Genetic algorithm inversion of induction vectors observed around the Kyushu island using non-uniform thin sheet approximation

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Induction vectors computed from short-period geomagnetic variations are known to primarily represent land-ocean distribution that emerges in the island effect and the coast effect. The land-ocean distribution, however, is also known to be well approximated by non-uniform thin sheets for periods from a few tens of minutes to several hours (Sasai, 1969). In this study, we report results of genetic algorithm inversions using non-uniform thin sheet approximation which yielded an optimized conductance distribution in the surface thin sheet to explain the notable westward components of the induction vectors observed in the Kyushu island.

Fujiwara and Toh (1996) derived nation-wide distribution of the induction vectors at first-order geomagnetic stations as many as 100. By subtracting the topographic effects such as the coast effect from the nation-wide dataset, we obtained residual induction vectors, which showed large anomalies in three regions. From north to south, they are (1) around the Hokkaido island, (2) Central Japan to the northern Izu-Ogasawara arc, and (3) in and around the Kyushu island and western Chugoku District. The first anomaly includes Northeast Japan Anomaly (Kato, 1968) and the conduction anomaly in the Ishikari sedimentary basin (Nishida, 1976). The second anomaly may imply that so-called Central Japan Anomaly (Rikitake et al., 1953) further extends to the northern Izu-Ogasawara arc. The third anomaly, called Offshore Western Kyushu Anomaly hereafter, is investigated in this study to clarify its relation to a mantle upwelling beneath the backarc side of the Kyushu arc, the presence of which is proposed by Seno (1999).

Seno (1999) pointed out that the regional stress field around the Kyushu island, unlike that of Northeast Japan and Southwest Japan, is extensional on the backarc side though the stress field in the subducting slab itself is down dip tensional. To interpret this, Seno (1999) assumed a mantle upwelling beneath East China Sea which forces the mantle beneath the Kyushu island flow from west-northwest to east-southeast. Shimoizumi et al. (1997) revealed the presence of a 2D conductivity anomaly offshore western Kyushu District using the geomagnetic depth sounding method, which is further confirmed by Sadeghi et al's (2000) tomographic study of seismic P-wave as a low velocity zone. In this study, a genetic algorithm inversion method using non-uniform thin sheet approximation is applied to derive a conductance distribution that accounts for the 3D spatial distribution and the frequency dependence of the observed induction vectors. The conductance map may reveal the spatial extent of the proposed mantle upwelling.

Figure 1 shows the result for a period of 64 min. The final model in Fig. 1 tells us which part of the model requires what amount of additional conductance to explain the observation. The upper diagram of Fig. 2 depicts observation minus topography while effects of topography and the additional conductance are both subtracted from the observation in the lower diagram. It is evident from the lower diagram that addition of the conductance anomaly is required to minimize the residuals. The final model implies:

(1) Although the mantle upwelling has a wide distribution from just west of the Kyushu island to the Cheju island in South Korea, the Tsushima strait may limit the northern extent of the anomaly.

(2) The upwelling may branch off in the course of its upward propagation since finer structures can be seen in the conductance anomaly.

This study provided us a model that explains Offshore Western Kyushu Anomaly in short-period geomagnetic variations. In future, a resolution analysis method of the model corresponding to the checker board test in seismic tomography studies should be established. Also, the inversion method developed in this study should be applied to the remaining two regional anomalies.

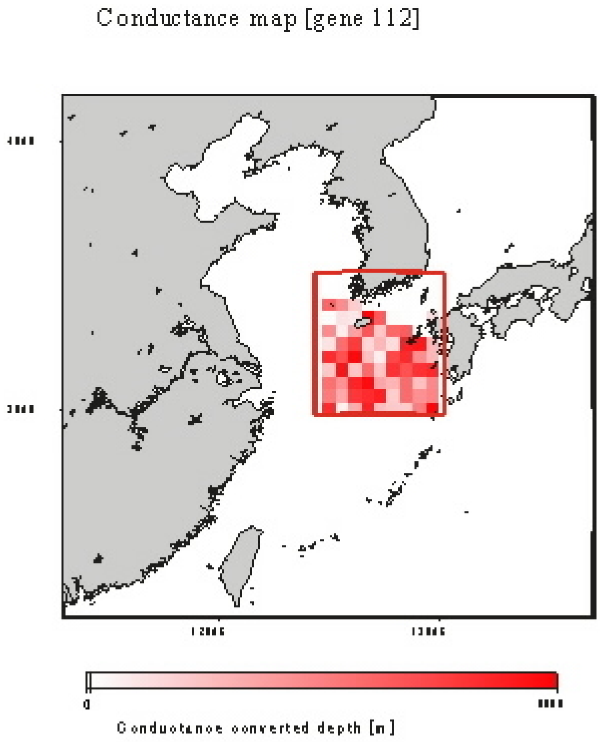

Fig.1 Final conductance map.

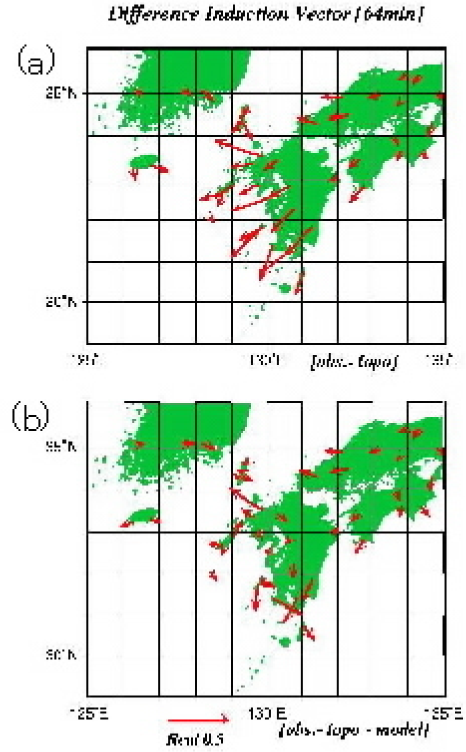

Fig.2 (a) Observed vectors.
(b) Final residuals.
* topographic effects are subtracted from both models