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# Observations for confirming earth-origin electromagnetic pulses

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I introduce the transition of observations for confirming earth-origin electromagnetic (EM) pulses.

Some people and radio scientists reported that they detected EM noise by radio receivers during their own works just when the Hanshinn-Awaji earthquake had occurred in 1995. The noise was more intense compared to their usual observed level.

In order to confirm whether the noise was surely generated in the earth or not, we began to observe them by constructing borehole of 100 m in depth in the campus of Kyoto Sangyo University and by inserting a vertical electric dipole antenna in it in 1999 [1]. Furthermore, for determining arrival directions of EM pulses detected in the borehole, we accomplished a new sensor system composed of horizontally and orthogonally arranged two magnetic search coils and a vertical electric dipole antenna [2]. At 14:49:50 on 6 January 2004, the system detected an intense EM pulse just when an earthquake occurred, and displayed arrival azimuths of the pulse on the computer display in real-time. We determined the source location of the EM pulse at a point along the obtained arrival azimuth by applying the travel distance estimated from the propagation theory [3], and identify it in the epicenter region of the earthquake [4].

Based on the successful observation of the earth-origin EM pulse, we had tried to detect earth-origin EM pulses at two or three observation points and to identify their source locations on the horizontal plane by the triangular measurement on real-time basis. We set up the same observation equipments at an Earthquake observatory (34.48N, 136.30E) of Nagoya University, where is about 82 km south-east of Kyoto Sangyo University. However, the obtained locations were not the real source points but spurious ones, because the spuriousness was caused due to interferences of EM pulses radiated from local power lines [5].

On the other hand, we had been constructing another observation site in electromagnetic quiet environment at 33.69N, 135.34E on the campus grounds of Seto Marine Biological Laboratory of Kyoto University located on a narrow peninsular (about 300 m wide) in Shirahama town, Wakayama-prefecture, and drilled a borehole of 100 m in depth and accomplished it in July 2008. At this site, we examined differences of amplitudes and phases of magnetic fields measured by horizontal magnetic search coils installed at 95 m-depth in a borehole and on the ground. We clearly confirmed that amplitudes of vertically incident EM pluses (lightning generated ones) and their phases at the bottom of the borehole were strongly depressed and largely delayed, respectively. So we estimated electrical parameter of the medium in the sedimentary layer, such as the electrical conductivity, the skin depth for a VLF signal, and its propagation velocity in the medium.

We detected another kind of EM pulses (different from lightning generated ones) with small amplitude of magnetic field and with one- or two-cycle oscillations. We tried to determine their propagation directions up- or down-ward from phase differences of waveforms of horizontal magnetic fields simultaneously detected at the 95 m-depth in the borehole and on the ground. Some of results indicated clear phase differences suggesting down- or up-ward propagations. However, others could not be distinguished their up- or down-directions because their waveforms did not show conformity with each other. We found the reason from results of their polarizations. Almost of all magnetic field vectors at the 95 m-depth indicated ellipsoidal polarizations on a vertical plane whereas those on the ground were linear polarizations. These EM pulses were artificial ones. Therefore we have been developing a method for obtaining three-dimensional arrival directions of EM pulses in the earth, by means of strict Poynting vector of detected pulses. Now we are going to observe them by this method.

Keywords: earth-origin electromagnetic pulses, developement of EM sensors, EM detections and their soruce locations, Relation between erath-origin EM pulses and earthquakes