



Multidimensional analysis and probabilistic model of volcanic and seismic activities

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A search for space and time regularities in volcanic and seismic events for the purpose of forecast method development seems to be of current concern, both scientifically and practically.

The seismic and volcanic processes take place in the Earth's field of gravity which in turn is closely related to gravitational fields of the Moon, the Sun, and the planets of the Solar System. It is mostly gravity and tidal forces that exercise control over the Earth's configuration and relief. Dynamic gravitational interaction between the Earth and other celestial bodies makes itself evident in tidal phenomena and other effects in the geospheres (including the Earth's crust). Dynamics of the tidal and attractive forces is responsible for periodical changes in gravity force, both in value and direction [Darwin, 1965], in the rate of rotation and orbital speed; that implies related changes in the endogenic activity of the Earth. The Earth's rotation in the alternating gravitational field accounts to a considerable extent for regular pattern of crustal deformations and dislocations; it is among principal factors that control the Earth's form and structure, distribution of oceans and continents and, probably, continental drift [Peive, 1969; Khain, 1973; Kosygin, 1983]. The energy of gravitational interaction is transmitted through the tidal energy to planetary spheres and feeds various processes there, including volcanic and seismic ones. To determine degree, character and special features of tidal force contribution to the volcanic and seismic processes is of primary importance for understanding of genetic and dynamic aspects of volcanism and seismicity.

Both volcanic and seismic processes are involved in evolution of celestial bodies; they are operative on the planets of the Earth group and many satellites [Essays... , 1981; Lukashov, 1996]. From this standpoint, studies of those processes are essential with a view to development of scenarios of the Earth's evolution as a celestial body, as well as to forecast of changes in its relief.

As the volcanic and seismic processes are of cosmic nature and occurrence, it seems logical to investigate their chronological structure in terms of astronomical time reference system or in parameters of the Earth orbital movement. Gravitational interaction of the Earth with the moon, the Sun and planets of the Solar system forms the physical basis of this multidimensional system; it manifests itself in tidal deformations of the Earth's lithosphere and in periodical changes in the planet rotation and orbital speed. A search for chronological correlation between the Earth's volcanism and seismicity on one hand and the orbital parameters dynamic on the other shows a certain promise in relation to prognostic decisions. It should be kept in mind that the calculation of astronomical characteristics (Ephemerides), which is one of the main lines in theoretical astronomy, spans many years both in the past and in future. It seems appropriate therefore to apply the astronomical time reference system to investigations of chronological structure of volcanic and seismic processes from the methodical viewpoint, as well as for retrospective and prognostic analyses.

To investigate temporal pattern of the volcanic and seismic processes and to find a degree of their dependence on tidal forces, we used the astronomical time reference system as related to the Earth's orbital movement. The system is based on substitution of calendar dates of eruption and earthquakes for corresponding values of known astronomical characteristics, such as the Earth to Sun and Earth to Moon distances, ecliptic latitude of the Moon, etc. In coordinates of astronomical parameters (JPL Planetary and Lunar Ephemerides, 1997, as compiled by the Jet Propulsion Laboratory, California Institute of Technology, on the basis of DE 406 block developed by NASA), we analyzed massifs of information, both volcanological (Catalogue of the World volcanic eruptions by I.I. Gushchenko, 1979) and seismological (database of USGS/NEIC Significant Worldwide Earthquakes, 2150 B.C.-1994 A.D.) information which displays dynamics of endogenic relief-forming processes over a period of 1900 to 1994. In the course of the analysis, a substitution of calendar variable by a corresponding astronomical one

has been performed and the epoch superposition method was applied. In essence, the method consists in that the massifs of information on volcanic eruptions (over a period of 1900 to 1977) and seismic events (1900-1994) are differentiated with respect to value of astronomical parameters which correspond to the calendar dates of the known eruptions and earthquakes, regardless of the calendar year. The obtained spectra of volcanic eruptions and violent earthquake distribution in the fields of the Earth orbital movement parameters were used as a basis for calculation of frequency spectra and diurnal probability of volcanic and seismic activity.

The objective of the proposed investigations is a probabilistic model development of the volcanic and seismic events, as well as GIS designing for monitoring and forecast of volcanic and seismic activities. In accordance with the stated objective, three probability parameters have been found in the course of preliminary studies; they form the basis for GIS-monitoring and forecast development.

1. A multidimensional analysis of volcanic eruption and earthquakes (of magnitude 7) have been performed in terms of the Earth orbital movement. Probability characteristics of volcanism and seismicity have been defined for the Earth as a whole. Time intervals have been identified with a diurnal probability twice as great as the mean value. Diurnal probability of volcanic and seismic events has been calculated up to 2020.

2. A regularity is found in duration of dormant (repose) periods has been established. A relationship has been found between the distribution of the repose period probability density and duration of the period.

3. Features of spatial distribution of volcanic eruptions and earthquakes of magnitude 7 were analyzed, and those related to the Earth rotation identified. Frequencies of their spatial distribution are calculated.

Using those parameters as the base, a scheme (algorithm) of probabilistic monitoring (long-range forecast) has been developed for volcanic and seismic events.

Refereces (in Russian):

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