NEW SEISMIC REGIONALIZATION OF USSR TERRITORY

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The new seismic regionalisation of Soviet territory has been carried out as a result of: a) a study of the earthquakes that have occurred in the USSR , b) the establishment of regular processes preceding earthquakes of various intensity, c) an analysis of geological conditions in which earthquakes occur, and d) investigation into specific ways earthquakes manifest themselves on the surface of the earth.

Research into geological conditions in which earthquakes occur has shown that earthquake foci arise predominantly in zones of the most contrast present tectonic movements.

The frequency of earthquency of earthquakes depends on their intensity. On the basis of the data provided by the seismic stations of the Soviet Union there have been obtained recurrence graphs for earthquakes of various intensity for the separate seismic regions.

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The new map of seismic regions shows the zones of various seismic dangers in Soviet territory. This map serves as a basis for organising construction in seismic areas. It makes a prognosis for seismic effects on installations. This prognosis is made with due regard for earthquake recurrence.

The new map of seismic regions in the USSR was made during 1961-1964. In the first place, seismic Regionalisation Instructions (I) were drawn up. Never before in the USSR or any other country had such instructions been worked out, and the compilers of the map had to overcome difficulties connected with both the new methods of work and the form of the Instructions. The latter were necessary for taking a single approach to the compilation of maps of the various seismically active regions on the USSR territory. Experience has shown that the Instructions helped those working in the various zones in planning and organising their research work, for they enumerate the main seismological and geological materials needed for drawing a map, and also show the general order of using these materials.

The seismic regionalisation carried out separately by zones has been the result of joint analysis of seismological, engineering-seismological and geological materials. The basic methods of seismic regionalisation were as follows.

The entire work was carried out in two stages. In the first stage, a seismicity prognosis, i.e., an earthquake forecast relative to a focal zone and not to the earth's surface, was made. Such seismic data as charts of epicentres, focus depths, sismicity graphs, seismic activity diagrams, etc., characterise precisely focal zones (2). Geological data determining the structural features of an area, the history of its tectonic development and particularly the latest movements also serve to assess zones of a possible earthquake and not a tremor on the surface (3).

In the second stage, the difference in the intensity of shocks on the surface of the earth was found. This was made on the basis of the obtained atat on the seismicity prognosis with due account of information, though very limitted, on the focus depths. Besides,data on the ratio between the magnitude of an earthquake and its intensity in the epicentre were used.

'The delimitation of zones of similar seismic dangers was carried out on the basis of seismic and geological data. Data on the distribution of earthquake foci, materials on seismic conditions and information about the geotectonic features of the given area served as a basis for singling out seismically dangerous zones. The intensity of expected earthquakes in the zones delimitated was determined on the basis of engineering-seismological data as regards the destructive consequences of previous maximum-force earthquakes in these zones. Moreover, data on the recurrence

of earthquakes of various intensity in the area under consideration were also taken into account.

In the process of seismic regionalisation, seismistatistical data, macroseismic and instrumental, were used.

The instrumental data on earthquakes were taken from the Atlas of Earthquakes in the USSR (4), Bulletins of the seismic station network, Bulletins of strong earthquakes and Catalogues of epicentres obtained with the aid of temporary seismic stations.

In the case of all the earthquakes their magnitudes M were used; they were as a rule determined from the shifts in the surface waves, recordered by general-type devices. The 1st group includes earthquakes with a magnitude exceeding 7 1/2, the 2nd group - with a magnitude of 6 1/2 to 7 1/2, the 3d group - with a magnitude of 5 1/4 to 6 1/4, the 4th group - with a magnitude of 4 1/4 to 5 and the 5th group - with a magnitude of 4 and less.

In many cases, earthquakes in energy Class K were also determined according to the published Instructions on Dynamic Measurements (5).

The precision with which the co-ordinates of earthquake epicentres are determined is of great importance for seismic regionalisation. Class A included epicentres found with an error of less than 25 km. If the error was within 25 to 50 km, the earthquake was included in Class B. This determined the boundaries of the isolines.

The fact that seismic stations were distributed unevenly in space and time distorted the actual seismicity of this or that area, which was naturally taken into account in seismic regionalisation, for instance, in the case of the Caucasus and Central Asia.

Data on weak earthquakes registered by a network of permanent and, in particular, temporary stations made it possible to give a more detailed characteristic of the seismicity of the zones studied. Weak earthquakes occur within the same structural seismic zone as strong ones. Numerous weak earthquakes, therefore, have enabled us to delimit zones of similar seismic dangers, for instance, in the Pamirs and the Kopet Dagh.

For vast territories and prolonged observations, weak earthquakes give a relatively stable characteristic of seismic activity, which made it possible to use seismic activity maps for determining the maximum magnitude in the zone concerned. The law of earthquake recurrence studied in detail in works by Soviet seismologists (2, etc.,) was used for assessing the intensity of expected earthquakes in regionalising the greater part of areas in the USSR (Kamchatka, the Caucasus, the Pamirs, Tien Shan and others).

It must be, however, pointed out that owing to the short periods of instrumental observations, the isolines of seismic activity maps should not be repeated in the isolines of maps showing seismic areas. The unsimilarity of seismic con-

ditions for small areas hinders day-to-day seismic regionalisation according to seismic activity maps alone.

A combined map of seismic activity in Soviet territory has been compiled on the basis of separate maps made according to zones. It shows the isolines representing the expected recurrence of earthquakes in energy Class 14 per 1000 sq.km. The zones of maximum recurrence on the whole correspond to the zones of high intensity shown on maps of seismic areas. The isolines, however, do not agree in detail; in some cases the isolines of a seismic activity map cross the isolines shown on a map of seismic areas. This, naturally, is the result of the methods used in drawing maps of both types. For seismic activity maps, data on earthquakes of Classes 10-12 and sometimes 13 were used, while the tectonic characteristics of the zone concerned were not used. As for seismic regionalisation,data on earthquakes of Classes 13-15 and also those on the seismotectonics of the given area were of substantial importance.

Comparative data on earthquake recurrence for various areas of the USSR are of special interest. This recurrence ranges from 20 years for some eastern areas of the USSR to 2000 years for some western regions of the country.

Information is much more valuable when the recurrence graph and the corresponding values of the seismic activity level and of the angle between the line on the graph and the X-axis are obtained for the areas singled out on the basis of seismic and geological data. The same applies to

the compilation of seismic activity maps.

Investigations have been made in the field of engineering seismology. In the process of research conducted to render more precise the map of seismic areas,data on the way the strongest earthquakes manifested themselves on the surface have been collected and systematised. Information about surface tremors describes the consequences of earthquakes with an assessment of their intensity according to the scale worked out by the Institute of the Physics of the Earth and adopted as State Standard 6249-52. Quantitative data on ground undulatory motions in strong earthquakes of various intensity measured according to the State Standard USSR 6249-52 scale are set out in the author's work (6).The new model of an international seismic scale, proposed by S.V.Medvedev, V.Schponhouer and W.Karnik, corresponds to the State Standard 6249-52 scale.

For sparsely populated mountainous areas there were instrumental data: on the magnitude of strong earthquakes and the co-ordinates of their focus, while there was no information about their intensity and epicentre. In order to make full use of such data special researches were carried out, particularly in the case of Central Asia (7), the Caucasus and other areas. For strong earthquakes, on which there are both instrumental and macroseismic data, regional relatioships between their intensity and magnitude were found. Moreover, earthquake investigation materials were used to find the mean areas of undulations of various in-

tensity. These data were used for determining the areas of surface tremors in those earthquakes on which there are only instrumental data. Thus, seismostatistical data turned out much more trustworthy. This made the map of seismic areas more accurate.

All data on the manifestation of earthquakes on the surface of the earth were related to similar ground conditions over the entire territory of the Soviet Union. Such were the following average types of ground: a) hard clayey and loamy grounds, b) sands and snady grounds, with subsoil waters at a depth of 8 metres and more, c) large-fragmented grounds, with subsoil waters at a depth of 6 to 10 metres.

In all cases when ground conditions were known, the assessment of earthquake intensity was corrected and reduced to average ground conditions. It was taken into account that seismically the best are non-weathered rock and semi-rock grounds, in which the magnitude of an earthquake decreased by unity. Water-saturated gravel, sandy and clayey grounds are seismically unfavourable, for during earthquakes they increase their magnitude by unity. Such relief features as, for example, precipitous shores, steep mountain slopes and revines may be of importance in assessing the seismic effect.

During the division of Soviet territory into seismic areas, tectonic data were of substantial importance for delineating zones of similar seismic dangers, for earthquakes are a manifestation of tectonic activity. Tectonic activity is caused by processes occurring in the entrails

of the earth at a depth of several hundred kilometres. These processes should manifest themselves on the surface of the earth over such a territory the linear dimensions of which are commensurable with the depth at which these processes take place, i.e., at hundreds of kilometres. However, we had to take into account the fact thet the heterogeneity of the earth crust's plastic properties in depth and width gives rise to difference in the intensity of vertical shifts on the territory under observation. The mechanism of earthquakes is the result of breaks in the continuity of the matter of the earth's crust with its separate sections being in relative motion.

Tectonically the seismoactive zones in the Soviet Union are divided into three categories:

1. Platform sections in which intensive movements have been taking place since the Tertiary Period; for example, Tien Shun and the Baikal Area.

2. Sections of the Alpine geosynclines, which in Soviet territory include the Carpathians, the Crimea, the Caucasus and the Pamirs.

3. Sections adjacent to the borders of the continental and oceanic regions situated in the area of Kamchatka and the Kuril Islands.

A comparison of geological and seismic data made it possible to reveal some regular features governing their relationships. The intensity of the latest tectonic movements serves as an indicator of the increased seismicity

of the territory concerned. During regionalisation, therefore, we singled out zones ehich shargply differ in the intensity of the latest motions. The velocity gradient of vertical movements, which represents the change in velocity per unit distance, was taken as a quantitative index of the intensity of these movements. In many cases, however, it was not possible to determine velocity gradients. This applies to areas where tectonic development has changed, as a result of which upward movement has been replaced by downward movement and vice versa.

An immediate comparison of geological and seismic materials was made with due regard for the fact that they characterise seismic activity for quite different intervals of time. In compiling the map of seismic regions it was assumed that seismic conditions for large-size seismically active structures are constant or an interval of several thousand years.

The previous map of seismic regions of the USSR territory was described in the paper the author red at the Second International Conference in Tokyo (8). The new map is based on more complete factual data obtained as a result of extensive regional investigations conducted by a number of institutes in these areas and also by the Institute of the Physics of the Earth in Moscow; all these investigations were carried out under the author's scientific guidance.

The new map shows, with the aid of isolines, areas where in conditions of average grounds it is possible for vibrations to arise in earthquakes of an intensity of 10, 9, 8, 7 and 6 according to the State Standard 6249-52 scale.

This map completes a stage of investigations in the field of engineering seismilogy. It makes a prognosis for seismic effects on installations.

Subsequently investigations in the field of seismic regionalisation should be conducted in the following directions:

a) Joint research into seismic and geological factors causing earthquakes, coupled with data on seismic conditions, the latest tectonic movements, the sturcture of the earth's crust and the geophysical parameters.

b) Investigation into the specific features of the seismic conditions in various parts of Soviet territory with a detailed analysis of earthquake recurrence and also a study pf forerunners of strong earthquakes and aftershocks.

c) Further elaboration of the main problems of engineering seismology with prospects for compiling detailed maps of seismic regions, which should take into accout the local specific features of the engineering-geological situation, spectra of vibrations, theri duration and other quantitative indices.

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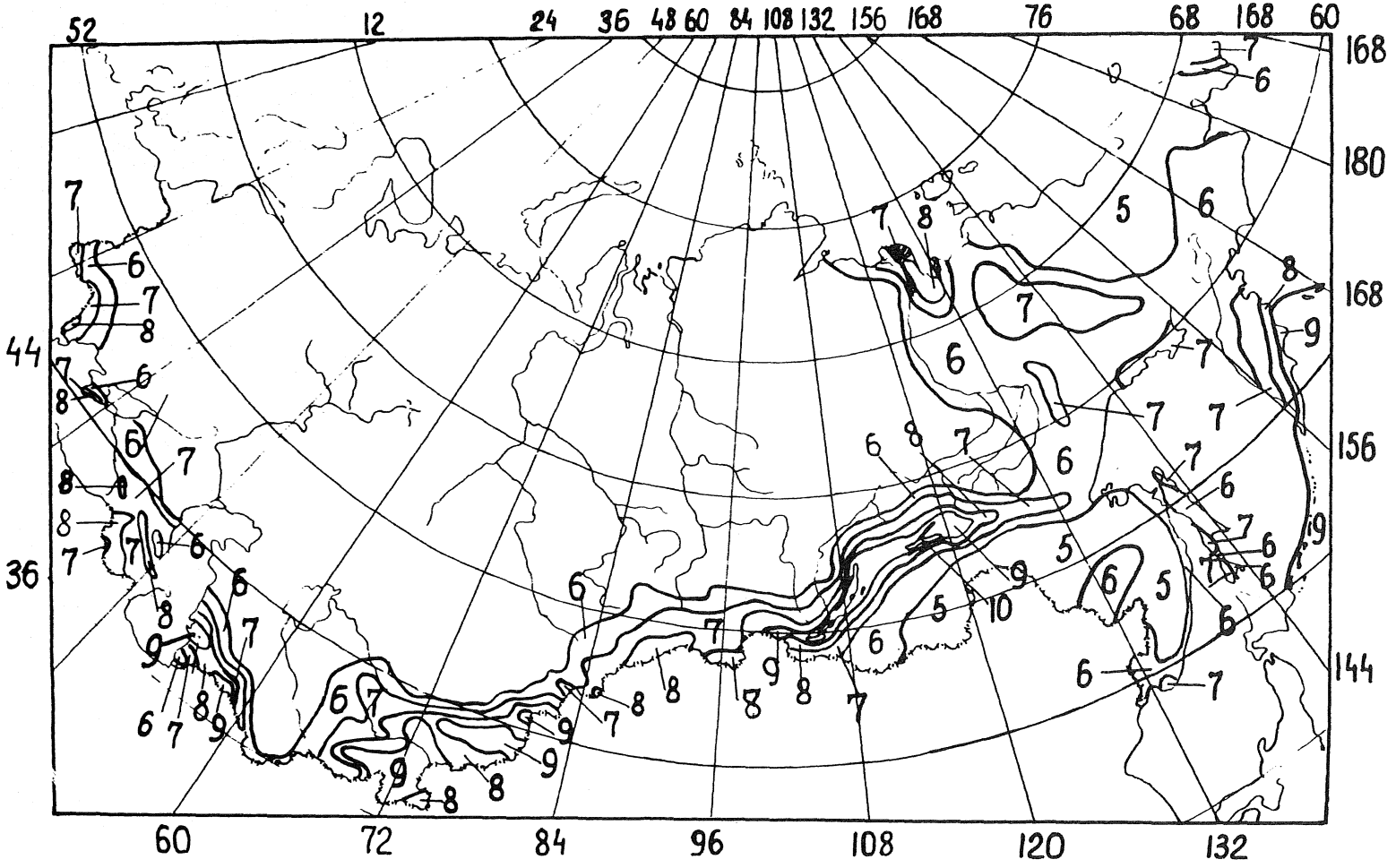

Fig.1. Map of seismic regions of the USSR territory.

The figures show intensity according to the seismic scale.