

Electric and magnetic field variations arising from the seismic dynamo effect for aftershocks of the M7.0 earthquake

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1. Introduction

Some clear examples of electric and magnetic field variations have recently been reported in association with earthquakes, and these variations have been interpreted in terms of the seismic dynamo effect. In order to confirm that this effect is a universal phenomenon, we made magnetotelluric (MT) observations above the hypocentral area of the M7.0 earthquake which occurred off Miyagi Prefecture on May 26, 2003. The MT site was selected at a location close to a seismic station, so that we can compare the MT signals with the seismic wave records. During the MT observation period after the mainshock, some moderate-size aftershocks of magnitudes between 2.8 and 4.1 occurred and MT signals appeared in association with all these aftershocks. In the seismic dynamo effect, electric field and magnetic field variations should be generated by electric currents resulting from the electromotive force due to movement of a conducting crust in the Earth's magnetic field. In order to confirm that MT signals are not due to vibrations of MT equipment, we designed a special measurement.

2. Experiment

We used two sets of audio-frequency magnetotelluric equipment (AMT) with a sampling rate of 150 Hz. In order to verify that electric field variations are not due to the instrumental effects, we used independent sets of electrodes and also we designed a special arrangement for cables connecting electrodes, so that we can distinguish possible effects of vibrations electrodes and cables from the seismic dynamo effect; we set cables on the ground for one set and in the air for the other set. Also for the magnetic field sensors (induction coils), we attempted two different types of magnetic sensor set-up. For one set, we buried the sensors in the ground. For the other set, we hang the sensors in the air between trees. The reason why we adopted this arrangement is simply to force the sensors to move with the frequency response different from the ground movement during seismic wave passage.

3. Results and Discussion

In the case of the electric field, two sets of records turned out to be the same. This clearly indicates that the observed electric field reflects the electric field flowing in the ground. In the records for the set-up in the air, low frequency oscillations are evident, but superposed on the oscillations, higher frequency components are also seen. The low frequency oscillations can be removed through band-pass filtering. We found that the records for the magnetic sensors hung in the air are not the same as those for the magnetic sensors buried in the ground. The output of an induction coil includes signals of the seismic dynamo effect and the effect of movements of the magnetic sensors in the magnetic field gradient. The magnetic sensors buried in the ground are supposed to move with the ground and hence the electromotive force will be generated in the induction coil in proportion to the gradient of the Earth's magnetic field, the order of which is 10^{-3} nT/m. If the sensors are hung in the air and free from the ground motion, we expect no contribution from the Earth's magnetic field, but in this case the local magnetic field moves relative to the sensors. Its gradient is typically the order of 1 nT/m.

4. Conclusion

As clearly understood from the above argument about the gradient of the static magnetic field, the output of the air sensors should be much larger than that of the ground sensors, if the common component representing the magnetic field due to electric currents flowing in the crust is negligible. But this is not the case. In fact, both are of the same order. Hence the effect of movement of the ground sensors in the Earth's magnetic field should be very small and we may regard the output of the ground sensors as representing the magnetic field due to the dynamo effect.