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Dynamics of the velocity field of volumetric waves and its communication with processes of seismic and volcanic activity in Kamchatka

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The original method of calculation of three-dimensional velocity fields on the basis of seismological data is considered. Authors have developed the algorithm in 90th years [1], in the last two years it has been updated [2]. Use of the data of digital telemetric stations of Kamchatka has raised accuracy of calculations, and continuity of the initial data has allowed the authors to perform calculations of the velocity field for various time intervals and to find out dynamics of changes of the velocity fields of P and S waves and their ratio Vp/Vs during the periods of simultaneous seismic and volcanic activity.

The principle of reciprocity of wave fields in three-dimensional medium is put in the basis of the considered method of calculation of the velocity of P and S waves. Use of this principle allows considering the group of travel times of a seismic wave from weak enough earthquakes up to some seismic station as travel times of a reciprocity wave from this seismic station up to various points of three-dimensional space.

The front of a reciprocity wave is restored on experimental data in area G which linear sizes are small in comparison with distance from point $\grave{I}_0$ up to station S_j, thus it is supposed, that the velocity of propagation of the front in area G can be considered as constant.

The considered method is differential; at the solution of the problem the differences of experimental times $(t_{ij} - t_{0j})$ from two foci from area G are used only. As the sizes of area G are small in comparison with the distance up to station it is possible to consider, that seismic waves from points $\grave{I}_0$ and M_i outside of area G pass approximately identical way. Thus influence of peculiarities of the structure of the crust under the

stations, presence of a regular error in times and in coordinates of the foci is excluded. Let's note the basic properties of algorithm.

1. Velocity of seismic waves is defined only in the field of the foci of earthquakes.

2. The method uses only differences of times of the first arrivals from a group of foci at the fixed station that allows removing influence of peculiarities of medium under the station and on the way of propagation of the seismic wave.

3. In calculations differences of coordinates of group of the foci are used only, due to it influence of regular mistakes in coordinates of the foci decreases.

4. Velocity of seismic waves is supposed to be smooth enough function, so that in area G it could be counted a constant.

5. Simultaneously with the velocity the output angle of the seismic wave from the focus to the station is defined, that can be used for refining of the velocity structure of the medium outside of the zone of the foci.

It is necessary to emphasize, that the given approach and algorithms of the method of seismic tomography are not antagonists, they rather supplement each other, as they define values of velocities of seismic waves in different areas and with different degree of detail.

As the experimental material the seismological data from the area of Karymsky volcanic centre in Kamchatka, where in January 1996 an important and outstanding volcanic event occurred, were used. Simultaneously with strong tectonic earthquake Ì=7.0 there was an eruption of a volcano silent for 28 thousand years and an eruption of active Karymsky volcano.

In connection with the large number of seismic events preceding and accompanying the volcanic process, the initial data have been divided into three time intervals. The first interval - on January 1, 1996 after 10 hours Greenwich, i.e. after the main shock of earthquake Ì=7.0. The second interval - on January 2, 1996 during the development of eruption in the caldera of Academy of Sciences. The third interval from on January 3 to February 20, 1996, during the period when eruption in the caldera of Academy of Sciences came to the end. It has allowed investigating reflection of development of volcanic process in the field of velocities of P and S waves [3-5].

The authors consider the vertical sections as the most interesting. In the work the vertical sections on the profile coming through seismic station Karymsky (KRY) and the epicentre of the main shock are analyzed. For construction of cuts in this section values of velocities in the points located in a strip of +/-10 km from this plane were used.

Let's note, that seismicity on January 1 is concentrated at depths more than 15 km whereas the quantity of the foci at depths up to 5 km and 15 - 30 km on January 2 considerably increased. The quantity of the foci deeper than 30 km decreased on the following days. The area of absence of the foci on January 1 at depths of 5-15 km is interesting. It is possible to assume that in this zone the focus of the main shock M = 7 was located, therefore in this zone there was a dump of the collected pressure and destruction of the medium. During the subsequent time periods the interval of absence of earthquakes at these depths gradually reduced.

For longitudinal waves according to January 1 let's note the presence of the isoline of velocities higher than 8.0 km/s on depths of 40-50 km., at simultaneous lowering of the isoline of 7.5 km/s up to depth of 40 km. During the following period the isoline of the velocity Vp = 7.5 km/s rose up to depth of 35 km. It is simultaneously possible to allocate characteristic lowering of isoline Vp = 6.5 km/s up to depth of 35 km on January 1 and up to depth of 22 km on January 2. We note also that this peculiarity of isolinies of velocity Vp on January 1 was observed under the epicentre of the main shock, whereas on January 2 it is observed under the area of eruption in caldera of Academy of Sciences as well. Significant velocity gradients on depths of 30-45 km on January 1 and on depths of 20-35 km on January 2 were observed. On the next days the velocity field is levelled, and the direction of isolines of the velocities of P waves becomes close to horizontal.

For S waves areas of high gradients of velocity are observed approximately at the same depths, as for the velocity of P waves. The velocity field Vs is morphologically quieter.

The ratio of velocities of P and S waves strongly differs from the standard Vs/Vs = 1.73. The field is mosaic; the isolines on January 1 and January 2 are almost vertical, low values of this attitude occur. On the data of January 1 abnormal low values of this parameter are observed in the interval of depths 25-40 km, on January 2 - in the area of 10-20 km. It is necessary to note the presence of a sharply gradient zone on January 2 on depth about 8 km, with minimum Vp/Vs equal to 1.59 on depths of 10-20 km. On the next days the field of Vp/Vs ratio is levelled and is practically equal to1.73.

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