THE NEW ELEMENTS ON THE MAP OF SEISMIC ZONING

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Synopsis

The zones of probable generation of earthquake sources differentiated according to their depths and M_{max}, as well as quantitative assessments of the probability of shakings are new elements on the map of seismic zoning. An example of the map with new elements is presented.

Introduction

In the USSR, USA, Japan, Italy and other countries different methods of seismic zoning (SZ) were proposed with the aim to satisfy constantly increasing demands on the contents, accuracy and reliability of the maps of SZ. In general these demands come to the following:

1. The seismic danger of a region is determined by the maximum or probable intensity of shakings and the presence of probable seismic sources zones (SSZ) with different magnitudes. On the basis of studying SSZ, regions with the intensity 6, 7, 8, 9 and more are distinguished. It is assumed that on other territories the intensity is 5 and less. The SSZ are differentiated by the M and the depths of seismic sources. The necessity of the evaluation of M_{max} is connected with the dosign of the buildings with regard to the dynamic loads using typical accelerograms, velocitygrams and seismograms. The scale of future catastrophes can also be evaluated by the correlation between the M and areas with the intensity of shakings 9, 8, 7.

2. The map of SZ should also contain information of the possibility of shakings with various intensity: mean time intervals between strong earthquakes, possibility of a strong earthquake in the nearest 10-50 years etc. These data should be accompanied by information about dispersion of values.

3. The method of using parameters presented on the map of SZ should be indicated when designing buildings with regard to dynamic loads.

However, the maps of SZ which would satisfy all mentioned demands are not yet compiled.

In the USSR a new map of SZ has been compiled by the method schematically presented on Fig. 1. A detailed account of the method is given in /1/. Using this method initial seismological data were reconsidered, a complex interpretation of seismological, geological and geophysical data

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was done to compile models of the maps of SZ of the republics and some seismoactive zones. On the basis of the authors' models were prepared models of the regional maps, which included zones where intensity was 6 and more. This work has been done by the editorial board (editor-in-chief Academician M.A.Sadovsky).

As an example, on Fig. 2 the region: the Crimea - the Caucasus-Turkmenia is shown. Author's models were presented by the following institutes:

For the Crimea - the Seismological department of the Institute of Geophysics of the Academy of Sciences of the Ukrainian SSR;

For the Georgian SSR - the Institute of Geophysics and the Institute of Geology of the Academy of Sciences;

For the Armenian SSR - the Institute of Geophysics and Engineering seismology of the Academy of Sciences and the Erevan State University;

For the Azerbaijan SSR - the I.M.Gubkin Institute of Geology of the Academy of Sciences;

For the Dagestan autonomous SSR - the Institute of Physics of the Dagestan Branch of the Academy of Sciences of the USSR.

For the North Caucasus - the Grozny Oil Institute of the Ministry of Higher Education.

For the Turkmenian SSR - the Institute of the Physics of the Earth and the Atmosphere. of the Academy of Sciences.

Distinguishing features of the legend of the new map of SZ as compared to previous maps of SZ.

As before, the basic load of the map falls on areas with the intensity of shaking 6,7,8,9 and more than 9. The difference comes to the following:

1) On the new map of SZ the most probable SSZ are presented. These zones are distinguished by the M_{max} : 6,1 - 7,0; 7,1 - 8,0; 8,1 and more. Theoretical isoseists (Fig. 3) and probable isolines of $\ddot{x}$, $\dot{x}$ and $x/2,3/$ are included in the legend of the map.

2) Another new element is the data on the possibility of shaking with some intensity. The possibility of shakings in Fig. 2 is shown by indexes near the figures of intensity in the given zone: 7_1, 7_2, 7_3 and so on. These indexes correspond to the mean recurrence once per 100, 1000 and 10.000 years or the probability - 0,5; 0,95; 0,945 that the event with the given intensity would not take place in the nearest 50 years. It is necessary to mention that the intensity of shaking on the usual maps of SZ is not the maximum possible intensity, but only probable. On the new maps its probability is determined more carefully.

3) On the map (Fig. 2) the epicentres of previous destructive earthquakes are shown. The epicentres are presented as signs of different size according to M divided into the following groups: 5,1 - 6,0; 6,1 - 7,0; 7,1 - 8,0; 8,1 and more. The class of accuracy of the location of epicentres and the depth of hypocentres are shown. All epicentres are divided by their accuracy into three categories: the most precisely determined were epicentres for 1956-1974 (thick contour); not so precisely-epicentres for 1911-1915 (thin contour); probable epicentres of destructive earthquakes for the beginning of the XX century, XIX century and earlier are shown by a broken line.

For the well studied earthquakes with M more than 7,1 isoseists of intensity 9 are shown (or contours of zones of aftershocks for the earthquakes in oceans and seas). The year of the earthquake is also shown.

The shallow earthquakes with the depths less than 70 km are shown by circles; if the depths are more, the epicentres are shown by triangles.

The delineation of SSZ and evaluation of the tendency of development of seismic processes in these zones in the nearest decades is the most complex and responsible task in the SZ. Different methods were proposed and used for the complex numerical interpretation of geological and geophysical data with the aim of delineation of SSZ.

Complex interpretation of seismological, geological and geophysical data.

Systematic ways of the delineation of the SSZ and the studying of the correlation of seismicity with the peculiarities of the structure of the Earth crust were worked out in the Caucasus, the Middle Asia and East Siberia /1/. Numerical methods of the interpretation of geological and geophysical data with the aim to recognize the SSZ and to evaluate M_{max} are of principal interest /1/.

The numerical ways were proposed in /4/ for the interpretation of a large number of various geological and geophysical parameters, rather complexely connected with seismicity, with the aim to delineate SSZ for three categories of M_{max} : $M_1 = 6.1/2 - 1/2$; $M_2 = 5.1/4 \pm 1/2$; $M_3 = 4 \pm 1/2$. The papers /5,6/ contain the description of the preparation of geological and geophysical data with the aim of using them for numerical interpretation. The method of the delineation of the SSZ with different M_{max}, described in /4-6/, should not be considered separately, without any connection with the studies of geological and geophysical causes of the generation of earthquakes. In each new region, it is necessary to solve the problem described in /4-6/ anew from the beginning to the end. An attempt was made to transfer the criteria worked out for the Caucasus, to the Carpathian region. In this case /6/ on the one hand were delineated the SSZ with $M = 6.1/2 \pm 1/2$, when there were no data to prove that such earthquakes were possible, on

the other - in zones where M_{max} was evaluated as 4.1/2, 5.1/2, earthquakes took place with M = 6,7-6,8 (Bulgaria: Shabla 31.3-1901, Gorna-Orachovica 14.6-1913).

The method of pattern recognition of the intersection of morphostructures as the SSZ is proposed in /7,8/. This method was already used in some seismoactive regions of the Earth and it deserves serious attention. It is necessary to develop this method, as in the Middle Asia, where this method was used, the Kyzyl Kum desert with strong earthquakes in 1929 (M = 6,5) and in 1976 (M=7,3) was not considered.

Yu.V.Riznichenko and E.A.Dzibladze proposed a method of the correlation of geological and geophysical data /9/. This method, on the one hand, is not comprehensive enough (for example, in the Caucasus is delineated a large area where earthquakes with M=6 are possible) on the another hand, one can not be sure that the evaluation of M_{max} is precise.

The distinguishing of the SSZ with $M \geq 6,0$ is the key question for the basis of the maps of SZ. This problem is not yet solved with the necessary detailing, accuracy and reliability, as follows from above-mentioned publications. In connection with this, when delineating the SSZ on Fig.2, geological criteria of seismic danger /1/ were used.

Evaluation of the probability of the intensity 7,8 and 9 in the nearest 50 years

Calculations based on the recurrence of earthquakes with different M or energetical classes K were used for the evaluation of probability of earthquakes. The evaluation of probability was done for zones with intensity of shakings 7,8 and 9. In most cases there are only scarse statistical data for the evaluation of probability of shakings with intensity 6.

The probability was evaluated that an earthquake with the intensity, accepted for this zone, would take place not earlier, than in 50 years from any arbitrarily chosen moment of time. Three types of zones were delineated. It is possible to suppose that in the most dangerous zones with the probability approximately 0,5, an earthquake with the intensity, indicated on the map for the given region, would not take place in the nearest 50 years (the mean recurrence period is 100 year). The some can be assumed with the probability 0,95 for less dangerous zones (mean recurrence period is 1000 years) and, finally, for the least dangerous zones - the probability is 0,995 (the mean recurrence period is 10.000 years).

The values of the indicated probabilities are presented on the map by the corresponding indexes - 1;2;3.

Long-term forecasting of seismic danger

The intervals of time between destructive earthquakes even in seismoactive regions can amount to several hundred

years. Therefore, from the practical point of view, it is essential that the tendency of the development of the seismic process should be evaluated in the given region for the nearest decades. A successful long-term forecasting based on the analysis of seismological data was done for the Kamchatka /10/.

New elements, described above, were absent in all official editions of maps of SZ of previous years. It is hoped that data on the SSZ with different M_{max} of possible earthquakes and the possibility of shakings will enable the users take into account many important elements of seismic regime in their practical work when designing safe buildings and other constructions.

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Captions

Fig. 1. Block-scheme of studies used for the construction of the map of SZ.

Fig. 2. The map of SZ of the Crimea, the Caucasus and Turkmenia.

Fig. 2a. The legend of the map of SZ and designations are in Fig. 2.

Fig. 3. Probable isoseists of earthquakes of various magnitudes with foci within the crust of the Earth.

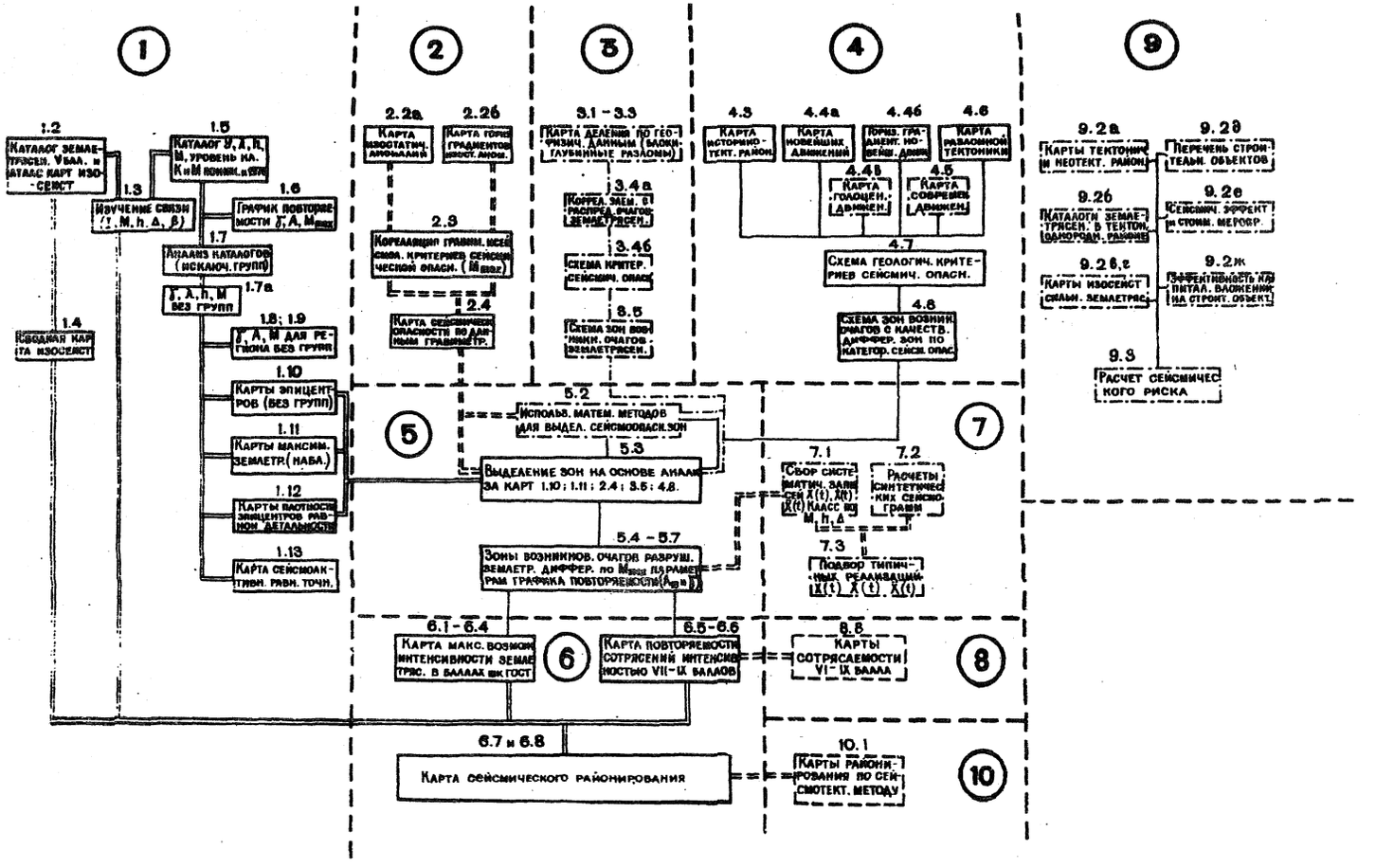

Рис.2. БЛОК-СХЕМА ПОСЛЕДОВАТЕЛЬНОСТИ ПРОВЕДЕНИЯ ИНТЕРПРЕТАЦИИ МАТЕРИАЛОВ ПРИ СЕЙСМИЧЕСКОМ РАЙОНИРОВАНИИ

FIGURE - 1

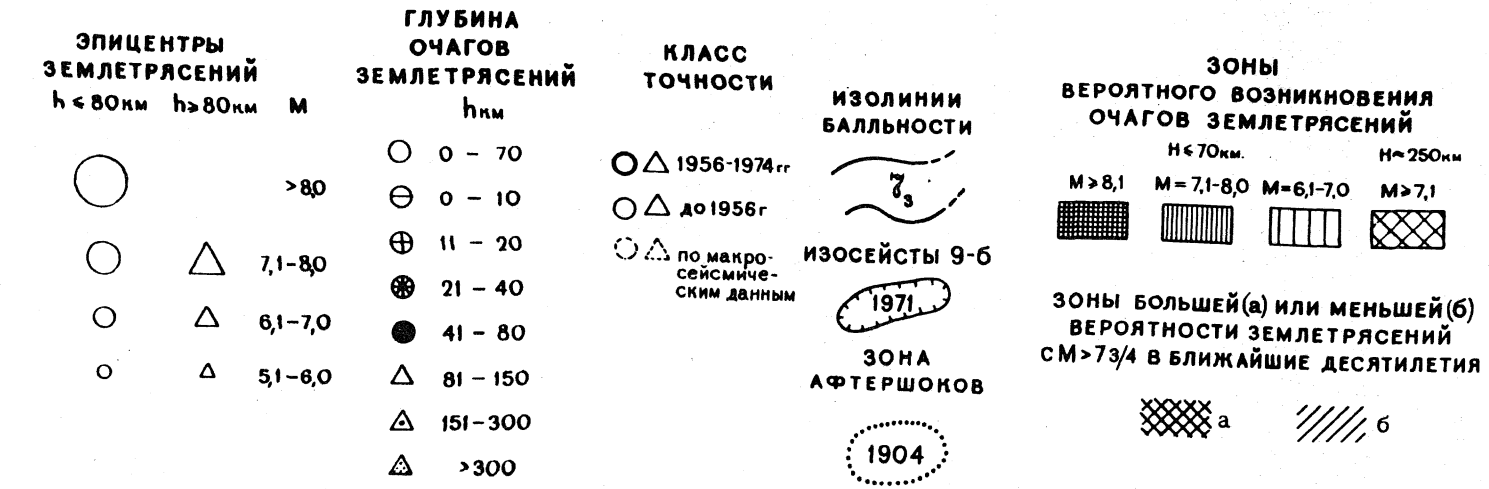

FIGURE - 2a

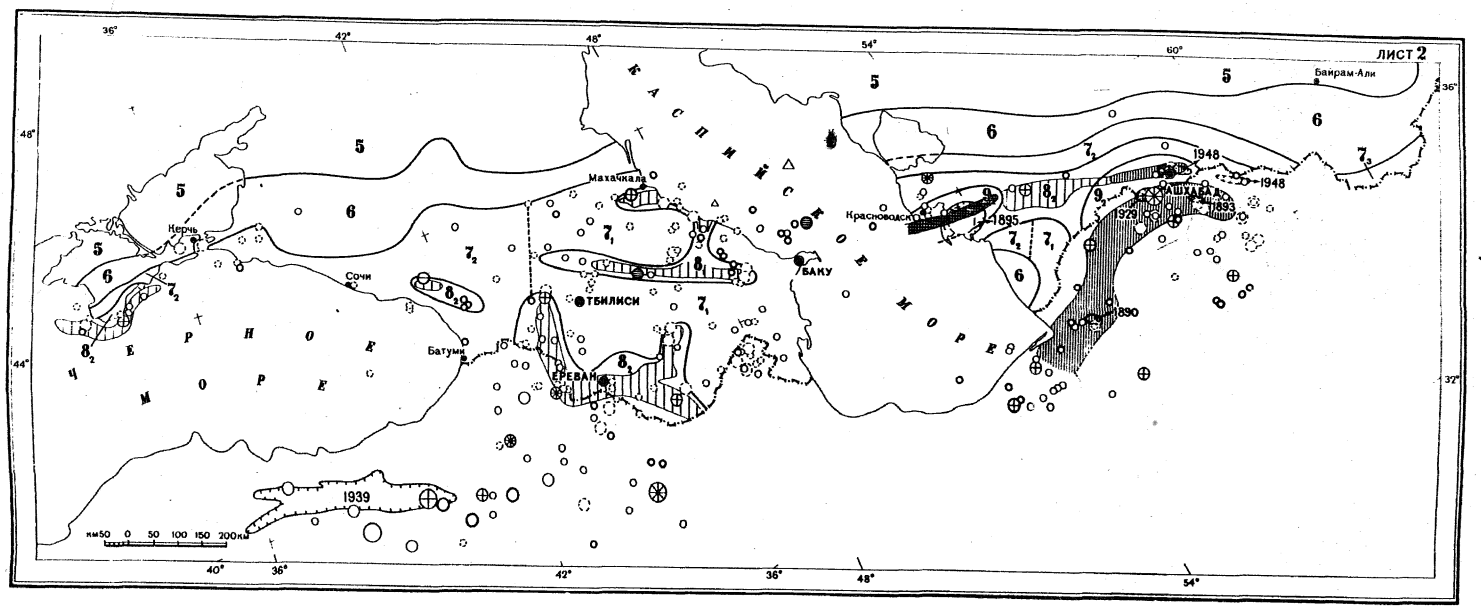

FIGURE - 2

ВЕРОЯТНЫЕ ИЗОСЕЙСТЫ ЗЕМЛЕТРЯСЕНИЙ

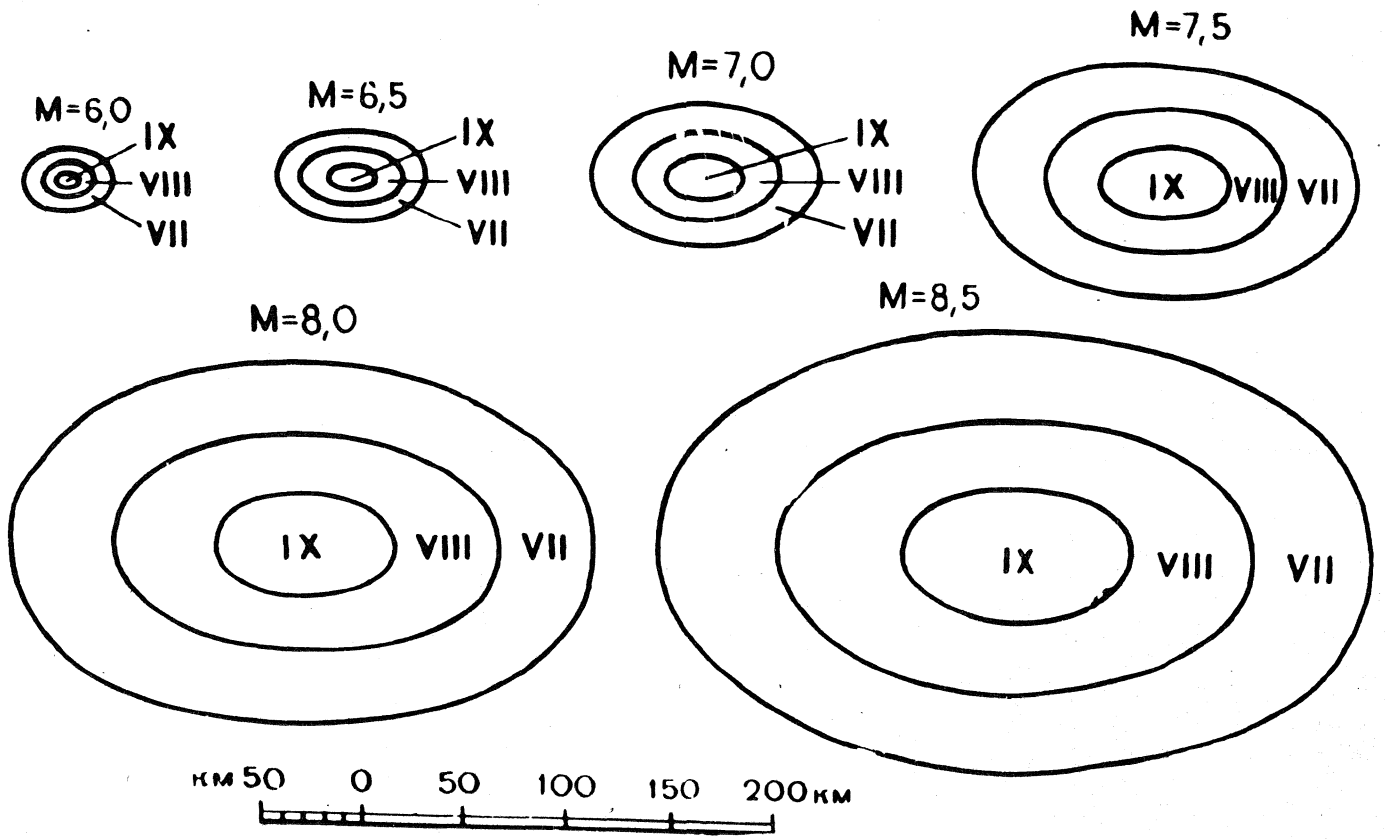

FIGURE - 3