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Background electromagnetic noise in the vicinity 1 Hz as a possible indicator of earthquake-related anomalies

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Abstract
Measurements of space-time distributions of the background emissions in the frequency range 0.5-5 Hz and their seasonal and diurnal variations are presented. The analysis of impedance ratio determines the presence of high space harmonics in the emission spectral distribution. The absence of this emission during the winter time correlates with the absence of any precursors before local earthquakes with $M \sim 6$. It is shown that the knowledge of the background emission behavior and its origin are very important for precursor phenomena monitoring.

Key words *electromagnetic emission – temperature – Earth surface – impedance – earthquake precursor – 1 Hz frequency range*

New electromagnetic emission termed «thermal geomagnetic emission» has been described elsewhere (Gokhberg, 1998). This emission occurs during the daytime and looks like broad band noise in the frequency range 1-5 Hz. The noise is supposed to be related to a thermal regime of the near Earth surface atmospheric layer. The example of the so-called type 1 emission is shown in fig. 1a.

During the local evening hours and night time the emission occurs with rising frequency noise bands, which look like a «fan». This type of emission (that we called as type 2) has been described in several papers (Larsen and Egeland, 1968; Beamish and Tzanis, 1986; Belyaev *et al.*, 1987) and explained using the theory of the ionospheric Alfven resonator (see fig. 1b).

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Diurnal and seasonal variations of intensity for both types are represented in fig. 2. One can see that the diurnal maximum of «thermal emission» (type 1, dark area) take place in between 12-14 UT or 15-16 LT for Borok Observatory (58.03°N, 39.97°E) and for «fan» (type 2, light area) between 16-18 UT or 19-21 LT.

The seasonal distribution for type 1 emission has one maximum during the summer time while for type 2 emission two maxima take place during the spring and autumn. Shown in fig. 3a are the thermal emission intensity (black vertical line) for each day during July 1998 and daily temperature variations measured at Borok Observatory. One can see a good correlation between the sharp gradient of the temperature decrease and deep decrease of the emission intensity starting from July 12 to 13. Similar features are seen in fig. 3b with intensity and temperature variations measured at Mondy Observatory (52.2°N, 104.5°E) during August 1997. For both observatories the general features of such an emission are similar if we take into account the shift of about 5 h in UT relative to their longitudinal position.

The analysis of the impedance $Z = E/H$ was produced for close to simultaneous records of Pc-1 and «thermal emission». The Pc-1 imped-

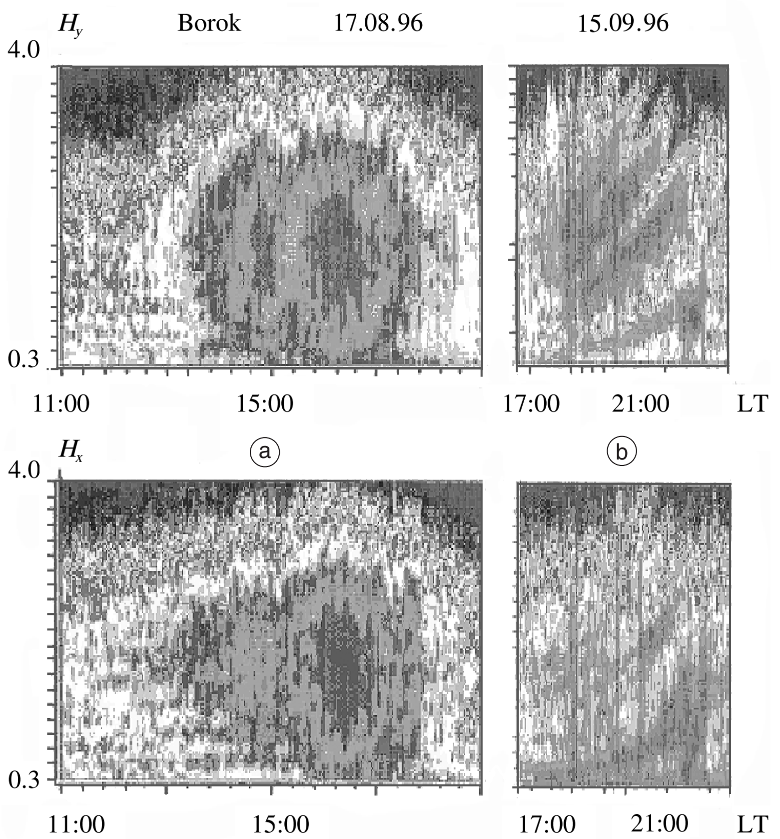

Fig. 1a,b. Frequency *versus* time presentation of H_y, H_x magnetic components during (a) daytime (thermal or type 1 emission) and (b) nighttime (fan or type 2 emission) conditions.

ance can be described by the plane wave impedance $Z = -i\omega\mu / k$, where $\omega = 2\pi f$, $\mu = 4\pi 10^{-7}$ G/m, $k = \sqrt{-i\omega\mu\sigma}$, where σ is the conductivity of the Earth crust upper layer.

In general cases, the «thermal emission» impedance can be described as $Z^* = -i\omega\mu / k^*$ where $k^{2*} = k^2 + n^2$ and n is the space harmonic number. If we know σ and ω we can determine n which is related to the source dimension and the distance from it.

The 3D fig. 4 shows the dependence of n^{-1} number on frequency ω and ratio Z/Z^* for $\sigma =$ = const. One can see that for the 20% ratio Z/Z^* increase the value 1/n (meter) is about several hundred meters if $\sigma \approx 1$ S/m (Rokitianski, 1962) which is roughly related to Borok Observatory conditions. The experimental statistical value for Borok Observatory is Z/Z^* (1.2-1.4). It means that due to global temperature modulation of the emission intensity, the space distribution is less than one kilometer and is related to the local observation condition and local sources.

The same results were obtained by gradient measurement on the distance less than one hundred meters for the local geomagnetic variation network at Borok. Using this experimental data one can conclude that type 1 emission correlates with the temperature regime and probably relates to the parametric instability of the near Earth surface local atmospheric layer.

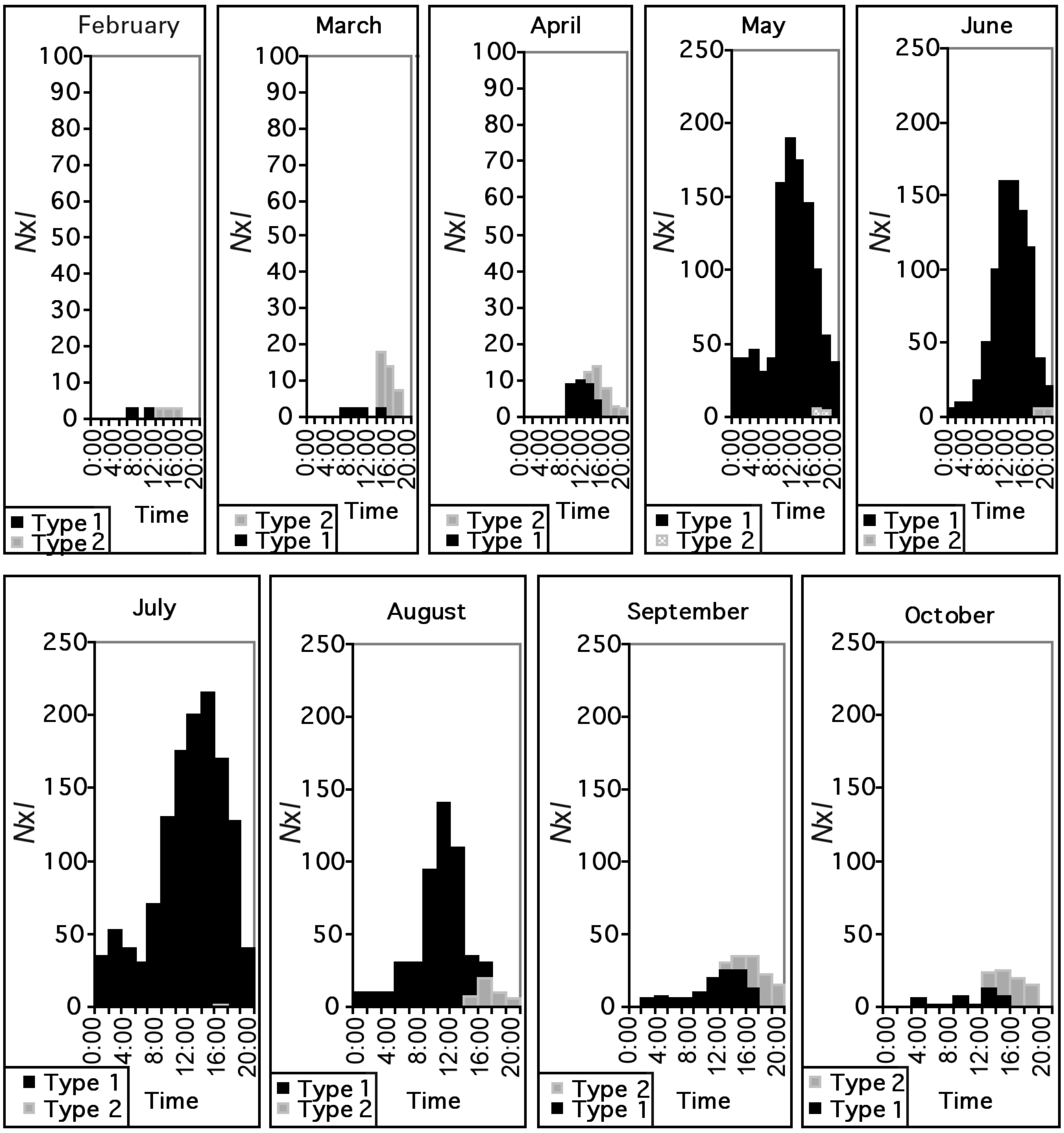

Fig. 2. Seasonal and diurnal intensity variations for type1 (thermal) and type 2 (fan) emissions. Vertical scale shows the product of events number (*N*) by intensity of thermal emission (*I*), horizontal scale shows UT (in hours).

For type 2 emission the absence of such a structure in electric field component demonstrates still higher differences Z^* from plane wave. Moreover the presence of the structure in vertical *Z* magnetic component (as in the fig. 5) also shows the presence of a source nearby and strongly complicates the explanation from the far zone ionospheric source.

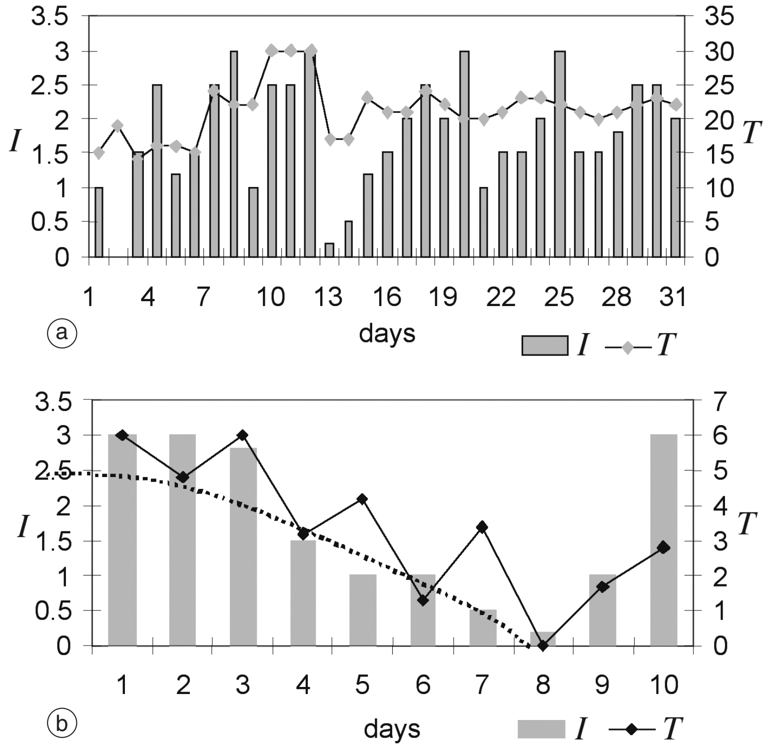

Fig. 3a,b. Intensity (I) and temperature (T) variations (a) at Borok measured during July, 1998 and (b) at Mondy during August, 1997.

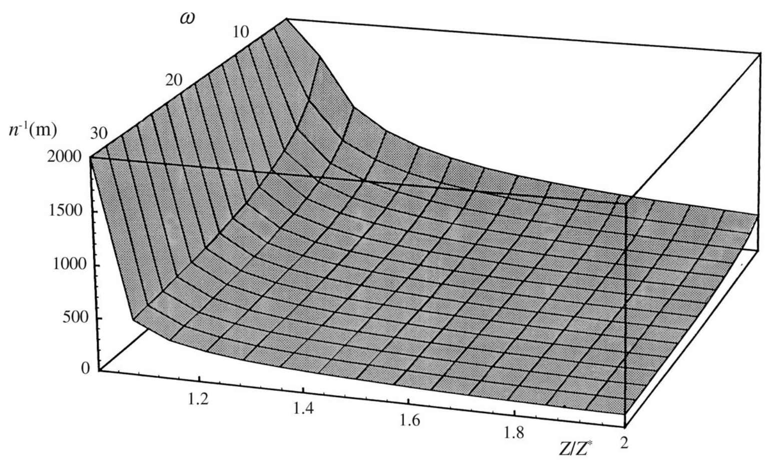

Fig. 4. Dependence of wave number (n) on impedance ratio and frequency (Z is the impedance of plane wave for Pc-1 emission and Z^* is the impedance of thermal emission).

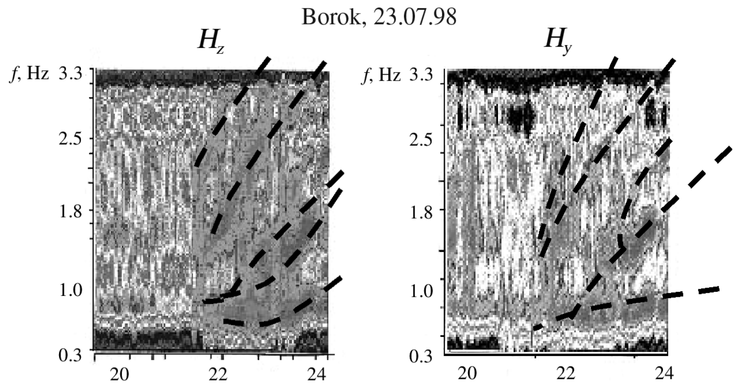

Fig. 5. Evidence of occurrence of the essential z component in fan emission that indicates the near source presence.

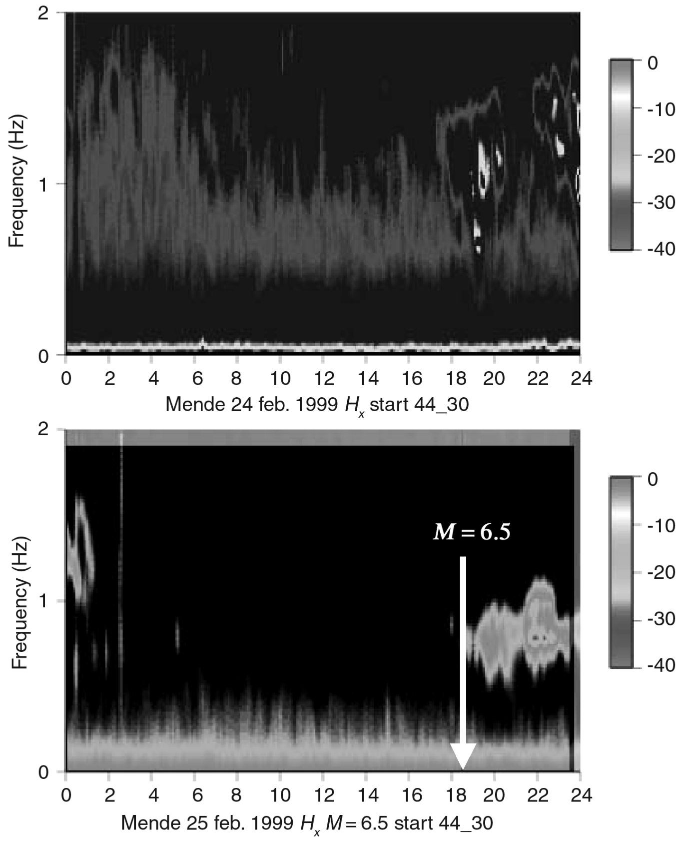

Fig. 6. Evidence of absence of the thermal emission during winter time (24-25 February, 1999) observed at Mondy Observatory before the moment of a local earthquake (shown by the vertical solid line).

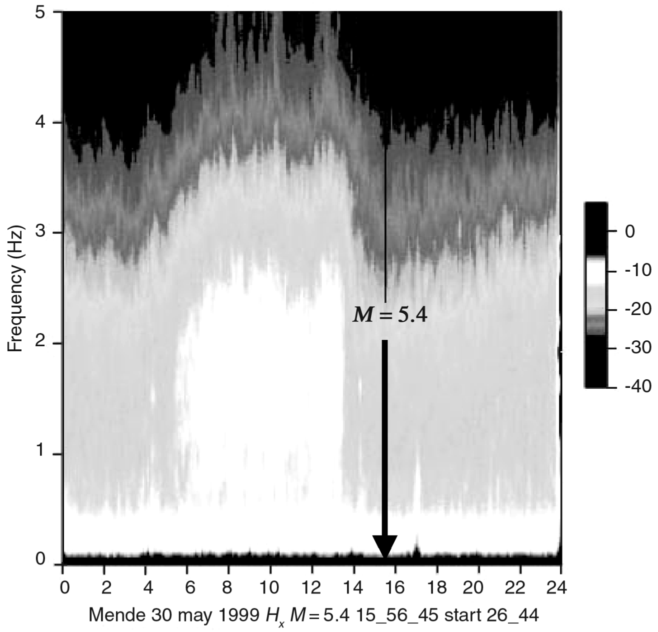

Fig. 7. Typical diurnal distribution of the thermal emission before the moment of a local earthquake (shown by the vertical solid line) possibly not related with earthquake preparation.

Note that the wavelength for Borok Earth crust conductivity condition is about several kilometers.

An increase in the noise electromagnetic emission intensity around 1 Hz before local earthquakes have been reported by Wolfgang Boerner (Chicago University) and Jack Dea (San Diego, Navy) (private communications).

Space and time distributions of the natural background noise level in the frequency range 1-5 Hz together with the impedance ratio algorithm which are represented here probably help to discriminate the anomaly related to the local earthquake preparation processes. For example, in fig. 6 the absence of this emission during winter time for Siberia does not determine such a precursor anomaly before earthquake with $M\sim\sim 6$ (52°N, 105°E) on 25.02.1999 18:58 UT. One can see only the pulsations of the magnetospheric origin.

Another example of the thermal emission during the summer time is presented in fig. 7. The emission cannot be considered a precursor before the local earthquake with $M\sim 5.4$ (the time of the earthquake is shown by black solid line) that occurs in the vicinity of the observation point, because it is the usual background level.

These two examples show that we have to be very careful before making any conclusions about precursor occurrence. In addition, it is important to investigate the behavior of the background level. We still hope to use type 1 emission for an earthquake preparation monitoring. An increase in the noise electromagnetic emission intensity around 1 Hz before local earthquakes detected by W. Boerner (Chicago University) and J. Dea (San Diego, Navy) in Southern California can be related to the local near surface atmospheric layer heating (see Gorny *et al.*, 1988). Thus the question is whether it is easier to measure anomalies in the temperature gradient directly or to detect the emission.

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