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GEOPHYSICS

1970

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Abstract

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UDC 550.341:550.311

GEOPHYSICS

V. M. ZOBIN

ON A REGULARITY IN THE ORIENTATION OF EJECTA FROM “DIRECTED EXPLOSIONS” ON VOLCANOES

(Presented by Academician M. A. Sadovskii, 30 VI 1969)

During eruptions of the “directed explosion” type, the erupted material is distributed with force over an area, independently of the relief ⁽¹⁾. It is of interest to investigate the relation between the orientation of the ejecta from “directed explosions” and the dominant orientation of rupture surfaces in earthquake foci in the region of a volcano.

The gigantic eruption of Shiveluch volcano in Kamchatka in 1964 belongs to eruptions of the “directed explosion” type ⁽²⁾. It was preceded by an intensive seismic preparation that lasted several months. For the two strongest volcanic earthquakes, nodal surfaces have been constructed ⁽³⁾. The principal parameters of the movements in the foci are given in Table 1. During the earthquakes there occurred horizontal

Table 1

Time in the focus	Earthquake region	Depth, km	M	Type of earthquake	I Az, deg.	I e*, deg.	II Az, deg.	II e*, deg.	i**, deg.	i**, deg.	k***, deg.	k***, deg.
11 XI 1964	v. Shiveluch	0-10	5.0	Volcanic	105	80 SSW	110	75 ESE	160	5	250	20

Time in the fo- cus	Earth- quake re- gion	Depth, km	M	Type of earth- quake	I Az, deg.	I e^* , deg.	II Az, deg.	II e^* , deg.	i^{**} Az, deg.	i^{**} e , deg.	k^{***} Az, deg.	k^{***} e , deg.
11 XI 196410 h 07 m	v. Shiv- luch	0-10	$5^{1/2}$	Same	200	80 SSW	105	85 ESE	330	5	240	25
19 VII 196601 h 40 m	Kamchatka Strait	20-30	$6^{3/4}$	Tectonic	210	80 SSW	120	85 ESE	160	5	255	10

* —angle with the horizontal plane.

** —axis of compressive stress.

*** —axis of tensile stress.

shears; the compressive and tensile stresses in the earthquake foci were directed almost horizontally. Comparison of the orientation of the ejecta deposits of the “directed explosion” of Shiveluch volcano with the orientation of nodal surfaces corresponding to possible rupture surfaces in the foci of volcanic earthquakes showed that one of the nodal surfaces is close in azimuth to the orientation of the deposits of the “directed explosion” (Fig. 1, *g*).

The mechanism of the focus of tectonic earthquakes of Kamchatka has been studied in sufficient detail (⁴). Let us compare it with the focal mechanism of the volcanic earthquakes of Shiveluch volcano considered above. The Kuril-Kamchatka seismoactive zone is characterized by nonconstancy of the orientation of stress fields as a whole, but over sufficiently small areas the regularities of the stress field remain unchanged (⁴). In this connection let us consider the focal mechanism of five earthquakes in Kamchatka Bay, located at a distance of 2–3° from the volcano (see Fig. 1, *g*). Their foci, as in the case of volcanic earthquakes, are located in the Earth’s crust. The principal parameters

movements in the focus of one earthquake typical for this region are given in Table 1. It can be seen that the mechanisms of volcanic and tectonic earthquakes in the region are similar. One of the two possible rupture surfaces in the foci of tectonic earthquakes is also close in azimuth to the orientation of the “directed explosion” of Sheveluch.

Consideration of the “directed explosions” of a number of other volcanoes of

Fig. 1

Figure 1: Fig. 1

the world and comparison of their orientations with data on the orientation of rupture surfaces in the foci of nearby tectonic earthquakes show the general

Fig. 1. “Directed explosions” of some volcanoes and rupture surfaces in the foci of nearby tectonic earthquakes. **1** –orientation of the ejected deposits of a “directed explosion” ; **2** –possible rupture surfaces in earthquake foci; **3** –averaged local possible rupture surfaces in earthquake foci

significance of the noted regularity. The source material for the study was taken from review works (^{1,4-6}).

Volcanoes of Japan. Among eruptions of Japanese volcanoes, the eruptions of Asama volcano in 1783 and Bandai-san volcano in 1888 belong to eruptions of the “directed explosion” type. Both volcanoes are located in the central part of Honshu Island (Fig. 1a). At Asama volcano the explosion covered a fairly narrow sector to the north of the volcano. During the eruption of Bandai-san volcano, 15-20 strong explosions occurred, of which the last had the greatest force and was directed horizontally northward (¹).

H. Honda et al. (⁶) give the parameters of rupture surfaces for three crustal tectonic earthquakes of this region (Fig. 1a). The orientation of the rupture surfaces of all these earthquakes is close; moreover, one of the two possible rupture planes of these earthquakes has a northern direction, i.e., is close to the azimuths of the ejection of the deposits of the “directed explosions” of Asama and Bandai-san volcanoes.

Katmai Volcano, Alaska. In 1912, at the summit of Katmai volcano, a powerful directed explosion occurred, destroying a significant part of the summit. The explosion was directed predominantly to the northwest (¹).

The compilation (⁵) gives data on the orientation of rupture surfaces of three crustal tectonic earthquakes whose epicenters are located south of Katmai, in the sea (Fig. 1). The azimuths of the two possible rupture surfaces of all three earthquakes are close, and one of the possible rupture surfaces is directed to the northwest.

Hibok-Hibok Volcano, Philippines. The eruption of the volcano occurred in 1948. A series of directed explosions was oriented to the northeast of the crater (¹). A. Ritsema (⁵) determined the orientation of the possible rupture surfaces of a tectonic earthquake recorded on Camiguin Island, where the volcano is also located. One of the possible rupture surfaces is oriented to the northeast (Fig. 1).

Volcanoes of Kamchatka. In addition to the example considered above of a “directed explosion” of Shiveluch Volcano, let us turn to data on the eruption

of Bezymianny Volcano in 1956, which, like Shiveluch, belongs to the Northern group of volcanoes of Kamchatka (Fig. 1).

During the eruption of Bezymianny Volcano, a gigantic explosion encompassed the summit crater and the extruded ancient crater on the southeastern slope of the volcano and was directed to the southeast at an angle of 30-40° to the horizon ⁽¹⁾.

We have already noted that the orientation of the ejecta deposits of the “directed explosion” of Shiveluch Volcano is close to the orientation of one of the two possible rupture surfaces in the foci of earthquakes of the Kamchatka Bay region. The “directed explosion” of Bezymianny Volcano is close in orientation to the azimuth of the second possible rupture surface.

Data on the averaged orientation of the possible rupture surfaces of tectonic and volcanic earthquakes and on the orientation of ejecta from “directed explosions” of various volcanoes show that the coincidence noted for Shiveluch between the azimuth of ejecta from volcanic “directed explosions” and the orientation of one of the two possible rupture surfaces has general significance. It may be assumed that the orientation of ejecta from volcanic “directed explosions” is not accidental; it is governed by the tectonic setting of the region.

Institute of Volcanology
Siberian Branch of the Academy of Sciences of the USSR
Petropavlovsk-Kamchatsky

Received
17 VI 1969

CITED LITERATURE

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Note: Figure translations are in progress. See original paper for figures.

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