# Preseismic geomagnetic deflection synchronized with GPS-TEC enhancement 2011 Tohoku-Oki earthquake

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The GPS-TEC enhancement stating ?40 minutes before the 2011 Tohoku-Oki earthquake has been observed (Heki, GRL, 2011). The geomagnetic declination change was confirmed nearby the fracture zone, at Easashi (ESA), Mizusawa (MIZ) by GSI and at Kakioka (KAK), Kanozan (KNZ) by JMA in respect to Kanoya (KNY) in synchronization with the GPS-TEC anomaly(Heki & Enomoto, JGR, 2013).These anomalies satisfy the criteria of earthquake precursor candidate (Wyss, AGU, 1991).

The magnetic declination; the difference between the direction of the horizontal components H of the Earth's magnetic field and the magnetic north is normally ?6.9 degree westward (=-415.7 arc min) from true north at the ESA site, but, as seen in the Figure, $\Delta$ D ([ESA]-[KNY]) gradually changes to the positive direction (eastward) starting from 40 minutes to the maximum $\Delta$ D value of $\Delta$ D? +0.32 arc min (= $9.31 \times 10^{-5}$ rad) just before the main shock. This change should be affected by generation of preseismic magnetic field ?$\Delta$ B?. As $\Delta$ D is small, we can approximate the relationship between $\Delta$ H, $\Delta$ D and ?$\Delta$ B? as shown in an insert of the Figure; i.e.

?$\Delta$ B?[nT] ? ?$\mathbf{H}$? [nT]?$\Delta$ D[rad]

The amount of H is normally 29037nT at ESA. The ?$\Delta$ $\mathbf{B}$? is then 29037 nTx$9.31 \times 10^{-5}$ rad = 2.70 nT, which is in agreement with the observed preseismic variation of $\Delta$ H (?2.38 nT) as seen in the Figure.

The preseismic geomagnetic field $|\Delta \mathbf{B}|$, resulting from the time-varying current at the earthquake nucleus zone by Biot-Savalt's law, is expressed, by assuming the time-varying source current element of the length $w_c$ t*, as:

?$\Delta$ $\mathbf{B}$?=$\mu_0$ ?$\mathbf{I}$? $\sin\theta$ $w_c$t*/$4\pi R^2$,

where $\mu_0$ is the permittivity of free space, ?$\mathbf{I}$? is the pressure-impressed current, which is 170kA in the Tohoku-Oki earthquake (Enomoto & Heki, GJI, submitted),  is an angle shown in the Figure, $w_c$ is the earthquake nucleation size, t*is the normalized preseismic time duration, R is the distance between observation site from the epicenter. The present model of the above equation at t*=1 gives ?$\Delta$ $\mathbf{B}$?=1.78 nT with R=181km: distance between the ESA and the epicenter of which the agreement with the observed value of 2.38nT is rather well.

Keywords: Tohoku-Oki earthquake, Precursor phenomena, Geomgnetic, Declination, GPS-TEC, Modelling