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Mapping and demarcating gold mineralization in Jashpur and Raigarh districts (Chhattisgarh) from Analytic Hierarchy Process and geophysical approach

Vishal Bajirao Nayakwdi[1] and Dewashish Kumar[1,2]*
[1]CSIR-National Geophysical Research Institute, Hyderabad -500007, India
[2]AcSIR – Academy of Scientific and Innovative Research, Ghaziabad, India
*corresponding author: dewashishkumar@ngri.res.in; dkumar.ngri@gmail.com

ABSTRACT

Mineral exploration is a vital activity for the sustainable and economic development of any region. This study focuses on the Jashpur and Raigarh districts of Chhattisgarh state in India. We integrate geology, electrical tomography, resistivity, induced polarization (IP) and Geographic Information Systems (GIS) to identify high potential zones of hydrothermal gold deposits. We followed a data driven approach that utilizes multiple data sets pertaining to geological, geochemical and geophysical studies. These data sets in the Analytic Hierarchy Process (AHP) were utilized to provide weights to various evidence layers through expert judgment and literature review. The weighted layers were combined to generate mineral prospective maps, which identified areas with significant economic potential. This study demonstrates the effectiveness of integrating state-of-the-art electrical tomography method and GIS in mineral exploration by providing a robust framework for identifying economically viable gold and other sulphide mineral deposits. Mineral Prospect Map (MPM) indicates that 130.40 sq. km area comes under the class of high mineralized zone. The results contribute to the sustainable development of the Jashpur and Raigarh districts, offering valuable insights for mineral resource management and exploration strategies.

Keywords: Chhotanagpur Gneissic Complex, Electrical resistivity tomography, Time domain IP, Mineralization, Chhattisgarh, India

INTRODUCTION

Finding new mineral deposits and utilising prospective zones within the region of interest for economic and sustainable growth, is a major motive in mineral exploration (Haldar, 2018). There is hidden information on geo-evidential features, which are considered indicators for exploring appropriate minerals and deposit types. Complexity arises due to the wide variety of geological processes, large spatial areas involved and the need to interpret data both from the surface and subsurface findings (Mansouri et al., 2017). Mineral potential mapping in recent years has been categorised as either data driven or knowledge driven (Pradhan et al., 2022; Zuo et al., 2023). A knowledge driven approach was used for this study. Multiple data sets or maps are required to be collected, analysed and integrated for mineral prospective mapping (MPM) in the region of interest to identify mineral-rich zones.

Present study aims to determine high potential zones of hydrothermal gold deposits in the Jashpur and Raigarh districts of Chhattisgarh in India, where many previous studies have also been done. For example, Geological Survey of India (GSI), Geomysore Services and MECL, explored gold as a G3 reconnaissance survey. Dora (2014) also studied ten different sites from Bastar craton for PGE mineralisation. Similarly, Kumar et al. (2017) studied and reported positive IP results and GSI also reported gold mineralisation around the study area (Kalsotra and Narang, 1983). An Analytic Hierarchy Process (AHP) method was applied to determine the weights of five different evidential layers, obtained from geological and geochemical studies as well as literature review, to demarcate high and economically explorable gold deposits. Prospectivity maps were created by merging the weighted evidential layers using the AHP technique (Du et al., 2016). As such, present study integrates high resolution electrical resistivity, IP tomography geophysics and GIS data to demarcate the mineral potential zones. State-of-the-art electrical resistivity tomography (ERT) and induced polarisation (IP) geophysical methods were used to study in detailed the subsurface geological structure(s) and mineralised zones within the rock mass of a geological setting in the study area. Subsequently, ERT and IP results were used to validate the mineral prospective map (MPM) as obtained in the present study.

STUDY AREA, GEOLOGY AND DRAINAGE SYSTEM

The study area falls in Jashpur and Raigarh districts of Chhattisgarh state, India (**Figure 1**). This study region is enriched with different types of mineral deposits and also known for its complex geological formations. It has a long history of mineral exploration activities. The geographic coordinates of the study area are 22°17' to 23°15' N and 83°30' to 84°24' E . It falls in toposheets 64N/10, 64N/11, 64N/14 and 64N/15. The study area comprises different geological features like, fractures, faults, lineaments and dykes (Figure 2). It exposes Precambrian rocks, represented predominantly by biotite granites and gneisses with xenoliths of older metamorphic and basic rocks, which are traversed by quartz veins (Kalsotra and Narang, 1983; Kumar et al., 2017) (Figure 3). It is also comprised of Lower Gondwana and Chhotanagpur gneissic complex rocks (Figure 3), exposed along an E-W belt and have numerous stringers and veins of quartz traversing mostly in NW-SE, NE-SW and E-W directions. Pegmatites, meta basic dykes, aplite veins, basic dykes and quartz veins are also found in the study area (Choudhary, 1969; Mishra et al., 2008).

The study area comprises undulating topography with numerous knolls, hillocks and linear ridges rising over a general level of 365 m above mean sea level. Ib and Maini