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Variations of the VLF magnetic field associated with earthquakes at local, regional and global scales

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Variations of the magnetic field in very low frequency (VLF) range recorded in Crimea, Ukraine (44.5 N, 34.1 E), during July – August 2002, and in Kharkov region, Ukraine (49.7 N; 36.2 E), during November 2004 - October 2005, have been statistically studied through the comparison with seismic records and world wide earthquakes data [1]. Observational station in the eastern part of Ukraine (Kharkov region) [2] is located in the seismically quite area while the site of observations in Crimea was close to regional fault at the border of the Mediterranean seismically active region.

Magnetic field observations were made with identical systems based on VLF receiver "Tezey" [3]. The system included three orthogonal coil sensors oriented in the geomagnetic north-south, east-west and vertical directions. Output signals from these sensors after processing procedure were recorded as a number of pulses per second.

Seismic events under study were considered as representative of local, regional and global seismic activity. The group of local seismic events included all earthquakes which sources were close to observational points, at distance of possible appearance of earthquake precursors. In this case, the source displacement had to be smaller than $\sim$exp(M) (in kilometers) [4] where M is earthquake magnitude. Regional seismic activity was studied using sets of earthquakes separated by distance from the site of observation and also earthquakes localized in the Mediterranean seismically active region. Global seismic activity was analyzed through earthquakes with magnitude $M > 4.8$. We fulfilled statistical analysis of data for entire time of observations and also using different daily time intervals from the whole day to several hours.

We found that strongest earthquakes observed in the Mediterranean seismically active

region ($M \sim 4.4$) were characterized by anomalous increasing of the variability of the magnetic field (1.5 - 4.0 times higher than usual level) about two days before the earthquakes commencement. We also compared results of VLF observations with seismic records made in the seismic station near our site of observation. Seismic records showed a number of small seismic events with magnitude $M < 1.0$ represented local seismic activity. These events are clearly associated with features characterized by 10% - 20% increasing of the magnetic field variability about half an hour before micro earthquakes beginning.

Analysis of VLF data obtained in the Kharkov region allowed recognizing of magnetic precursors for the strongest earthquakes at different distances from the observational station. In particular, for Indonesia earthquake (26.12.2004, = 9.0) anomalous increasing of the magnetic field variability was observed 14 days before the earthquakes commencement. At the same time the increase of infrasound emission was recorded at the Vernadsky station (Ukraine) in Antarctica.

Thus, strong earthquakes have well pronounced effect on distant VLF variations of the magnetic field. Weak earthquakes also have to be taken into account during analysis of appearance of the regional or global seismic activity in the magnetic field variations.

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