Hybrid inversion using magnetotelluric data with structural boundaries

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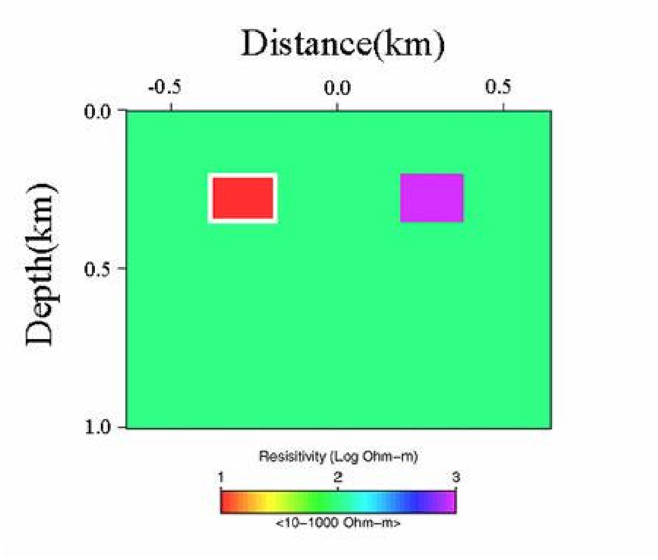
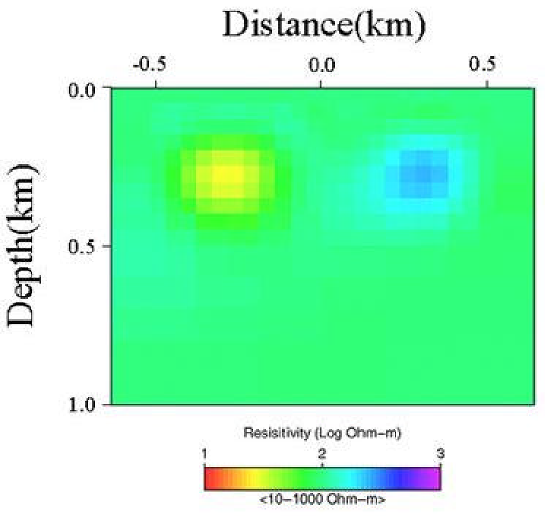
Magnetotelluric method is applied to many fields, for example earth resource exploration (petroleum exploration, geothermal exploration, mineral resources exploration and others) or geological survey (fault zone, plate subduction zone and others). It has been difficult to reconstruct sharp structural boundaries in two-dimensional magnetotelluric data inversion, while seismics or some other methods are tried to image boundaries of difference in physical properties. Since it is sometimes natural to have gaps in resistivity in underground structure, a new inversion is proposed to reconstruct sharp structural boundaries. The new technique reconstructs sharp boundaries by optimizing the factor of roughening matrix on the given boundaries to minimize ABIC by changing boundary factor from 0.0 to 1.0. If boundary factor is 0.0, then block boundary with the information of structural boundary is reconstructed discontinuous. If boundary factor was 1.0, then block boundary with the information of structural boundary is reconstructed as a smooth interface. The information of boundaries given by the other method, for example seismic reflection methods could, therefore, be accommodated in MT inversions. After the formulation of the new inversion scheme using ABIC, two numerical models were constructed and used to simulate synthetic MT data. The synthetic data were then examined to see if the method could reconstruct the numerical models or not. First numerical model had two anomalies(10ohm-m, 1000ohm-m) in 100ohm-m homogeneous resistivities(fig(a)). Apparent resistivity and phase of TM mode at 24 sites were calculated with the finite-element method. The size of almost elements was 50 m horizontally and 50m vertically. The image by ordinal inversion method was smooth image. In reconstructed image by ordinal inversion method, the 10ohm-m anomaly was reconstructed as smooth resistivity structure that had 30ohm-m, the 1000ohm-m anomaly was reconstructed as smooth resistivity structure that had 250ohm-m and 100ohm-m homogeneous resistivity structure was reconstructed as smooth resistivity structure(fig(b)). This new inversion method was applied to this model. Boundary information was added to this model around the 10ohm-m anomaly(fig(a)), difference image from one by ordinal inversion was given. In reconstructed image by new inversion method, the 10ohm-m anomaly was reconstructed as sharp structure that had about 10ohm-m. The block boundaries added boundary information were reconstructed as sharp boundaries(fig(c)). The value of ABIC in the image by new inversion method decreased from one by ordinal inversion method. When input data was thinned out, the image by new inversion method was reconstructed with sharp structural boundaries. In numerical model, the images by this method were more improved than those by ordinal inversion method. This method was applied to field data from Kumano basin at Nankai trough, marine magnetotelluric survey was carried out in Dec 2002 to Jan 2003 in Naknai trough. The given image by ordinal inversion method was smooth model. The survey line of seismic reflection method was same line as marine magnetotelluric survey. Plate boundary given by seismic data was similar to the legion changing resistivity in the image by magnetotelluric data. Boundaries information on the plate boundaries from seismic data was added to inversion process, the given image was difference from one by ordinal inversion method. Resistivity was changing sharply on plate boundaries, the value of ABIC decreased from ordinal inversion, The huge value of resistivity not suitable in deep structure in the image by ordinal inversion method disappeared in the image by new inversion method. We think the present method is really useful for imaging sharp boundaries in resistivity in subsurface structure and that the method would be one of schemes to enable further joint inversion using seismic and geodetic data.


Distance(km)
-0.5
0.0
0.5
0.0
0.5
1.0
Depth(km)
Resisitivity (Log Ohm−m)
1
2
3
<10−1000 Ohm−m>

(a)


Distance(km)
-0.5
0.0
0.5
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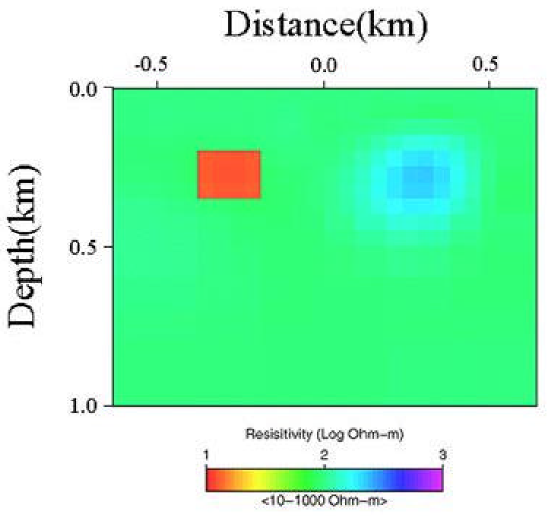
0.5
1.0
Depth(km)
Resisitivity (Log Ohm−m)
1
2
3
<10−1000 Ohm−m>

(b)


Distance(km)
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0.0
0.5
0.0
0.5
1.0
Depth(km)
Resisitivity (Log Ohm−m)
1
2
3
<10−1000 Ohm−m>

(c)