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CHRONICLE

New Maps of General Seismic Zoning of North Eurasia

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Comprehensive long-term studies on the general seismic zoning of the Russian Federation and North Eurasia, including the territories of the former Soviet republics and adjacent seismic regions, have been accomplished. The studies performed from 1991 to 1997 were related to the problem "Seismicity and Seismic Zoning of North Eurasia" (directed by V.I. Ulomov) developed at the Joint Institute of Physics of the Earth (the general director is V.N. Strakhov) within the framework of the Russian Scientific–Technical Program "Global Changes in Nature and Climate" (directed by N.P. Laverov) under the financial support of the Russian Ministry of Science and Technologies. The studies continued the works on the seismic zoning of the former USSR territory, started in 1990. However, their conceptual, methodological and scientific–organization level was different [Ulomov, 1992]. In 1992, the program "Seismicity and Seismic Zoning of North Eurasia' was coordinated with a new international program on the global seismic hazard assessment (GSHAP) [Ulomov *et al*., 1993] and was incorporated in the latter. The results of various research stages were regularly published in the journal *Fizika Zemli* [Ulomov, 1993, 1995a, 1996b, 1997], thematic collections [Seismicity and …, 1993, 1995], other domestic and foreign publications, and WEB pages.

The new program of study [Ulomov, 1992] was carried out by a numerous specialists from research institutes of the Russian Academy of Sciences and its Siberian and Far East Divisions, and from academic institutes of the former Soviet republics (see the list at the end of the paper). The program comprised five working groups which studied various aspects of the problem. The groups were directed by leading specialists. Their tasks included the

- development of methods for the general seismic zoning (V.I. Ulomov and A.A. Gusev);
- unification of the earthquake catalog (N.V. Kondorskaya and V.I. Ulomov);
- modeling of earthquake source zones (V.I. Ulomov and V.G. Trifonov);
- development of a seismic effect model (A.A. Gusev and L.S. Shumilina); and
- seismic hazard assessment and (V.I. Ulomov and L.S. Shumilina).

The concept of general seismic zoning program (GSZ-97) includes the following moments:

(1) the notion of a maximum possible magnitude constrained by the structural–dynamic properties of the geophysical medium and seismic processes (geological block sizes, strength, and interaction intensity between the blocks);

(2) two-stage approach to the seismic hazard assessment based on interrelated models of earthquake source zones and seismic effect produced by them;

(3) a stochastic–deterministic approach to the analysis of seismic and geological–geophysical data and stochastic approach to the seismic hazard assessment and seismic zoning parameters.

Along with the new method, a set of GSZ-97 maps was based on a rather uniform seismological and geological–geophysical database for the entire territory of the Northern Eurasia, represented in mapped and electronic form involving the ArcView GIS software (V.I. Ulomov, Sh.S. Anderzhanov, and Yu.M. Kolesnikov were responsible for this work). The set incorporates:

- a specialized catalog of earthquakes with $M \geq 4.5$, from ancient times to 1990; with $M \geq 3.5$, from 1960 to 1990; and with $M \geq 5.8$, from 1991 to 1995 (N.V. Kondorskaya and V.I. Ulomov, editors);
- catalog of paleoearthquake sources (A.A. Nikonov, E.A. Rogozhin, and V.S. Khromovskikh);
- catalog of potential sources of large earthquakes (G.I. Reisner, E.A. Rogozhin, and L.I. Ioganson);
- catalog of fault plane solutions for earthquakes with $M \geq 6.0$ (L.M. Balakina, A.I. Zakharova, A.G. Moskvina, and L.S. Tchepkunas);
- map of source seismicity (V.I. Ulomov, N.S. Medvedeva, T.P. Polyakova, and L.S. Shumilina);
- map of seismic regionalization (V.I. Ulomov);
- neotectonic map (A.F. Grachev, editor);
- map of active faults (V.G. Trifonov and A.I. Kozhurin, editors);

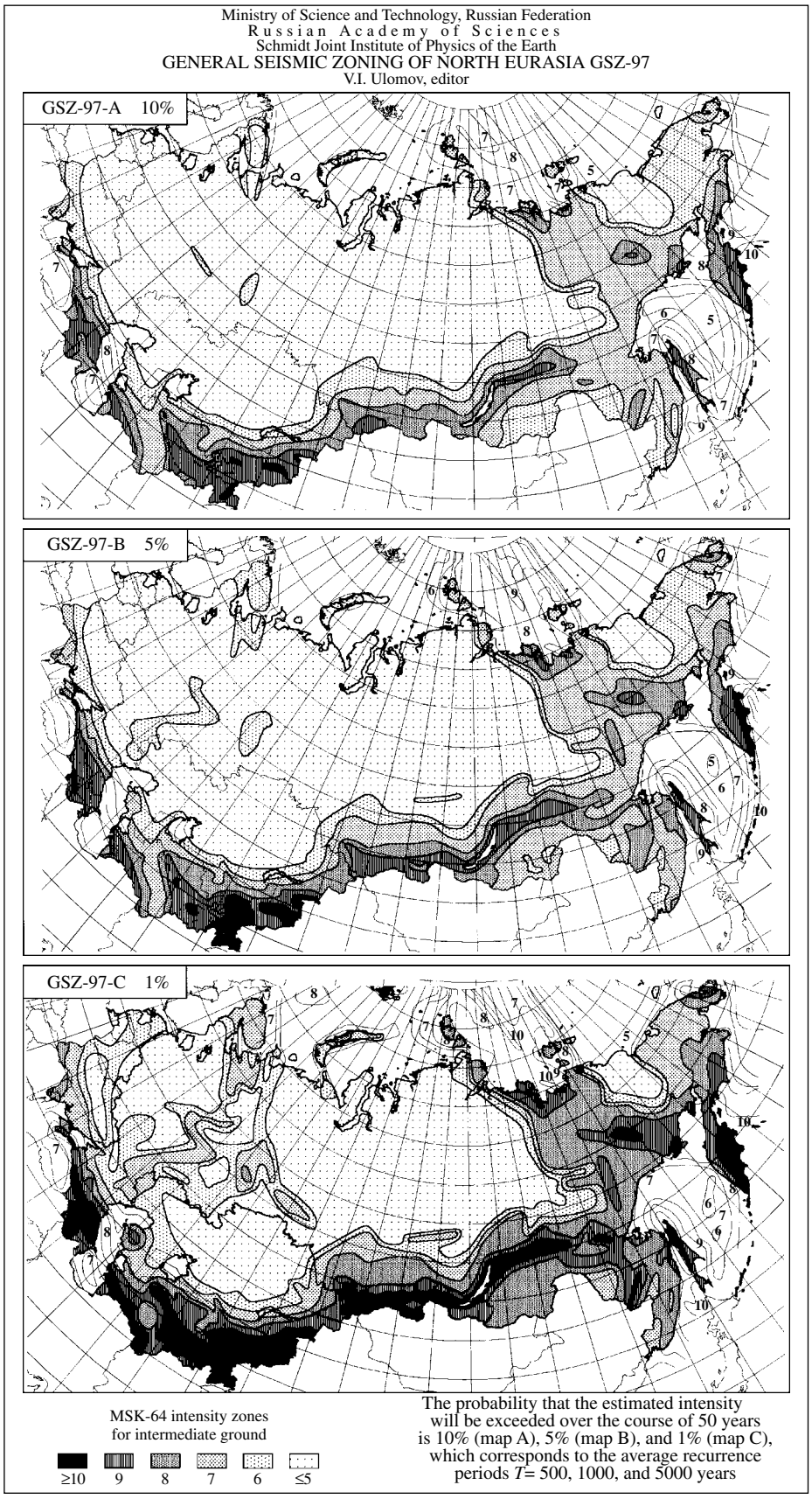

Fig. 1. Set of the GSZ-97 maps.

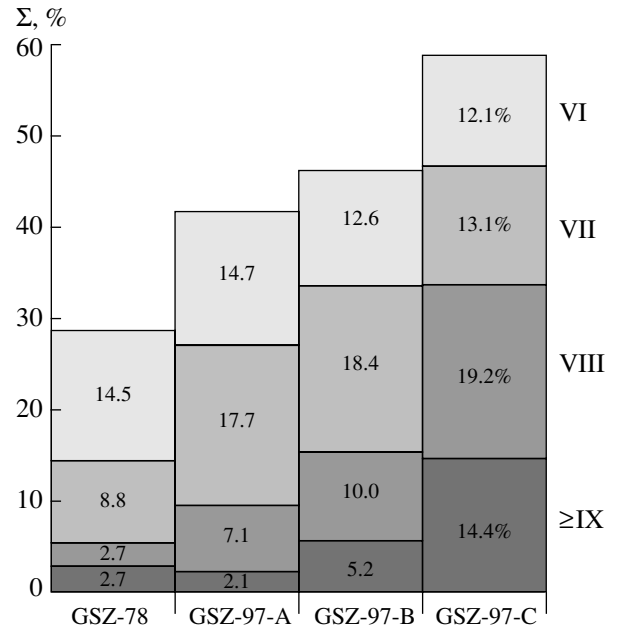

Fig. 2. Comparison between the GSZ-97 and GSZ-78 areas of seismic intensity zones.

• map of isostatic gravity anomaly gradients (by M.E. Artem'ev and M.K. Kaban);

• map of the seismogeological taxonomy (N.V. Shebalin and V.G. Trifonov);

• map of shelf seismotectonics (I.P. Kuzin, A.I. Ivashchenko, and B.A. Assinovskaya);

• a technique for identification and seismic parametrization of earthquake source zones (V.I. Ulomov);

• map of earthquake source zones (a lineament–domain focal model) in North Eurasia and the characteristics of their seismic regime (V.I. Ulomov);

• seismic hazard assessment software (A.A. Gusev, V.M. Pavlov, and L.S. Shumilina);

• 25 × 25-km^2-cell grid showing the earthquake recurrence for the entire territory of North Eurasia (L.S. Shumilina, Sh.S. Anderzhanov, Yu.M. Kolesnikov, and N.S. Medvedeva);

• a set of seismic hazard zoning maps of North Eurasia on three risk levels (V.I. Ulomov and L.S. Shumilina).

The basic differences between the new methods described in detail by Ulomov [1995c, 1998] and Gusev and Shumilina [1995] and the previously used ones [*Seismic Zoning* …, 1980; Riznichenko, 1965] are as follows: a parametric lineament–domain focal model of earthquake source zones (ESZ) for the entire territory of North Eurasia was developed; seismic sources represented by finite-size structures (rather than point sources previously considered) was used at all GSZ-97 stages, from the identification of seismically active structures to the evaluation of ground motions; various nonstandard data on regional seismicity (fractal structure, nonlinear behavior of earthquake recurrence plots, and nonlinear seismic effect attenuation, etc.) and seismic sources (size, orientation, moment magnitudes, stress release, source distribution in the seismically active layer rather than at a fixed depth as was made previously, etc.). The new method of seismic hazard assessment and seismic zoning, including the related software, was called EAST-97 (Earthquake Adequate Source Technology).

A set of new GSZ-97 maps covering the territory of the Russian Federation was prepared within the framework of the technical assignment of the Ministry of Civil Engineering (January 31, 1996) and was included in the new edition of the Building Standards and Regulations (SNiP-II-7) "Civil Engineering in Seismic Regions." The set comprises:

• GSZ-97-A map designed for the large-scale civil engineering; the map shows the areas with a 10% probability that the estimated intensity will be exceeded during a period of 50 years (or 90% probability that the intensity will not be exceeded);

• GSZ-97-B map designed for objects of enhanced importance; the map shows the areas with a 5% probability of exceeding the estimated intensity during a 50-year period (or a 95% complementary probability);

• GSZ-97-C map designed for objects of prime importance; the map shows areas with a 1% probability of exceeding the intensity during a period of 50 years (or a 99% complementary probability).

For the first time, general seismic zoning was implemented in terms of the GSZ-97 program over the entire territory of North Eurasia, including the shelves of marginal and interior seas (Fig. 1). The GSZ-97 set of maps must replace the standard GSZ-78 map now in use, which became inadequate.

Figure 2 presents the diagram of the area distribution (in percentage with respect to the total area of the Russian Federation) over MSK-64 intensities of 6, 7, 8, and $n \geq 9$, which was constructed by using the GSZ-97 (A, B, and C) maps for the continental Russia's territory. The first column in the diagram shows a similar distribution obtained from the data of the GSZ-78 map without the intensity differentiation in earthquake recurrence periods (which is indicated by the indexes 1, 2, and 3 on the GSZ-78 map). As seen from the figure, even the most "risky" GSZ-97-A map indicates that the various intensity areas are larger than the corresponding areas in the GSZ-78 map. A small decrease in the 9-point area in the GSZ-97-A map constructed for a recurrence period $T = 500$ years is due to the fact that, in the vicinity of Lake Baikal, the GSZ-78 map associates this zone with the period $T = 1000$ years (index 2). The GSZ-97-B map demonstrates an increase in the area of this territory as compared to the GSZ-78 map. The area of the 6-point zone is least variable, being partially replaced by the 7-point zone and varying in shape from map to map. The areas of other zones increase by

a factor ranging from 2–3 to 5–7 as compared to the GSZ-78 map, although their shapes vary to a lesser degree. The exceptions are the entire territory of the East European Platform (EEP) and the eastern cis-Uralian region. Neither of the GSZ-97 maps is consistent with the Temporal Diagram (T = 10000) of the EEP, approved in 1987 by the Interdepartmental Council on Earthquake Resistant Construction for objects of prime importance (atomic power stations, etc.). The greatest increase in the seismic hazard level is observed in the Caucasus and Far East, especially the Primorski Krai.

The results of the comprehensive studies on the problem "Seismicity and Seismic Zoning of Northern Eurasia," new methodological principles, basic conceptions, and GSZ-97 set of maps of the Russian Federation territory were widely tested and discussed. They were approved and adopted as documents appropriate for the rational development of the social and production infrastructure in seismically active regions of Russia by the following organizations and persons:

- enlarged meeting of the Scientific Council of the Joint Institute of Physics of the Earth, Russian Academy of Sciences (chairman V.A. Magnitsky) and the Subcommittee on Seismic Zoning (chairman is V.N. Strakhov) of the Interdepartmental Council on Seismic Zoning and Earthquake Resistant Construction (chairman S.I. Poltavtsev) established by the Government of the Russian Federation on January 9, 1994 (resolution no. 10);
- Vice-President of the Russian Academy of Sciences, academician N.P. Laverov (March 23, 1998);
- Russian Deputy Minister of Civil Engineering S.I. Poltavtsev (March 28, 1998);
- Scientific–Technical Council of the Russian Ministry of Civil Engineering (decision no. 23-13/1 of April 21, 1998);
- Department of the Geology, Geophysics, Geochemistry, and Mine Science Division, Russian Academy of Sciences (resolution no. 13100/8-69 of May 20, 1998).

The final decision on the classification of construction projects and application of the GSZ-97 maps should be accepted in the legislative order by the superior policy-making authorities of Russia.

Institutions responsible for investigations into the problem "Seismicity and seismic zoning of North Eurasia" and for the construction of the GSZ-97 maps:

the Schmidt Joint Institute of Physics of the Earth, Russian Academy of Sciences (RAS) (leading institution, Moscow); the Institute of the Earth's Crust, Siberian Division, Russian Academy of Sciences (SD RAS), Irkutsk; Joint Institute of Geology, Geophysics, and Mineralogy, SD RAS, Novosibirsk; Institute of Geological Sciences, SD RAS, Yakutsk; Institute of Marine Geology and Geophysics, Far East Division, Russian Academy of Sciences (FED RAS), Yuzhno-Sakhalinsk; Institute of Volcanology, FED RAS, Pertropavlovsk-Kamchatski; Institute of Volcanic Geology and Geochemistry, FED RAS, Pertropavlovsk-Kamchatski; Northeastern Interdisciplinary Research Institute, FED RAS, Magadan.

Institutions participating in the GSZ-97 program:

Geophysical Survey, RAS; Geological Institute, RAS; International Institute of Earthquake Prediction and Mathematical Geophysics, RAS; Kola Research Center, RAS; Institute of Geophysics and Mining Institute, Ural Division, RAS; VNIIGeofizika and Lower Volga Research Institute of Geology and Geophysics, Russian Ministry of Natural Resources; Voronezh State University; Tatar Geological Exploration Department, Tatneft' Joint-Stock Company; Kucherenko Central Research Institute of Constructions, Ministry of Civil Engineering, Russian Federation; Experimental Expedition, Baku, Azerbaijan; National Survey of Seismic Protection, Erevan, Armenia; Institute of Geophysics, Geology, and Geochemistry, Belarus Academy of Sciences, Minsk; Institute of Geophysics, Tbilisi, Georgia; Institute of Seismology, Ministry of Science and Academy of Sciences of Kazakhstan, Alma-Ata; Institute of Geophysics and Geology, Academy of Sciences of Moldova, Kishinev; Institute of Earthquake Resistant Construction and Seismology, Academy of Sciences of Tajikistan, Dushanbe; Institute of Seismology, Academy of Sciences of Turkmenistan, Ashkhabad; Institute of Seismology, Academy of Sciences of Turkmenistan, Tashkent; Subbotin Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev.

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