Resistivity imaging of source regions of Iwaki and N-Ibaraki normal faulting sequences

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Following the 2011 Tohoku-Oki earthquake, M9.0, several areas of the inland Japan were activated due to significant change of the stress field. Among all, intense swarm-like seismicity associated with shallow normal faulting was induced in Ibaraki and Fukushima prefectures in the boundary area between Kanto and Tohoku districts, Japan. In order to elucidate a structural model of electrical resistivity in this region and to get insights on causes of those induced earthquakes, MT surveys were performed in Jan. 2012 and from Dec., 2013 to Jan. 2014, by using Phoenix and Metronix wideband MT instruments.

We first estimated impedance tensors and induction vectors with the aid of the BIRRP code (Chave and Thomson, 2004) at the same sets of periods (from about 0.03s to 1000s) for both of the wideband MT instruments. We also combined the 3-D MT and induction-vector (IV) inversion code by Siripunvaraporn and Egbert, 2009 and the 3-D phase-tensor (PT) inversion code by Patro et al., 2013 to yield a 3-D PTIV inversion code. This modification aimed at finding a 3-D resistivity model free from influences of the static or galvanic effects.

We applied the PT-IV 3-D inversion code to the Iwaki and N-Ibaraki datasets. In order to investigate the influence of the initial model on the final structural model, we did several inversion runs with initial resistivity values ranging from 20 to 2000 Ohm-m. All the inversion runs could get respective final models with RMS of about 2. Although some differences in the final models are detected, overall characteristics and scales (in length and intensity) are similar for all the final models. Generally, induced earthquakes are distributed in the higher electrical resistivity zones. We delineated a separate low-resistivity anomaly directly beneath the hypocenter of the M7.0 Iwaki earthquake indicating crustal fluids in this region. Together with previously obtained seismic image (Kato et al., 2013), we hypothesize that strong crust underwent structural failure due to the infiltration of crustal fluids into the seismogenic zone from deeper levels, causing the Iwaki earthquake.