Geological Interpretation of Heliborne Geophysical Data from the Kaladgi Basin; Southern India

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SUMMARY

Geological interpretation from the Kaladgi Basin is based on integration of heliborne time domain electromagnetic (HELITEM), magnetic and gamma-ray spectrometry data with available geological mapping, ground exploration data, various published papers and spectral remote sensing data such as Landsat 7ETM+ and ASTER GDEM imagery.

Electromagnetic (EM) data, magnetic, radiometric, Landsat TM and Aster datasets were used for delineation of surface and subsurface extent of geological units and structural elements and for better understanding of the overall structural pattern of the Kaladgi Basin, including distribution of its local depocentres, the resistive basement surface and the magnetic basement topography. The interpretation of the available data details the localisation of intrusive bodies, basaltic lava flows, mafic dykes, basement faults and major intrabasinal fault systems.

Three dimensional grids (voxel models) of EM data were used for visualization in three dimensions.

Key words: geological interpretation, geophysical airborne survey, Kaladgi Basin, India

INTRODUCTION

The E-W trending Kaladgi-Badami Basin is a Proterozoic intracratonic basin of the Western Dharwar Craton located along its northern edge. Geological structure of the study area consists of three major litho-tectonic units including Archaean to Palaeoproterozoic basement of the Dharwar Craton which consists of the Peninsular Gneiss Complex and the Dharwar Supergroup, Proterozoic metamorphosed sedimentary sequences of the Kaladgi Basin and Cretaceous basaltic lava flows of the Deccan Traps (c.f. Jayaprakash et al., 1987; Chadwick et al., 2003; Ray et al., 2008; Meert et al., 2010; Chakraborty et al., 2010).

The sedimentary fill of the Kaladgi Basin comprises the Kaladgi Supergroup, which consists of Meso-Neoproterozoic shallow marine to fluvial deltaic and terrestrial basin margin sediments (Chaudhuri et al., 1999). While the Kaladgi Supergroup sediments unconformably overlie the Archaean basement Peninsular Gneiss and Dharwar Supergroup units in the south, towards north the sediment package is concealed under the Deccan Traps. The sedimentary sequence in the Kaladgi Supergroup has been divided along an angular unconformity surface into two groups; the lower Bagalkot Group and the overlying Badami Group.

DISCUSSION

Sedimentary formations of the Kaladgi Supergroup appear to be non-magnetic or their magnetic response is weak, while magnetic response of the crystalline basement is slightly elevated. Several N-S oriented major linear oriented magnetic units within the basement in the southern part of the Kaladgi Basin have been interpreted as metasediments with ferruginous quartzite or/and Banded Iron Formations, belonging to the Dharwar Supergroup. Two major subsurface intrusive bodies have been outlined within the basement in the south-western part of the Kaladgi Basin. The intrusives show a moderate to strong magnetic signal. Numerous smaller-scale, circular or semicircular, distinct magnetic anomalies scattered across the intrusives have been interpreted as apophysis of the intrusions, or alternatively as younger intrusive stocks

The NE-SW oriented linear magnetic anomalies along the southern margins of the Kaladgi Basin are interpreted as mafic dyke swarms intruded into the Dharwar Craton. Their north-eastward continuation is precluded by overlying basalts of the Deccan basalts. Basaltic lava flows show variable thickness and cover the northern, western and partly central part of the Kaladgi Basin. The basalts are characterised by a high-amplitude, short-wavelength magnetic response.

The most prominent magnetic NW-SE structural zone of the Kaladgi Basin, located in its NE margin, is interpreted to be related to the Banhati – Mantor – Helagali – Bagalkot – Mudenur Lineament, (part of the Wajarakuru Fault Zone) (c.f. Anand and Mita Rajaram., 2002; Chawla, 2010). Another dominant NE-SW magnetic lineation running across the basement of the Kaladgi Basin in its eastern part is correlated with the Belgaum – Vannur - Lokapur Lineament and Salligeri to Pottlur Lineament, (Chawla, 2010). Distinct NE-SW structural zones in the eastern part of the Kaladgi Basin are interpreted to be major, relatively broad, deep reaching, intra-basinal fault systems, which presumably controlled local depocentres of the Kaladgi sedimentary area. The southern margin of the Kaladgi Basin and the adjacent outcropping crystalline basement is strongly dissected by a complex N-S, WNW-ESE and NE-SW fault pattern. The WNW-ESE oriented steep extensional faults bound tilted blocks which form a series of half-grabens along the margin of the basin. The fault system is correlated to the Murgod – Yakkundi – Hire Kumini Lineament (Chawla, 2010).

The Depth to Magnetic Basement interpretation shows that the Kaladgi Basin is an open relatively deep basin. It is divided into several sub-basins separated by fault-controlled NE-SW and NW-SE oriented basement ridges. By utilising the magnetic basement elevation grid and the digital elevation model a sediment thickness grid was generated. This grid represents the thickness of non-magnetic material overlying the interpreted magnetic basement. The average thickness of non-magnetic material is appreciable, generally 400 metres or more, with isolated pockets of thicker material up to 800 m. The basement elevation grid ranges from approximately 600 m to -200 m relative to datum (WGS84), and shows shallow outcropping basement along the southern boundaries of the survey area.

The aim of the EM Depth to Resistive Basement interpretation was to map the interface between conductive cover and resistive 'basement'. As such, two resistivity contrast boundaries were picked: the first corresponds to the bottom of the shallow conductive unit interpreted as the base of the Deccan Volcanics and the second – picked at the base of a deeper sub-surface conductive zone – is interpreted as the weathered paleo-surface of the crystalline basement (Figure 2). This second boundary can largely only be seen in areas where the volcanics are not present at the surface, suggesting that the volcanics are an effective mask to the EM system preventing deeper penetration. The EM data suggests that the basement is generally deepest along a NE-SW trend roughly through the centre of the survey area, where depths are approximately 500-600m below ground. There is a pronounced basement high in the east central area of the basin.

Utilising the CDI data, the 3-D voxel model was generated to represent the conductivity distribution beneath the survey area in three dimensions (FIGURE 1). Visualisation and analysis of the data was used to assist with the geological interpretation and to identify electromagnetic anomalies of interest.

Electromagnetic anomaly picking for the Kaladgi Basin suggests that the EM anomalies follow conductive and resistive zones, which in many places represent boundaries of geological units and fault zones.

CONCLUSIONS

The Kaladgi Basin is an open relatively deep basin, filled up by Meso-Neoproterozoic shallow marine to terrestrial basin margin sediments unconformably sitting at the top of the Palaeoproterozoic to Archaean basement. Deccan basaltic lava flows cover the northern, western and partly central part of the Kaladgi Basin. The current configuration of the Kaladgi Basin shows several sub-basins separated by fault-bounded NE-SW and NW-SE oriented basement ridges. The EM data suggests the maximum depth of the basement approximately 500-600m below ground. The sedimentary fill of the Kaladgi Basin appears to be non-magnetic or its magnetic response is weak. Electromagnetic data indicates that the sedimentary formations of the Kaladgi Supergroup are conductive, with several indistinct resistive layers. Its non-conformable contact with underlying rocks of the Dharwar Craton is present in the electromagnetic data as a distinct interface between the conductive Kaladgi Supergroup and the resistive Dharwar basement.

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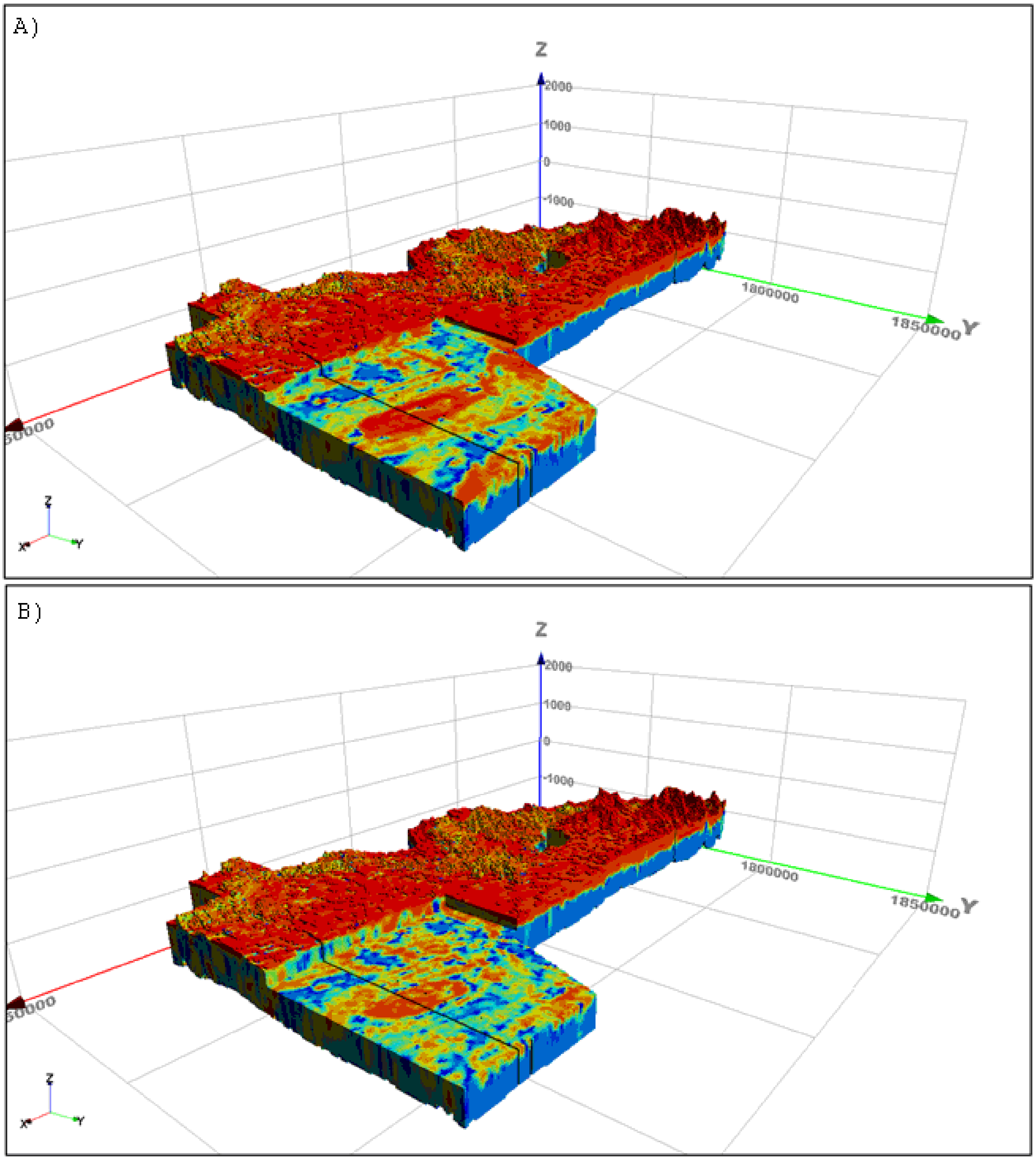

Figure 1. Kaladgi Basin 3-D voxel model viewed towards the SW, showing basalt lava flows in red, at various altitudes; A) 450m,; B) 350m, bottom

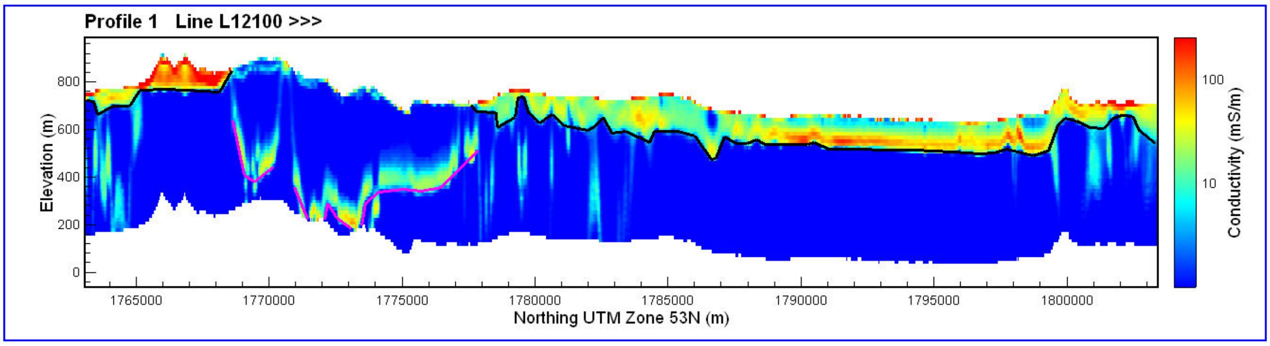

Figure 2. CDI image showing the surfical conductive zone (black line) corresponding the base of the Deccan volcanics, and the resistive basement in the basin (pink line)