Geological Milieu of the Bijawar Basin based on interpretation of geophysical data; Central India

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SUMMARY

Integrated interpretation through physical properties of rocks provides better approach towards understanding of geological set-up. High resolution heliborne time domain electromagnetic, magnetic and radiometric dataset acquired over Palaeo Proterozoic Bijawar Basin has been interpreted to enhance the geological understanding. The process involved knowledge driven analysis through correlation with geological units that outcrop and data driven analysis for extrapolation of information. Radiometric data in conjunction with spectral remote sensing data was used for generation of surface geology map. Spatial distribution of rock magnetization properties defines the subsurface extension of litho-structural elements and magnetic basement configuration. Electromagnetic data aided demarcation of resistive basement topography and various conductive layers. Radio-elemental distribution refines the unconformable contact shared by Bijawar Group with overlying and underlying group of rocks and also outlined the formational boundaries of arenaceous-argillaceous-carbonate- volcano-sedimentary sequence. Subsurface extent of basic volcanics is much more than its surface manifestation and appears to extend well below the overlying Vindhyan Supergroup of rocks. The unconformable contact of Bijawar Group with underlying basement and overlying Vindhyan Supergroup is marked by distinct change in conductivity parameter and has been outlined in depth to resistive basement topography. Fault system and its manifestation over different litho-units indicate multiple tectonic episodes.

Key words: Integrated interpretation, geophysical properties, Palaeoproterozoic, Bijawar basin

INTRODUCTION

The geological interpretation of Palaeoproterozoic intracratonic Bijawar Basin is based on integration of heliborne geophysical data with other data such as previous mapping and spectral remote sensing data. The approach involved knowledge driven analysis through correlation with geological units that outcrop and data driven analysis for extrapolation of information.

Radiometric, Landsat 7ETM+ and ASTER datasets were used for interpretation of the surface extent of geological units along with linear structural elements such as mafic dykes and quartz reefs. Magnetic data was interpreted for subsurface geology and electromagnetic datasets defined the conductive horizons.

Metamorphosed sedimentary and volcano-sedimentary sequences of Bijawar Basin are flanked from all sides by Bundelkhand Granitoid Complex except in south where sediments of the Vindhyan Supergroup unconformably rest over Bijawar basinfills. Shallow dipping; often sub-horizontal, largely undeformed sedimentary sequences of the Bijawar Group suggest conditions of shallow carbonate platform with a clastic influx from the nearby landmass, typical for very shallow marine environment with several periods of an intensive tropical weathering (Chaudhuri et al., 1999; Bose et al., 2001; Chakraborty, 2006; Banerjee et al., 1982). Contact between the basement complex and the sedimentary fill is unconformable and marked by polymictic conglomerate and chert breccia with a significant proportion of the mafic magmatism. Deposition of different parts of sedimentary sequence of the Bijawar Group directly on the crystalline basement and unconformable contacts within the Group suggest repeating periods of vertical movement, which resulted in erosion of the uplifted areas on which overlying sequence was deposited (Kumar, 1984, Kumar et al. (1990). The end of the evolution of the Bijawar Basin is marked by a regional uplift and erosion. Subsequently, Lower Neoproterozoic sedimentary sequences of the Vindhyan Supergroup were deposited over the Bijawar Group with an unconformity.

The Bijawar strata define a broad, regional syncline trending ENE–WSW. The axis of the syncline is slightly curved and plunges gently towards the east. In the western part of the Bijawar Block a NW-SE trending syncline with a south plunging fold axis occurs. The Vindhyan deposits postdate its formation. Existence of such an oriented structure, almost perpendicular to the ENE–WSW regional syncline suggests polyphase tectonic evolution of the Bijawar Basin.

METHODOLGY ADOPTED AND DISCUSSION

Surface contact between the Bundelkhand Granitoid Complex and the Bijawar Group was determined by radioelemental distribution in conjunction with spectral remote sensing data as part of Integrated Geological Interpretation, allowing an accurate assessment of the outcropping unconformity. The distinct radiometric signature along the litho-boundary separating the Vindhyan Supergroup of rocks in juxtaposition allowed mapping the study area. The extrapolation of the surface geological attributes was based on magnetic and electromagnetic (EM) to prepare the integrated geological map.

The spatial distribution of rock magnetisation properties has been used for interpretation of the depth to magnetic basement (DTB) topography and the subsurface extent of geological units and structural elements with magnetic signal, including mafic intrusives, basaltic lava flows, pyroclastic flows, mafic dykes, basement faults and major intrabasinal fault systems. Sedimentary and volcano-sedimentary formations of the Bijawar Group appear to be non-magnetic or their magnetic response is weak. The Dargawan Intrusive Formation in the central part of the Bijawar Basin and the Kawar Volcanic Formation in its eastern and western areas show strong magnetic signal, which shields the magnetic response of the Bundelkhand Granitoid Complex. This refines the extent of Kawar volcanic beyond the surfacial isolated pockets in the vicinity of basin margin to deep inside the basin. A disperse moderate magnetic signal in the north-western part of the Bijawar Basin is interpreted to be generated by Fe-bearing shale of the Karri Ferruginous Formation. The NW-SE oriented linear magnetic anomalies at the northern and north-western margins of the Bijawar Basin are interpreted as mafic dyke swarms intruded into the Bundelkhand basement. Numerous small-scale, circular or semicircular distinct magnetic anomalies scattered across the Bijawar Basin have been interpreted as mafic/ultramafic intrusive bodies.

The DTB interpretation suggests that the Bijawar Basin forms a fairly shallow, flat depocentre, with an undulation running along its northern margin. Along the northern and western margins of the basin a complex pattern of depressions occurs. One third of the total area of the survey is covered by magmatic products such a sill, lava flows and pyroclastic flows with a strong remanent magnetic response and the DTB values obtained for these locations are unreliable.

EM data was used for delineation of the resistive basement surface and various conductive layers. The EM interpretation includes depth to resistive basement interpretation, conductivity distribution in three dimensions (voxel models) and identification and modelling of electromagnetic anomalies.The EM data shows three interfaces between conductive cover and resistive ‘basement’, including the unconformable contact between the Bundelkhand Granitoid Complex and the Bijawar Group in the north, a conductivity contrast located towards the top of the basaltic Dargawan Intrusive Formation and the unconformable contact between the Bijawar Group and overlying Vindhyan Supergroup in the south . The Basement-Bijawar contact and Bijawar-Vindhyan contact generally dip gently to the south whereas the Sill Weathered Contact is much more flat lying with noticeable surface relief indicating either different thickness of the weathered profile over sill or vertical offset along fault. The lateral extents of the sill interpreted from the magnetic data have been used in conjunction with the electromagnetic data to assist in determining the location and depth of the contact. It would appear that the sill may extend to the south beneath the Vindhyan Supergroup.

In this area it can be seen there is an apparent thick package of conductive material extending to an elevation of 100m. However, the control provided by the Integrated Interpretation means it is possible to identify two individual zones of elevated conductivity at different levels of which the shallower zone has been attributed to the Vindhyan Supergroup. The deeper zone may correspond to southern extension of the weathered sill or possibly conductive units within the Bijawar Group.

FIGURE 1 displays highest elevations along an N – S trending axis running through the centre of the study area. This is manifested as broad elevation highs at the Basement-Bijawar and Bijawar- Vindhyan interfaces. However, the Sill Weathered Contact appears to be faulted and down-thrown to the east of the elevation high, with the down-thrown surface apparently dipping gently towards the east.

Distribution of EM anomalies shows good accordance with the geological structure and the tectonic pattern. EM modelling shows a relatively flat-lying conductor between 120 and 240m below the surface, perhaps deepening to the east.

Another anomaly appears to be a conductor at 120-180m deep, which is shallowly dipping to the north at 0-20°. This dip may be increasing to the east.

The most conductive zones imaged by the 50mS/m isosurface tend to be a series of scattered, small scale features apart from an extensive ENE – WSW trending zone apparently associated with interpreted surficial Quaternary deposits in the central north of the study area and a number of relatively large features located in the south west (FIGURE 2). The largest of these bodies appears to define the extents of the Bajna Dolomite Formation which fills the interpreted syncline.

CONCLUSIONS

Integrated interpretation using input from magnetic, radiometric and electromagnetic dataset in conjunction with satellite imagery study serve as useful tool in detailed understanding of the geological framework of the area. The Bijawar metasediments were deposited in shallow flat configured basin. Tectonic activities in different phases involved basement as well as cover rocks or at times only Bijawar basinfills. Unconformable contacts of Bijawar Group with basement or Vindhyan Supergroup correlate with distinct boundary between conductive overlying unit and underlying resistive horizon. Post Vindhyan deformational episode might have disturbed the unconformity surface.

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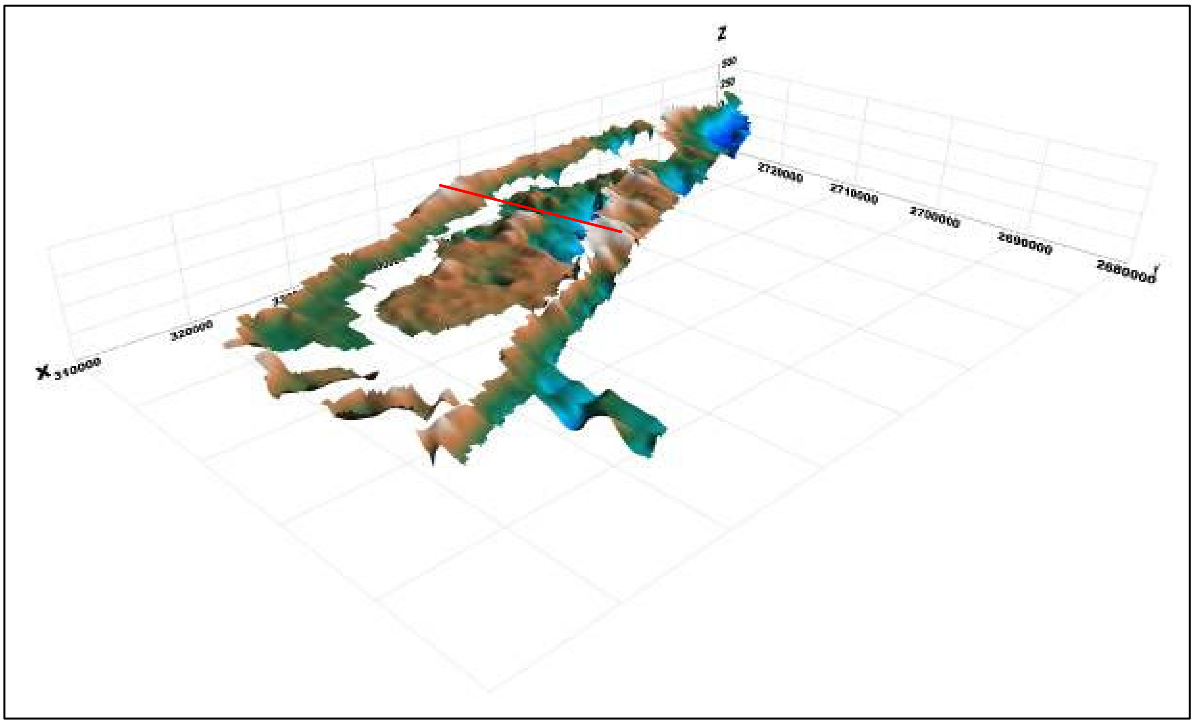

Figure 1. 3D view of Bijawar Block showing three interpreted conductivity horizons. 3D view is to the north east. The red line in the top image marks approximate axis of the elevation high.

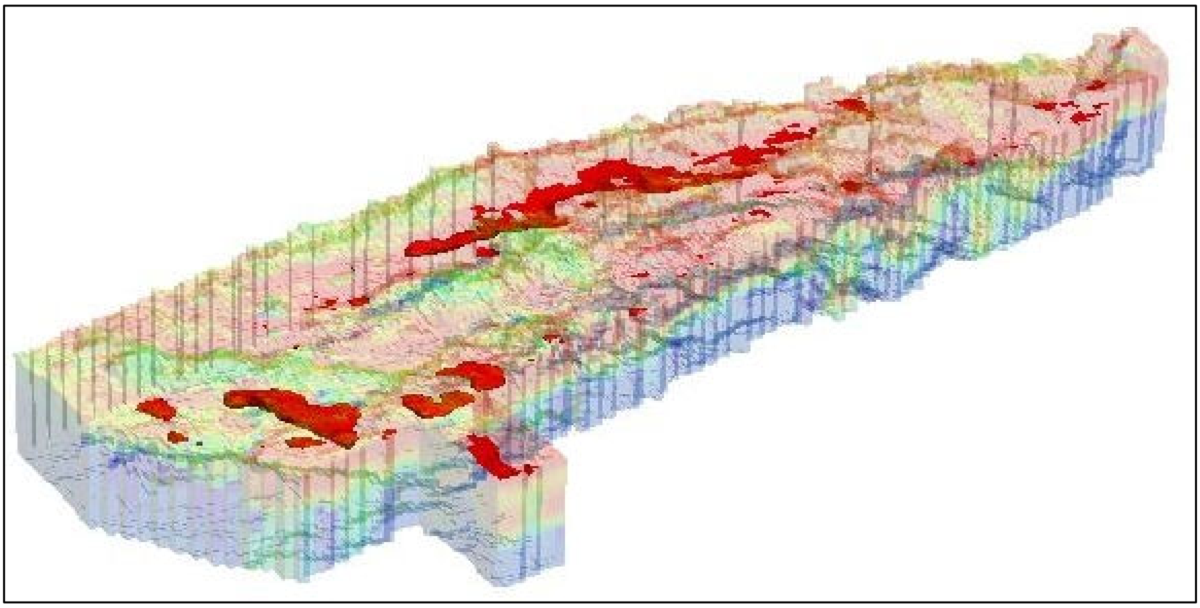

Figure 2. Semi-transparent view of 3D voxel model of the Bijawar Block with isosurfaces (50mS/m) highlighting the conductivity distribution. View is to the North West.