Potential mechanisms that produced the pre-seismic electromagnetic phenomena that immediately preceded the 2011 Tohoku-Oki earthquake and other strong inter-plate earthquake

Y. Enomoto (Shinshu Univ.), K, Heki (Hokkaido Univ.), T. Yamabe (Shinshu Univ.)
S. Sugiura and H. Kondo (Geneses Res. Inst.)

Various types of precursor anomalies preceding the 2011 Tohoku-Oki earthquake have been reported in terms of seismic, geodetic, geochemical and geo-electromagnetic activities of which the anomalies grew with time since about 10 year leading up to the M9.0 main shock[1]. The ionospheric electron enhancement and the geomagnetic declination change starting about 40 minutes prior to the M9 main shock have attracted an attention as possible imminent prediction of earthquake occurrence[2].

Geo-physicochemical evidences strongly suggests that deep Earth fluids along fault plane have an important role in generating the above-mentioned anomalies leading up to the M9 main shock[3]. Taking into account the coupled interaction of rock ruptures with the gas flow as a working hypothesis for the earthquake quasi-static rupture stage[4], we conducted labo-experiments of uniaxial rock rupture of gabbro or basalt with high-pressure gas flow of CO_2,N_2, CH_4 or H_2O vapor at the temperature of about 160°C. The electric current per unit the gas/rock-rupture interacted area was successfully measured as high as 1 mA/m^2, independent of gas and rock species and even without electrode bias(Fig.1a). The max-earthquake nucleation dipole current (ENDC) is estimated as 208kA in the 2011 Tohoku-Oki earthquake. The ENDC induces geomagnetic change of 1.82 nT and geomagnetic deflection of 6.27×10^{-5} rad at Esashi which agree well with the observed results of 1.97nT and 9.84×10^{-5} rad, respectively(Fig.1b & c).

The observed precursor period of 40 min. could be explained as the effective time for which the deep Earth gases passed through the whole nucleation zone with crack gap of 0.22mm and the gas viscosity of 9.76×10^{-4}Pa・sec (Fig.1d). In conclusion, the present model provides well-reasoned explanation for geomagnetic anomalies, observed in the 2011 Tohoku-Oki earthquake and strong inter-plate earthquakes.

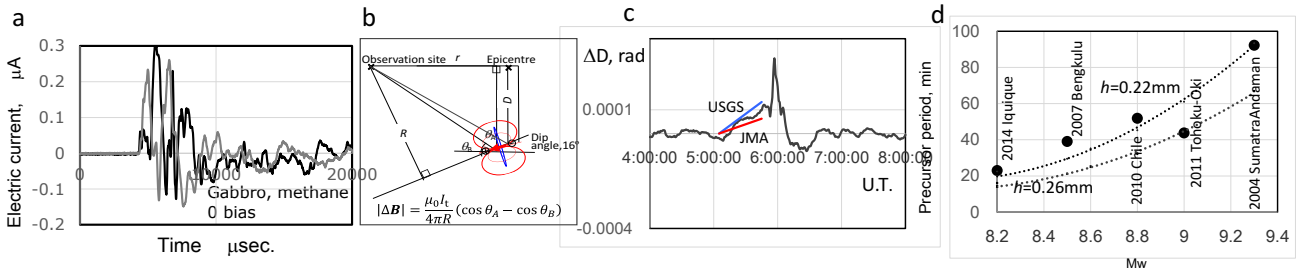

Fig.1 (a) Electric current due to rupture of gabbro with CH_4 flow, (b) geometric illustration, (c) declination ΔD at ESA relative to KNY; ▬ and ▬ theoretical estimations based on USGS and JMA data of the epicenter and the focal depth, and (d) precursor periods of GPS-TEC anomalies vs M_w, for interplate earthquakes. *h:* effective crack gap.

References

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