3D INVERSION OF MT DATA FROM GARHWAL HIMALAYA

M. Israil[1], Anita Devi[1], Pravin K Gupta[1], B. Tezkan[2], P. Yogeshwar[2]
[1]Indian Institute of Technology, Roorkee-247667, India; mohdfes@iitr.ac.in
[2]Institute of Geophysics and Meteorology, University of Cologne, Albertus-Magnus-Platz, 50923 Köln, Germany

Summary

Three dimensional (3D) geoelectrical model of Sub-Himalaya region, Uttarakhand, India has been presented. The model is obtained by 3D inversion of 26 sites Broad Band Magnetotelluric (BBMT) data recorded study area extended from Indo-Gangetic Plane (IGP) in south to the Lesser Himalayan region in the north. Two major Himalayan thrusts: Main Frontal Thrust (MFT) and Main Boundary Thrust (MBT) passes through the region. The 3D inversion was performed with MATLAB based AP3DMT code (Singh *et al.* 2017). To keep the optimum computation time, we have selected full impedance tensor at 43 periods in range from .001 to 1000s for 3D inversion. In the inverted model, shallow conducting features are associated with Piedmont fault (PF), MFT and MBT. The southern region is represented by a low resistivity (< 50 Ωm) zone at shallow depth (5-7 km). This zone, geologically represents the loose sediments of the Indo-Gangetic Plains (IGP). The highly resistive (> 500 Ωm) layer below the IGP sediments is the basement rock that represents the top of the subducting Indian Plate. The model is correlated with the model obtained from 3D inversion of the Roorkee-Gangotri (RG) profile. It was found that due to less area coverage in the MT sites in comparison to the RG profile the depth of investigation in the two data sets are different in spite of the same period band used. This suggests that the depth of investigation of MT is also controlled by the total length or the area covered by the MT sites in addition to the period band and subsurface resistivity structure. General features of the inverted model are consistent with the geology and tectonics of the region.

Introduction

The Himalaya is one of the youngest and highest mountain range, which originated from continental collision tectonics and underthrusting of the Indian Plate beneath the Eurasian Plate. Regional N-S compression, resulting from horizontal movement of rock masses along the north dipping thrust planes, caused crustal shortening, horizontal extrusion and lithospheric delamination (Le Fort 1975). In this process, leading upper brittle portion of the subducting Indian crust has been sliced and stacked up southwards to form the Himalayan mountain belt.

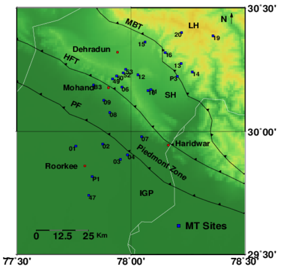

Figure 1: Simplified Tectonic map of the study area and MT sites locations. MBT: Main Boundary Thrust, MFT: Main Frontal Thrust, PF: Piedmont fault, IGP Indian-Gangetic Plain, SH: Sub Himalaya, LH: Lesser Himalaya (compiled from Valdiya 1980 and Arora et al. 2012. (The map is created with GMT software version 5 (http://gmt.soest.hawaii.edu/)

3D geoelectrical model of a part of the Uttarakhand Himalayan region is presented using 26 BBMT data recorded from Sub-Himalaya and Lesser Himalaya, Uttarakhand, India. The locations of MT sites are shown on a simplified tectonic map in Fig. 1. Two major thrusts - Main Frontal Thrust (MFT) and Main Boundary Thrust (MBT) - are passing through the study region. Indo-Gangetic plane lies to the south of MFT, in which Piedmont fault(PF) separates upper Piedmont in the north to the lower Piedmont in the southward (Thakur and Pandey 2004). A MATLAB based 3D inversion code - AP3DMT (Singh *et al.* 2017) was used for this purpose. We recently presented 3D inversion of Roorkee-Gangotri (RG) profile data (Devi et al. 2019). In this study we have selected part of the MT sites and studied the effect of reducing the span of MT site of depth of investigation while using the same frequency band in the two data sets.

3D Inversion of MT data

In order to optimize the computational time, we have chosen the full impedance tensor (Z_{xx}, Z_{xy}, Z_{yx}, Z_{yy}) for a subset of periods in range of 0.001 to 100 s . The error floor was set to 10% of product $|Z_{xy}|$ and $|Z_{yx}|$ for all the four components.

The 3D model grid dimensions were 76, 76 and 42 cells in x, y and z direction respectively, with 6 air layers. Below the surface, the top layer thickness was 50 m and the thickness of each subsequent layer was increased by a factor of 1.2, extending up to 100 km. In the central zone of the model domain, the horizontal grid spacing in x & y directions were 2km respectively.

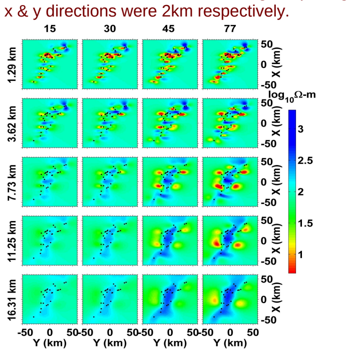

Figure 2: Depth slices showing the final inverted model development with iterations (15, 30, 45 and 77).

The model covariance parameter values were set as 0.3, 0.5 and 0.1 in the x, y and z-direction. Initial guess model was a 100 Ωm homogeneous half space. Inversion run converged from initial normalized RMS misfit values of 33.11 to 1.59 in 77 iterations. Inverted model in the form of XY plane depth slices are shown in Fig. 2.

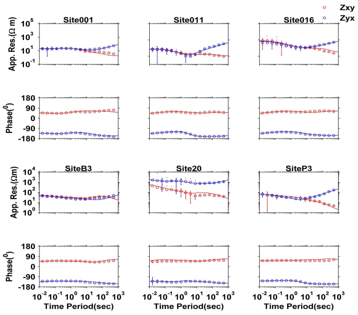

Figure 3: Misfit plot of apparent resistivity and phase derived from the full impedance tensor for selected sites for off-diagonal components

Fig. 3 shows the misfit of apparent resistivity responses extracted from off-diagonal elements. It can be seen that the detailed model features are disappeared in deeper depth (Below 11 km). Whereas these features retained in the inverted model if the initial guess model contained features in deeper depth (Fig. 4). nRMS misfit in the two inversion are nearly same.

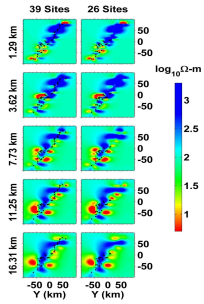

Figure 4: Depth slices showing the final inverted model development with (a) 39 MT sites with 100 ohm-m half space guess model and(b) 26 MT sites with inverted model of (a) as initial guess model

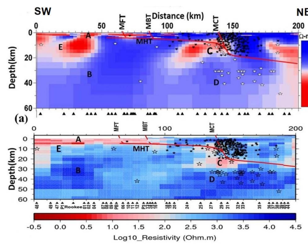

Figure 5: Depth sections of RKG full 39 sites model.

Conclusions

3D geoelectrical model obtained from d on 3D inversion of magnetotelluric data recorded from Sub-Himalayan region has been presented. The model is consistent with the tectonics and geology of the sub-Himalayan region.

References

Arora, B., Gahalaut, V., and Kumar, N. (2012). Structural control on along-strike variation in the seismicity of the northwest Himalaya. Journal of Asian Earth Sciences, 57:15–24.

Devi, A., Israil, M., Gupta, P. K., Varshney, S. K., and Meqbel, N. (2019). Transverse tectonics structures in the Garhwal Himalaya Corridor inferred from 3D inversion of magnetotelluric profile data. (Pure and Applied Geophysics)..

Le Fort, P., 1975, Himalayas: the collided range. Present knowledge of the continental arc; American Journal of Science, 275(1), pp.1-44.

Singh, A., Dehiya, R., Gupta, P.K. and Israil, M., 2017, A MATLAB based 3D modeling and inversion code for MT data; Computers & Geosciences, *104*, pp.1-11.

Thakur,V. C., and Pandey, A.K., 2004, Active deformation of Himalayan Frontal Thrust and piedmont zone south of Dehradun in respect of seismotectonics of Garhwal Himalaya; Himalayan Geology, 25(1), 23-31.

Valdiya, K. S. (1980). Geology of Kumaun lesser Himalaya. Wadia Institute of Himalayan Geology.