Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SEM36-03 Room:413 Time:April 30 15:45-16:00

Electric conductivity of earth's medium derived from earthquake-excited electromagneic siganals

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We have been observing electromagnetic (EM) pluses excited by earthquakes, using tri-axial electromagnetic sensors installed in a deep borehole of 100 m in depth. We simultaneously captured waveforms of EM pulses in the borehole and of seismic waves installed near the borehole. We have confirmed that the detected EM waves were co-seismic ones readily generated by piezo-electric effect in earth's crusts [1].

We detected an EM pulse in the borehole when an earthquake of M3.0 occurred at 10 km depth and at 5.4 km north of the EM observation site at 03:57 on Dec. 25, 2013. Figure 1 shows waveforms of (a) east-west component (S_{ew}) of the seismic wave, and of (b) east- west component (H_{ew}) of magnetic field of the EM pulse. The waveform of the S_{ew} wave shows an impulsive amplitude at the arrival of its S-wave, which is because the earthquake hypocenter was close to the EM observation site. On the other hand, the waveform of H_{ew} shows that its amplitude was increasing from about 1 sec prior to the S-wave arrival, and after that it was decreasing.

The amplitude change of H_{ew} can be explained as follows: Since the electronic conductivity of the earth's medium is large, the amplitude of an EM wave shows an exponential decrease as a function of the distance, in which the decay rate is so-called Skin depth. Since the source of EM pulse was propagating with the S-wave velocity, the amplitude of the EM wave measured at the EM observation site is exponentially increasing as time goes on, and after the S-wave arrival it is exponentially decreasing. Therefore we obtained the Skin depth ?for the frequency of 20 Hz and the electronic conductivity as 850 m and 0.0175 S/m, respectively.

[1] M. Tsutsui, submitted to IEEE Geoscience, Letters, 2014.

Keywords: seismic wave, electromagnetic wave, observation in the earth, skin depth, electric conductivity

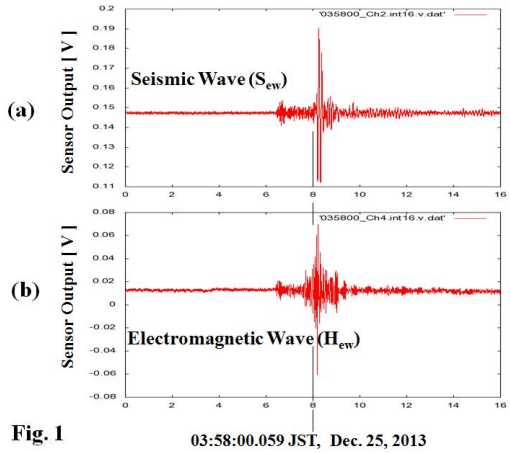

Fig. 1