot".

NORTH RUSSIA REGION

(58-70N; 30-52E)

The local seismic survey is located in Apatity, near the mining and quarry industry. They monitored the natural seismicity around the White Sea and Spitsbergen, where the seismic station Piramida operates. Greatest attention is paid to blasting in the few quarries close to Apatity station. Mineblast events appear in Annual irregularly, mostly between 1987-1990. The number of events in the catalogs therefore represents neither the level of natural nor industrial seismicity.

In the early instrumental period, the local seismicity was studied by Panasenko, working at the Apatity station. His catalog data are included in the General Catalog. Recent reports in the Annual described the natural seismicity around the White Sea as a result of some general tectonic process affecting all of Scandinavia.

The list of events includes the epicenters in the southern part of the region: Karelia and the two great Lakes, Ladoga and Onega. There are historical data about natural earthquakes here. Many recent epicenters were found there, but no data in the Annuals enables the discrimination of earthquakes from explosions.

The time-of-day distribution of events in the earthquake catalog from 1967-1990 is as follows:

GMT	expl	eqs	GMT	expl	eq
00-02	4	6	12-14	27	22
02-04	20	7	14-16	10	9
04-06	25	1	16-18	1	13
06-08	42	15	18-20	1	7
08-10	37	21	20-22	-	4
10-12	33	32	22-24	-	10

The Apatity explosions typically begin in the early morning, about 0500-0600 local time, and continue till 1900 in the evening. Very few occur at night.

The fact that most events in the earthquake catalog for this region occurred during the daytime indicates that they are dominantly explosions. Most of them occurred from 0600 to 1800 GMT (0900-2100 local time). This daytime distribution of events shows that most of these events are explosions. But some, about 10 or more are probably natural earthquakes. 10-15 from a total of about 150 - are not many, but they deserve to get attention.

The list of announced explosions near Apatity in 1991-1992 was published with mines location and the charge specified. These data listed in a separate catalog.

SAKHALIN REGION

The Regional Sakhalin Catalog, 1962-1999, includes 539 earthquakes from the General Catalog and 146 from the Obninsk Bulletin. At present, no data from local seismological centers are available in electronic format.

One hundred six events from the Obninsk Bulletin are in 1991-1999, other 40 mostly duplicate in the General Catalog, but only 3 have identical parameters. Other events have slightly different origin time or/and coordinates in the Obninsk Bulletin and the General Catalog.

As in the other Far East Regions, there are many deep earthquakes in Sakhalin.

SAYAN REGION

(48-58N; 87-100E)

Officially, the Sayan Region is a part of the "Altai-Sayan Zone", monitored by the seismic survey in Novosibirsk. But the character of the seismicity of the Sayans differs from that of the Altai, with the rate of seismicity much higher in the Sayans. The industrial blasting is not significant here. Of the earthquakes of this region from 1776-1961, 176 are included in The General Catalog; only five from that period are found in the Obninsk Bulletin, two of these are identically replicated in the General Catalog. Six large earthquakes (M from 7 to 8.3) are known here from 1761-1931, 22 are of M=6-6.9, and 80 events of M=5-5.9 are in the General Catalog before 1962.

Some of the other earthquakes in the General Catalog are the same as reported in the Obninsk Bulletin or the ESSN Annuals, but differ in origin time or/and coordinates. In the recent period, 1962-1990, the source catalogs included:

			identical with		
		total	**Obn**	**ESSN**	**Gnrl**
1962-1990	**Gnrl**	**1,204**	**2**	**621**	
1962-1990	**ESSN**	**4,435**		**621**	
1962-1990	**Obn**	**40**	**2**		**2**
1991-1999	**Obn**	**49**			

The depth values in the Regional Catalog are mostly listed as 3, 15 and 33 km. The first two came from the Obninsk Bulletin, indicating what travel time curve they use to process the data. The value of 15 is an assumed depth, which was believed by the compilers of the General Catalog to be typical for the region. Local surveys avoided any depth estimation because of big distance between the seismic station and very few cases of epicenter being under station. Unfortunately, until 1980 the energy class, K, was rounded to an integer; only from 1981 does the first decimal place of K appear. The General Catalog uses K to calculate M. However, they then rounded the calculated M, as in 3.5, 4, 4.4. It was found that the random scattering of K estimation on a single station is about 0.35 unit of K if there is no significant site effect.

UKRAINE REGION

(46.5-52 N, 21-37 E)

Ukraine is a region of low seismicity. The rare earthquakes that have occurred may be interpreted as a marginal extension of Carpathian seismicity. Most of the earthquakes hypocenters are in the crust; a very few have a depth of about 100 km. Stations recording these earthquakes are located in the western part of the region and in Carpathia (Lvov, Uzhgorod, Rakhov, Kosov, Mezhgorie, Morshin, Nizhneye Selische, Trocnik, Gorodok), or to the south, in Crimea (Yalta, Feodosia, Simferopol, Sevastopol, Alushta, Kasantin, Sudak). There is, however, active blasting in the Ukraine. The seismic surveys have worked hard to eliminate the quarry blasts from their catalogs, but some of them probably still linked.

URALS REGION

In the Urals, Both rock bursts and quarry blasts are probably numerous, but no data are available with which to characterize them. Only in the last few years does the study of Ural seismicity begin in Kazan and Tataria.

In the Novaya Zemlya region, a prolongation of the Ural orogenic belt, there were no seismic surveys until recently. Seismologists were interested more in the higher seismic activity in the Far East, Yakutia, Baikal, Central Asia, and the Caucasus. Some data on earthquakes were obtained from historical documents. Regarding modern earthquakes, the ESSN data are an anomaly, or "local result"; i.e., they were recorded during a deep seismic profiling study in 1988-89.

Figure A9. Map of epicenters in the Composite Regional Catalog for the Urals Region.