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A multidisciplinary geophysical study for sub-basalt imaging in central western India

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Abstract

Integrated studies incorporating multiple geophysical data to map geological structures have become a very useful tool. Results obtained from a similar experiment using wide-angle seismic and magnetotelluric data from the central western part of India, known as Kutch, are presented here. The region is suited to such a study because it is an extension of the central Indian basalt province. Since basalt eruptions are believed to have occurred around the Cretaceous-Tertiary boundary, the low velocity Mesozoic sediments trapped beneath may be good hydrocarbon prospects.

Two wide-angle profiles on-land up to a maximum receiver spread of 74 km have been used to acquire the seismic data using 7-8 explosive sources. Together with these, seven co-located wide band natural magnetotelluric (MT) soundings were recorded. The datasets for this study were collected and provided by the Oil and Natural Gas Corporation, India. Sonic and Induction well log records from a dry well in the area were also available for the study.

Both data sets have been analysed individually using the appropriate inversion tools for each. The two dimensional velocity models obtained from the tomographic inversion of the seismic data confirm the presence of variable thickness low velocity layers beneath the basalts across the two profiles. Basalt thickness varies from a couple of hundred meters to a kilometer. Precambrian basement with a velocity of about 6 km/s and as shallow as 5 km is also observed from this analysis. Sandwiched between the basement and the low velocity sediments, another high velocity layer (5.2 km/s) possibly a limestone sequence is also noticeable. On the other hand, one-dimensional inversion of magnetotelluric data produces a three-layer resistivity model in which resistivity increases with depth. The basalt layer observed in the seismic model, which is expected to be more resistive than the sub-basalt sediments, could not be resolved by magnetotelluric data. The reason is attributed to the well-known problem of a buried thin resistive layer in a conducting environment. Also, evidenced from the well log records, thin sedimentary sequences trapped within the basaltic layer itself make it appear to be relatively more conductive. This explains the insensitivity of this MT dataset to a thin basalt layer. Meanwhile, the MT data provides a good constraint on the basement. Hence, the integration of both kinds of information will constrain the model and produce a better image.

The joint analysis is useful in such cases as their individual sensitivity to the different geological environments. While the wide-angle seismic data and the well log records can explain the presence of fine scale features, the MT and gravity data constrain the regional features in the model. Combined together, they produce a more reliable subsurface model.