On elucidation of the regional anomalous phase contained in the Network-MT data in the Chubu district, central Japan

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SUMMARY

We show a result from 3-D inversion of the Network-MT impedance tensors obtained in the Chubu district, central Japan, with the aid of the wsinv3dmt code (Siripunvaraporn et al., 2005). In a wide area facing the Japan sea, anomalous phase (more than 90 degree) was detected in the response functions. In order to stabilize the inversion, we started the inversion with 10% and 20% error floor for the off-diagonal and diagonal elements of the tensor first. This first stage inversion could not explain the anomalous phase. Then, in the second stage, we put 5% error floor both for off-diagonal and diagonal elements. We reached a final model with RMS=2.5, where the phase anomaly was explained by localized and shallow conductive Fukui Plain which faces the Japan Sea. For the other features, along the Noubi Earthquake (M=8.0) seismic fault zone, a shallow and narrow conductive zone was located, and in the mid-crust beneath the zone, a rather resistive layer (higher than 1k Ohm m) was distributed. In addition, a deep seated conductive zone was detected along the Fukui-Gifu boundary (and along the Niigata-Kobe Tectonic (strain accumulating) Zone). The conductive zone indicates existence of dehydration from the Pacific Plate, and may cause the strain rate accumulation.

Keywords: inversion, Network-MT, anomalous phase, case study

Network-MT survey in the Chubu district

Network-MT survey has started since Jun, 2011 in the western part of Chubu district, central Japan, where one of the largest inland earthquakes in Japan, the 1891 Noubi Earthquake (M8.0), took place. Since both the Philippine Sea Plate and the Pacific Plate are subducting beneath the area, and there exists the Niigata-Kobe Tectonic Zone revealed by the dense GPS array (GEONET), where the most significant strain rate accumulation in the inland area of Japan was detected before the 2011 great Tohoku Earthquake, we aimed at obtaining wide and deep resistivity structure beneath whole Chubu district to investigate dehydration process on the subducting plates and generation mechanism of the Niigata-Kobe Tectonic Zone.

In 20 toll areas, we measured potential differences on dipoles of from several to several 10s km lengths with the aid of the local metallic telephone lines and self-made Pb-PbCl2 electrodes after observation procedure of Uyeshima et al. (2001) and Yamaguchi et al. (2009). Owing to the long baselines, we can avoid static effects due to small-scale near-surface heterogeneities (Uyeshima, 2007). Magnetic fields were measured at 2 stations in the target area and at the other 2 stations for the purpose of remote referencing.

Anomalous Phase in the Network-MT data

We first estimated response functions (Yx and Yy) in the frequency domain between each potential difference (V) and two horizontal components (Bx and By) at a geomagnetic station (NEO-station) as expressed by:

$$V(\omega)=Yx(\omega)*Bx(\omega)+Yy(\omega)*Bx(\omega) \quad (1).$$

We used geomagnetic records at another geomagnetic station (WJM-station) for the purpose of remote referencing. For response function estimation, we used the bounded influence remote reference processing code (BIRRP, Chave and Thomson (2004).

Since the Network-MT response functions must be free from the galvanic effect due to the small-scale near-surface heterogeneity, for almost all the cases, phase values between mutually-perpendicular electric and magnetic field lie between 0 and 90 degree. As is shown in Fig. 1, however, we detected the anomalous phase (greater than 90 degree, Ichihara and Mogi, 2009) in the mode where the E-field and B-field are respectively parallel and perpendicular to the Japan Sea coast, which grows in the period range longer than 10^3 s, at almost all the stations in Fukui Prefecture near the Japan sea coast (in the most back-arc side of the target region). As for the other mode where the E-field and B-field are respectively perpendicular and parallel to the Japan Sea coast, the phase is normal.

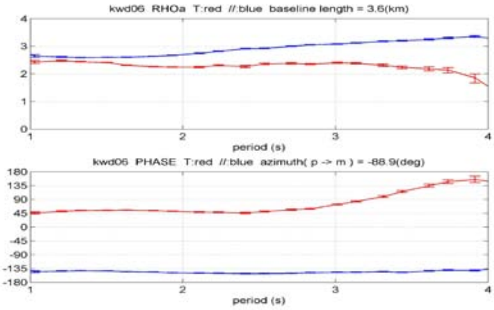

Figure 1. An example of the Network-MT response function containing the phase anomaly. Baseline length and azimuth of the electric measurement are 3.6 km and 88.9 degree unti-clockwise from the north, respectively. Red or blue curve indicates response function where the baseline azimuth and direction of the magnetic field variation is mutually perpendicular or parallel, respectively. Intensity in apparent resistivity and phase values of the response functions are shown in the upper and lower panels, respectively.

3-D inversion

In order to examine generation mechanism of the regional phase anomaly and elucidate the regional 3-D structure, we inverted the Network-MT response functions converted into a form of the impedance tensor after a procedure of Uyeshima et al. (2001). We used the wsinv3dmt code (Siripunvaraporn et al., 2005). In order to stabilize the inversion, we started the inversion with 10% and 20% error floor for the off-diagonal and diagonal elements of the tensor first. This first stage inversion could not explain the anomalous phase as shown in Fig. 2. Then, in the second stage, we put 5% error floor both for off-diagonal and diagonal elements. We reached a final model with RMS=2.5, where the phase anomaly was explained by localized and shallow conductive Fukui Plain which faces the Japan Sea as shown in Fig 3.

As for the other features of the 3-D model, along the Noubi Earthquake (M=8.0) seismic fault zone, a shallow and narrow conductive zone was located (Fig. 4), and in the mid-crust beneath the zone, a rather resistive layer (higher than 1k Ohm m) was distributed (Fig. 5). In addition, a deep seated conductive zone was detected along the Fukui-Gifu boundary (and along the Niigata-Kobe Tectonic (strain accumulating) Zone, Fig. 6). The conductive zone indicates existence of dehydration from the Pacific Plate, and may cause the strain rate accumulation.

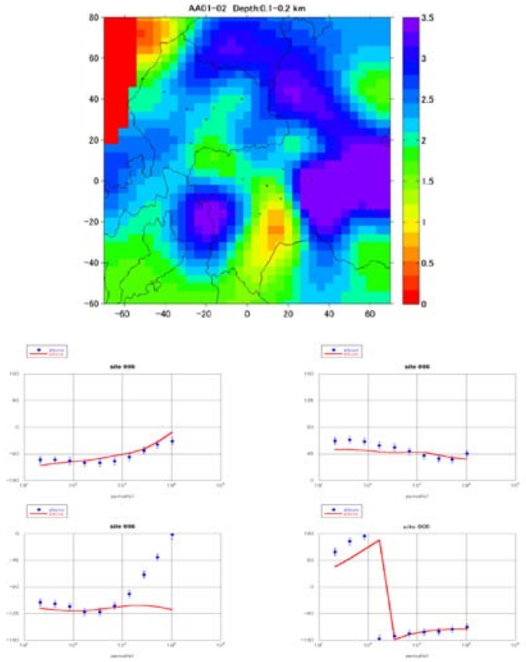

Figure 2. Upper panel: Plan view for the best fit model in the first stage (sea text) at depths of 100-200 m. Lower panel: Phase responses of the impedance tensor at a site, where anomalous phase was detected in Zyx. Synthetic response in red line could not explain the anomalous phase.

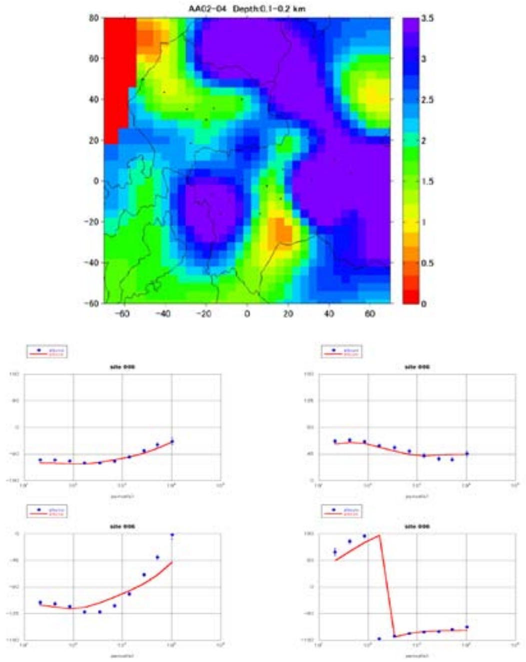

Figure 3. Upper panel: Plan view for the best fit (and the final) model in the second stage (sea text) at depths of 100-200 m. Lower panel: Phase responses of the impedance tensor at a site, where anomalous phase was detected in Zyx. Synthetic response in red line successfully reproduces the anomalous phase.

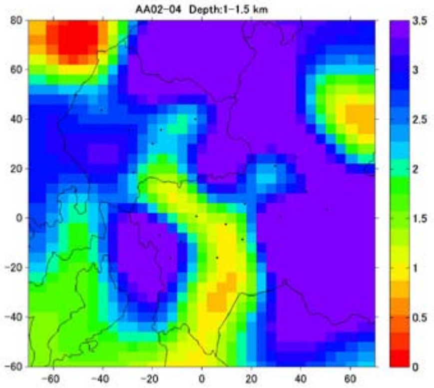

Figure 4. Plan view model at depths of 1-1.5 km.

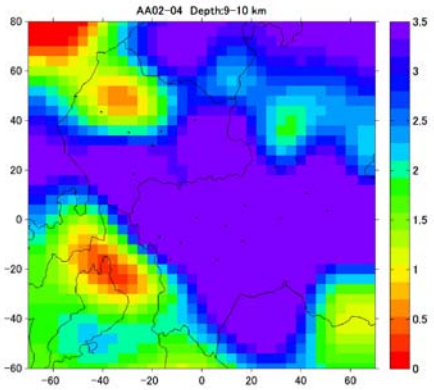

Figure 5. Plan view model at depths of 9-10 km.

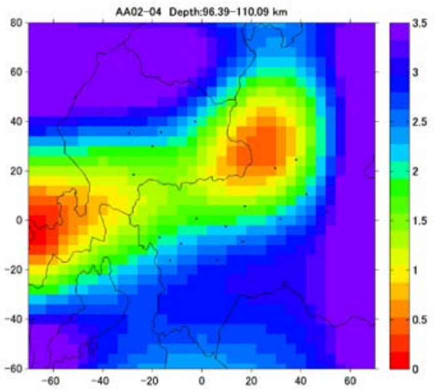

Figure 6. Plan view model at depths of 96-110 km.

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