Identification of wave-guide mode propagation of earth-origin electromagnetic pulses in the earth

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Using an electric field sensor inserted in to a bore-hole of 10 cm in diameter and 100 m in depth, which was constructed in the campus of Kyoto Sangyo University, we have been observing ELF electric field in the deep earth. This system can make it possible to detect electric noises in the earth separately from those above the ground clearly. We have been continuing its observation since September 1999. In the second half of 2000, we detected intense electric pulse swarms in both regions, in the earth and above the ground. We identified them as the earth-origin ones, because the intensity of the pulse swarms detected above the ground is 15 dB weaker than those in the earth, in which features of time-variation of spectral forms detected in the both regions were same to each other during the period more than few hours [1]. Furthermore, the pulse noise swarms show clear lower frequency cutoff in their spectra. This suggests that impulsive noises had been propagating in a kind of wave-guide formed in the earth interior. We know tweek atmospherics as another example of wave-guide mode propagation of natural electromagnetic (EM) pulse waves which propagate in a space between boundaries of the conductive ionosphere and the ground surface [2]. In this case, EM waves with wave-length longer than the double ionosphere height can not propagate. Thus the intense pulse swarms detected in the earth would behave in similar way to that of tweek atmospherics. In the space between the ground surface and the earth crust at about 200 km in depth would play a similar role of wave-guide boundary in the earth since it is reported that the electrical conductivity of the earth crust below about 200 km in depth up-turns [3].

In order to identify the wave-guide mode propagation of impulsive EM noises detected in the earth, we began to develop a system for detection of magnetic components of EM pulse noises in the earth and a method of obtaining a specific wave property of the wave-guide mode from the analysis of detected noise data. A typical property in wave-guide mode propagation of the pulsed noise is dispersion characteristics seen in its dynamic spectra. When the wave-guide boundaries are imperfect electrical conductive medium, the wave components near the cutoff frequency suffers group delay. In such the case, the spectrum of the pulsed signal would exhibit a dispersion characteristics of group delay near the lower cutoff frequency.

Recently, we have accomplished the system and the analysis method, and found an event showing the dispersion characteristics. Since the observed lower cutoff frequency of the spectrum was about 200 Hz, the pulsed noise would be expected to propagate in a wave guide in the earth.

The developed system can be applied to the direction finding of the pulsed EM waves in the earth, we are going to identify the source location of the EM pulse noise excited in the earth. This would be helpful for a study on the relation between the stress imposition onto the earth crust and the excitation of EM pulses.

[1] M. Tsutsui, Detection of earth-origin electric pulses, GRL, Vol.29, No.8 35/1-4, 2002.

[2] M.Yamashita, Propagation of tweek atmospherics, J. Atmos. Terr. Phys., Vol.40, 151-156, 1978.

[3] T. Rikitake, Global electrical conductivity of the earth, Phys. Earth Planet Inter., Vol. 7, 245-250,1973.