PROBABLE INFLUENCE OF THE EARTH'S ELECTROMAGNETIC IMPEDANCE ON PC3- PC5 PULSATION SPECTRUM DURING AN EARTHQUAKE PREPARATION PROCESS

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Summary*: Connection between the variation of the geomagnetic field and seismic activities is an essential element ofthe fundamental problem of earthquake forecasting. It, in its turn, is divided into separate blocks such as* ***specific geomagnetic pulsations*** *generated in a certain area. Consequently, in order to consider them as an earthquake* ***indicator*** *it is necessary to clearly distinguish their properties from the ones of global geomagnetic pulsations.*

Key words: *geomagnetic field, earthquake indicator.*

There is diversityin the geomagnetic field pulsation spectrum and its generation area is mostly distributed in the space near the Earth. The Earth also may possibly be a source of some types of pulsations,namely, in some cases, in order to consider the local geomagnetic field perturbation as an indicator of an upcoming earthquake it is necessary to haveinductive connection between the Earth and ionosphere, the modeling of which is quite difficult and inexplicit in regard to the mechanisms. During an earthquake preparation process, especially at its final stage, the medium parameters change. We can simply consider the local geomagnetic pulsations as a result of the mechanical vibrations of the upcoming earthquake focus, the high-frequency part of which is not shown in seismic records. However, there is another version, according to which the pulsation generator isthe high-frequency variation of telluric current intensity.In any case, geomagnetic field perturbation is an induction impact of the Earth processes. Firstly, we should admit the connection between the mechanical vibrations of the seismic activity focus and the variation of the electromagnetic properties of the geological medium. Polarizability, electric conductivity, piezo-electric and electro-kinetic properties of the mediumare significant here, for example, electro-osmosis phenomenon may develop in a disperse medium consisting of solid and liquid phases, which contributes to the generation of spontaneous electric fields and stray currents. Here, the geomagnetic pulsations may show up in either a direct or indirect way in the form of the modulators of very low frequency (VLF) electromagnetic radiation. Recently, there has been a significant progress in the studies of the mechanisms of theVLF radiation accompanying earthquakes. However, in the studies of the mechanisms of geomagnetic pulsation generation there is no other alternative then the variation of the Earth's electrical impedance [1], for example, the pulsations connected with an earthquake with frequency (1-0.001) Hz diapason, first revealed in the records of Dusheti Observatory [2], could not be explicitly explained. An electrical impedance variation model was first used for the interpretation of electromagnetic telluric sounding data, though, as it appeared, it could only enable to qualitatively explain, e.g., Pc 3, 4, 5, 6 pulsation generation. Later, at Dusheti Observatory it was revealed that the shortest-period Pc1 pulsations [3] may also be connected with earthquakes. Thus, we can conclude that seismic processes may cause geomagnetic pulsations with any frequency. However, it does not mean that pulsations definitely generate before any earthquake.

Variation in electrical impedance means variation in the Earth's electric inductivity. The inductivity effect on the ionosphere changes in accordance with the depth, where the impedance variation takes place, i.e., according to so called skin layer, VLF electromagnetic waves may break out from the Earth's depth and cause ω frequency geomagnetic pulsations on the basis of the following formula:

$$\omega = 2\left(\frac{c}{\Delta}\right)^2 \frac{\varepsilon_0}{\mu_m}\rho, \quad (1)$$

Where c is the light speed, Δ is the skin layer thickness, ρ is the medium resistivity, ε_0 is the vacuum dielectric constant and μ_m is relative magnetic conductivity. Consequently, it means that in an inhomogeneous medium, where the electric conductivity is variable, electromagnetic waves may generate in a wide spectrum of frequencies, in extremely low frequency (ELF) and very low frequency (VLF) diapasons. It does not mean that all the frequencies will clearly appear in geomagnetic pulsations. As the observation data show in most cases there are the same situations as described above. However, these frequencies probably appear in an unobvious formin geomagnetic field values.Correctness of this assumption can be verified by Fourier analysis of the geomagnetic field records, namely, we can determine variation ofspectral intensity density in accordance with the frequency. This makes it possible to determine whether geomagnetic pulsations had generated before a certain earthquake. On the local basis we can speak about the similarity of geomagnetic field pulsations at Dusheti Geophysical Observatory and the ones at Oni Seismic Station. Moreover, we verified the above saidassumption for the earthquake M=3.7that occurred on March 4, 2019 at 166 km distance (Lat41.8, Long41.7 Black Sea) from Oni Station. *Figure 1* shows middle-latitude Dst index variation (black) and X components of the geomagnetic field variations at Dusheti Observatory (blue, Lat42.088 Long44.701) and at Oni Station (green, Lat42.573 Long43.437). Although the pulsation levels are different, there is an obvious synchronicityin the variations of the vibration intensity and frequency. The global magnetosphere effect is also obvious in the given time interval according to the Dst index. However, the effect of this source is not strong as far as the Dst index depression does not exceed the statistical middle value ≈ 25 nT. Therefore, the records of both the observatory and the station were reduced to the global index level.

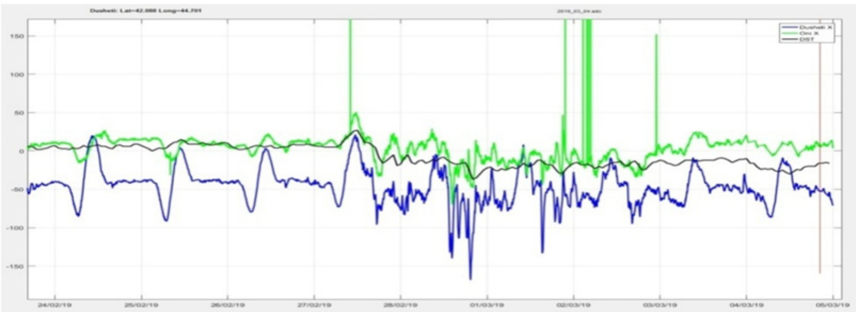

Fig. 1.

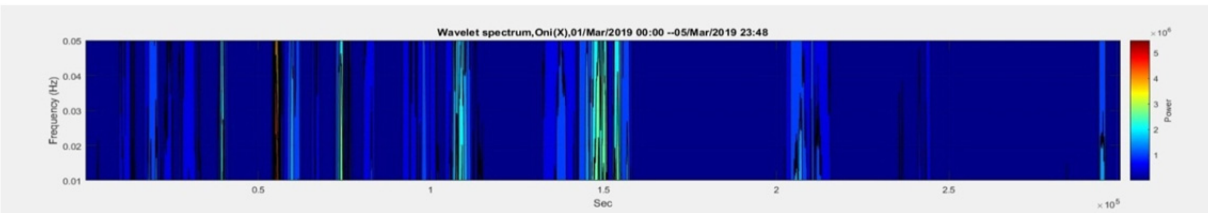

Fig. 2 a

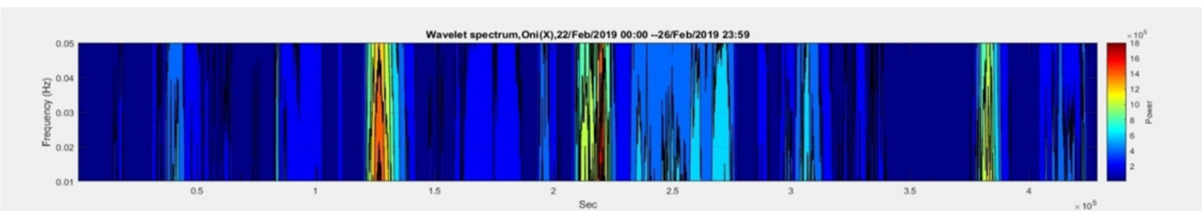

Fig. 2 b

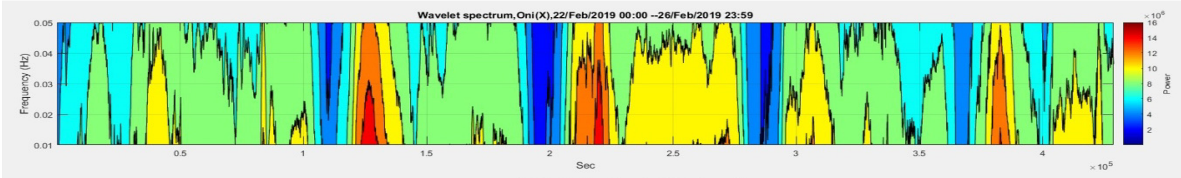

Fig. 2 c.

Figure 2 is a Fourier schemeillustrating the variation of the spectral intensity density of the pulsations at Oni Station.Comparison of Figure 2a and Figure 2b shows that before the above mentioned earthquake the spectral density significantly increases in the middle- and long-period pulsationdiapason. Figure 2c shows the pulsation count level effect, namely, 50 nT level variation increases the spectral intensity density by one order. Such an effect, although, comparatively less (≈ half an order), also corresponds to Figure 2a. We should note that at Dusheti Geophysical Observatory the effect of the given earthquake has not been recorded. It makes us suppose that there was a local geomagnetic effect. However, the mentioned above cannot be categorically argued, as the intensity of variations in Dusheti in comparison to Oni, is higher, which may be due to the differences in both local and different level of magnetometer counts. It should also be noted that the pulses, the effect of which was observed in Oni, under condition of a quieter background than Dusheti, are clearly irregular in nature, the indicator of which is the level of DST index. As for the amplitude of the pulses, their separation is a difficult task, although we can assume that their magnitude does not exceed 10 nT, as in the case of the Borok observatory [4].

Conclusion:

We can consideran abstract magnetic tube, the base of which is a certain area, including the epice-ntrumzone of an earthquake. As a matter of fact, we should consider a hypogenicphenomenon, leading to a change in the structure of the given magnetic field tube.Such a phenomenon, the most correct in physical concepts, is a change in the characteristic electrical impedance in the hypocenter zone. It becomes obvious that in the hypocenter of the earthquake, mechanical mixing of rocks takes place, which also causes thermodynamic transformations.

Let us assess the pulsation diapason from *Formula (1)* for the following parameters: the depth of the given earthquake $\Delta \approx 2$ km, ρ – /1-10/ Ohm*meter, which is characteristic of the Black Sea coastline [5]. Thus, we received the diapason characterizing frequencies $\omega(\rho) \approx 2*10^{-2}\rho \approx /2\text{-}2*10^{-2}/$Hz. Accordingly, *Figure 2* shows the low frequency part of the geomagnetic pulsation spectrum, i.e., Pc3-Pc5 diapason of the regular pulsations. Thus, the example studied by us shows that the geomagnetic pulsations generated before an earthquake may appear in either an obvious or unobvious forms in the records of nearby geomagnetic stations.

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