Basement structure of the Central Ganga Basin along the Chitrakoot - Faizabad profile

M. Demudu Babu, A. Manglik, S. Thiagarajan, and M. Suresh*
CSIR-National Geophysical Research Institute, Hyderabad- 500007, India

*Email: demudubabutechgeo7@gmail.com

Keywords

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Summary

We have carried out magnetotelluric (MT) study along the 240 km long Chitrakoot - Faizabad profile across the Central Ganga Basin for mapping of the basement structure and extent of the Faizabad Ridge. Broadband MT data have been acquired at 20 sites with inter-station spacing of 8-10 km. The subsurface electrical resistivity image has been obtained by Occam inversion of these data, which reveals very thin sedimentary cover between Chitrakoot and Allahabad. At Allahabad, the basin thickness suddenly increases to more than 2 km and a graben-type structure is seen. Further north, around Amethi the basement comes up to about a km and then increases to more than 2 km around Faizabad. Between Amethi and Faizabad, the thickening of sediments is consistent with the flexure related basin formation. A relatively shallow basement along this profile compared to the results of Manglik et al. (2015) indicates that the Faizabad Ridge is present in this section of the Ganga Basin. More MT data would be required further north to explore the northern extent of the Faizabad Ridge.

Introduction

Ganga Basin is one of the largest foreland basins formed due to the collision of the Indian and the Asian plates and underthrusting of the Indian plate. It is traversed by several transverse faults and ridges which are buried under the thick alluvial cover, e.g., Delhi-Hardwar ridge, Faizabad ridge, and Monghyr-Saharsa ridge (Rao, 1973). Faizabad ridge is inferred as an extension of the Bundelkhand cratonic block into the Ganga Basin in the NNE (Sastri et al., 1971). Since the ridge is buried beneath the thick sedimentary cover, its exact direction and northward extent is unclear. Previous geophysical studies, mainly for hydrocarbon exploration, have provided useful insight into the nature of this ridge but there have been different views on whether this ridge extends NNE or in E-W direction. Therefore, we have carried out MT survey along a profile passing over the inferred position of this ridge as electrical resistivity contrast between the resistive granitic rock-mass of the Bundelkhand craton and conductive Vindhyan rocks can help in mapping this ridge.

There is also a renewed interest in the Ganga Basin from the perspective of earthquake hazard due to its proximity with the seismically active Himalaya belt and the presence of thick alluvial sediments (Agocs, 1957; Sastri et al., 1971; Mishra et al., 1997; Manglik et al., 2015). The present work is also useful for such study.

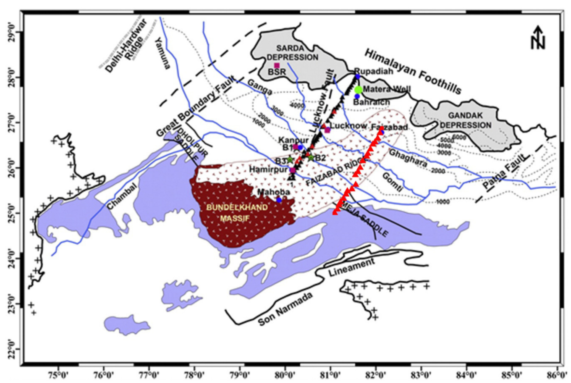

Figure 1: Location of the present MT profile, shown by red triangles, across the Ganga Basin superimposed on the generalized tectonic map (modified from Rao, 1973; Srivastava et al., 1983; Manglik et al., 2015). Block triangles show the MT profile of Manglik et al. (2015).

Data acquisition and processing

We have acquired broadband MT at 20 sites along the 240 km long Chitrakoot - Faizabad profile with inter-station spacing of 8-10 km. Locations of these sites are shown in Figure 1 as red triangles. For comparison, MT profile of Manglik et al. (2015) is also shown in the figure.

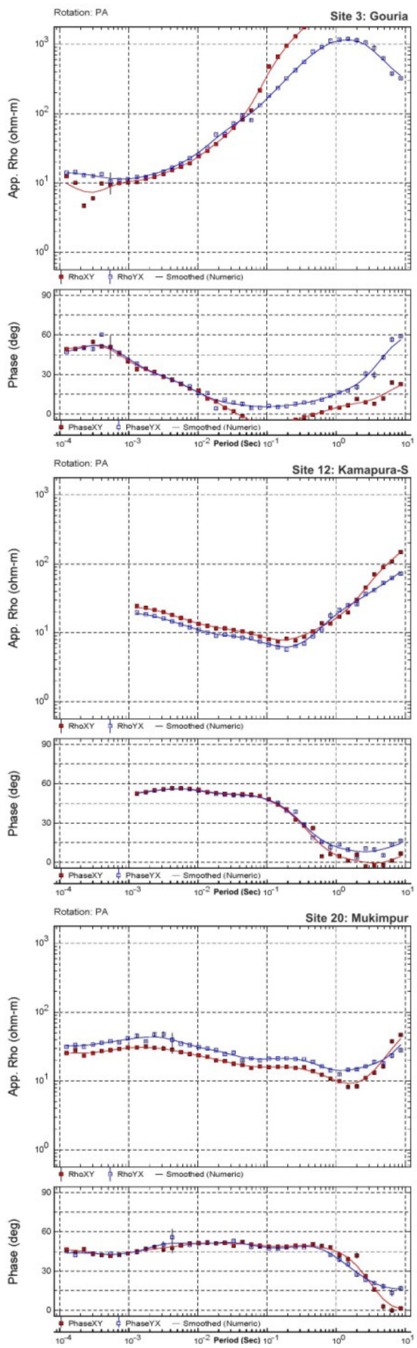

Figure 2: Raw apparent resistivity and phase curves along with error bars for three representative sites 3, 12 and 20.

Broadband induction coils MFS-06 and MFS06e (M/s Metronix GmbH) covering the frequency range of 10 kHz to 0.00024 Hz were used to record magnetic data. For the electric field, Pb-$PbCl_2$ and Ag-$AgCl_2$ non-polarizing electrodes were used. These time series were recorded by using the MT data acquisition ADU-06 and ADU-07e (M/s Metronix GmbH). The electric dipole length was 80 m at most sites.

The recorded time series data were processed by using Mapros software (M/s Metronix GmbH) to obtain impedance tensors in terms of apparent resistivity and phase curves. First, time series were cleaned by removing bad sectors and selecting only good segments of the time series containing coherent electric and magnetic field signals. Next, power spectra were computed and stacking was performed to estimate impedance tensors and apparent resistivity and phase.

Apparent resistivity and phase curves of three sites (sites 3, 12 and 20) in the frequency range of 10 kHz to 0.1 Hz are shown in Figure 2 to give an idea of the quality of the data along the profile. These sites represent the southern, middle and the northern segments of the profile. It can be seen from the curves that the southern site rests on the resistive basement with a very thin near-surface conductive layer. The splitting of xy- and yx- curves at frequencies lower than 100 Hz indicates 2-D nature of the crustal structure. At site 12, the thickness of conductive sedimentary layer is more and it increases further at site 20.

Results

In general, the subsurface structure above the basement is simple and 1-D is nature, as can be seen in Figure 2. Therefore, we have performed 1-D Occam and layered inversion of the smooth, invariant data by using commercial software WinGLink and obtained the electrical resistivity structure along the profile. The resistivity model of the subsurface down to 6 km depth obtained by combining all 1-D Occam inversion results is shown in Figure 3.

The result reveals the subsurface structure has lateral variations along the profile which can be classified into four broad zones. The southernmost zone south of Chitrakoot reveals thickening of the conductive layer southward. In this area, the rocks of the

Vindhyan Supergroup are exposed on the surface. Thus, our results show the margin of the Vindhyan basin and thickening of these rocks further south. The next zone around Chitrakoot has very thin layer of conductive sediments. Zone-3, covering sites 8 (around Allahabad) and 12, is interesting as it has a shape akin to a graben structure bounded by normal faults. The conductive sedimentary sequence is thick in this zone. Zone-4 between sites 13 (around Amethi) and 20 (Around Faizabad) shows gradual northward thickening of the sedimentary sequence, which can be attributed to the flexure of the Indian plate. In this zone, the thickness of the sedimentary sequence is about 2 km which is much less than that obtained by Manglik et al. (2015) for the region north of Lucknow. Thus, our results suggest the presence of the Faizabad ridge in this region and relatively less flexure of the Indian plate compared to that obtained for the Lucknow profile.

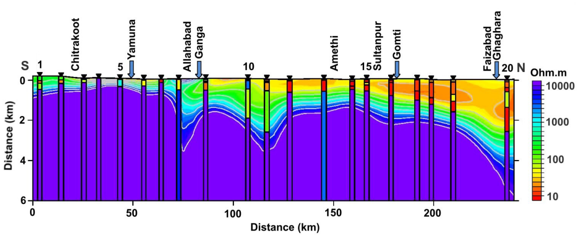

Figure 3: Subsurface electrical resistivity section obtained by Occam inversion of MT data. Locations of major rivers and cities are also marked.

Conclusion

The results of Occam inversion of MT data of 20 sites along the Chitrakoot - Faizabad profile in the central Ganga foreland basin reveal heterogeneous shallow subsurface electrical structure of the Indian Plate and lateral variations in the thickness of sedimentary sequence overlying the plate. The resistive block representing the Faizabad ridge extends all along the profile and the overlying conductive structure shows the presence of a graben-type structure around Allahabad and flexure of the plate from Amethi northward. The basement is much shallower than that obtained for the Lucknow profile.

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Acknowledgments

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