Magnetometer array studies in India: Present status, data interpretation and assessment of numerical modelling results

B R ARORA
Indian Institute of Geomagnetism, Colaba, Bombay 400005, India

Abstract. Significant results from several array of magnetometers deployed in India to probe deep geoelectrical structures of the crust and the upper mantle are reviewed in this paper. Emphasis is on critical appraisal of earlier results so that the article summarizes what has been done so far and what caution is to be taken on future work.

Two large-scale arrays over northwest and peninsular India during 1979–80, have been followed up with six more linear or two-dimensional arrays over different parts of the country. "Trans-Himalayan" conductor aligned along the strike of Aravalli range, delineated by arrays over northwest India, essentially represents one of the major continental induction anomalies mapped by electromagnetic methods. Efforts for quantifying the induction effects through numerical models are shown to be constrained due to the large inter-station spacing, lack of information on the regional background conductivity distribution and the non-inclusion of the frequency dependence of induction effects. A more comprehensive modelling, not biased by these factors, enables approximating the Trans-Himalayan conductor as an asymmetric domal upwarp in the middle and lower crust located between Delhi-Hardwar ridge and Moradabad fault. Numerical modelling results for southern peninsular, despite the constraints, indicate that the strong and complex induction pattern can be adequately attributed to the combination of conductors connected with triple junction between Indo-Ceylon Graben, Comorin ridge and the west coast rifting.

Induction features derived from the Valsad array, operated over basalt-covered region of western India, demarcate an enhanced conducting zone beneath Plume-associated triple junction in the Gulf of Cambay, apart from characterizing the presently active seismic zone as a resistive block.

Keywords. Electromagnetic methods; magnetometer array studies; geoelectrical structures; transient geomagnetic variations; conductivity anomalies; geomagnetic depth sounding.

1. Introduction

Magnetometer arrays are deployed to investigate the electrical conductivity structure of the earth's crust and the upper mantle. Electrical conductivity distribution thus derived serves as a window to look into the earth's interior and possibly throw light on the geological processes. The parametrization of the earth in terms of electrical conductivity has its significance owing to its dependence on the chemical composition and thermal state, association with low velocity zone and partial melting, correlation with stress changes and a possible precursor for earthquake studies. Over the last two decades, magnetometer array studies (MAS) have been increasingly used for probing and mapping conductive structures in a variety of geological environments such as sedimentary basins, ancient platforms and crystalline shields, orogenic belts, rift zones etc. Some important findings from MAS have been reviewed in Hutton (1976), Adam (1980), Singh (1980), Alabi (1983), Gough (1983) and Hjelt (1988).
In India, systematic MAS commenced in 1979 as a collaborative exercise between the Indian Institute of Geomagnetism (IIG), the National Geophysical Research Institute (NGRI) and the Australian National University (ANU). Under this joint scheme, two arrays using the ANU set of Gough-Reitzel magnetometers were carried out over the northwest and peninsular India. Following this a set of Gough-Reitzel magnetometers has been indigenously fabricated at IIG. Under the various projects sponsored by the Department of Science and Technology (DST), Government of India, some six linear or two-dimensional arrays have also been carried out by IIG over different parts of the country. The geographical locations of these arrays on the map of India are shown in figure 1. This paper is an attempt to review the notable results of some of these arrays. The results of the Garhwal and the Kangra array are discussed in some detail to illustrate the state-of-art of the widely used interpretational techniques to deduce the flow path of internal induced currents and associated conductive structures from transient geomagnetic variations. Towards the end of the section on these interpretational techniques, a reference is made to the method adopted for numerical modelling of the mapped structures. Giving the main anomalous features of data, we will focus our attention on the quantification of the results from the NW India and Peninsular India.

Figure 1. Map of India showing the locations of magnetometer arrays, operated between 1979–1988, together with the position of mapped conductive structures.