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Composite Geoelectrical Investigation to Delineate Groundwater Feasibility in Hard Rock Area of Raipur, Chhattisgarh, India

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ABSTRACT

In hard rock terrains, groundwater movement, migration, and storage occur through subsurface fractures. To assess the fractures and associated water, the authors carried integrated geophysical investigation with Wenner, GRP, Schlumberger, and Pole-Dipole array in the Indian state. The resistivity survey was carried out using a CRM-500 resistivity meter. The analyzed results are also re-verified with the help of IPI2WIN software. Initially, lateral and surface variations of resistivity were plotted by using Wenner and gradient resistivity profiling array. Then the low resistivity points were investigated with Schlumberger and Pole-Dipole array. In interpretation, low resistive zones identified correspond to the possible fractured zones. The results allowed mapping of the weathering zone at depth 12 to 15 m, and deep fracture lies below depth 55.0 m depth. The present study validates that the integrated geophysical survey is a powerful exploration technique to scrutinize and identify water-bearing fractures in the hard rock area.

KEYWORDS

Drilling Site, Fractures, Groundwater, Hard Rock, Lineaments, Profiling Array, Weathered Zone

1. INTRODUCTION

Groundwater exploration in hard rock areas is often more challenging, so borehole drilling generally failed. Generally, tube-wells drilled without proper integrated geophysical and hydrogeological investigation often cannot yield groundwater in hard rocks. In hard rock terrains, groundwater is trapped in fractures, cracks, and local rock faults. Thus potential groundwater yield bank on the interconnectivity of fractures and their size.

Good contrast between the resistivity of fractured rocks and undisturbed hard rock is observed if these fractures are water-saturated. The fractured zone shows lower resistivity than hard rock's (Karous and Mares 1988).

The Vertical Electrical Sounding (VES) technique is widely used in soft and hard rock areas to delineate the ground water-bearing hydrogeological formations. The direct-current (D.C.) resistivity method specifically for a vertical electrical sounding (or Schlumberger sounding) is

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effectively employed in groundwater investigation because of the technical simplicity, straightforward interpretation, and rugged nature of the associated instrumentation.

In central Deccan Traps of central India, several types of research have been systematically executed by using geophysical and hydrogeological (Singhal 1997; Pawar et al. 2009; Rai et al. 2011; Ratnakumari et al. 2012; Rai et al. 2013) to characterize and find fractures zones, groundwater movement, and aquifers.

Schlumberger's sounding is well known and used as a vertical sounding technique for finding the resistivity variations with depth. However, it is complicated and unfruitful to operate resistivity soundings everywhere without a priori information, especially in hard rock terrains. Because in hard-rock areas, water-saturated fractures are randomly distributed both horizontally and vertically. So if the vertical electrical sounding is conducted randomly, with no prior input, it may skip fracture hence groundwater.

Kearey and Brooks (1984), and Telford et al. (1990) have discussed the geophysical survey geometries and array. In this following integrated geophysical study, we used four D.C. electrical survey arrays to explore the fracture in hard rock with minimum ambiguity. Recently many researchers worked on composite geophysical investigation in different geological settings, Yadav and Singh (2007). Correlations between electrical resistivity and geotechnical parameters were also investigated by Devi et al. (2017).

In the present study, Integrated geophysical techniques were employed in Raipur, Chhattisgarh, India. The study aims to figure out the practical merits and demerits of electric geophysical methods and delineate the hard rock terrain's water-bearing fracture zone.

In this study, the resistivity surveys were executed using Aquameter CRM 500 instrument. The CRM 500 is an indigenous microprocessor-based resistivity meter). The Aquameter CRM 500 is a high-power version (40 Watt), valid for a wide range of resistivities. This instrument gives depth information up to 600 meters based on field conditions. Aquameter CRM 500 is a single button operation system that gives reliable and in-depth results, even in harsh field conditions.

2. STUDY AREA AND HYDROGEOLOGY

Study Area During ILTC 2018-19, Geophysical Investigation was carried out at Kamal Vihar, Raipur, and Chhattisgarh. The study site is located in toposheet No.64G/11. The study area falls on 21°12'16" N 81°40'2" E latitude and longitude position (DMS). The Google earth pro software image (Figure 1) clearly shows the study points on the map.

2.1 Hydrogeology of the Area

The Chandi formation of the Raipur group is the principal geologic unit exposed in Raipur city. Its thickness varies from 103 m to 136 m (Sinha et al., 2002). Chandi formation comprises Deodongaer shale, sandstone, and limestone. Limestone exposed to various places in the city is cavernous and jointed. Deodongaer, a member of Chandi formation, consists of thinly laminated siliceous shales and sandstone that overlies the Newari limestone with a sharp contact (GSI, 2005). The Gunderdehi formation also occurs in the Raipur city, which comprises mainly Newari members (limestone). The local geology is shown in the table-1.

Groundwater occurs both in shale and limestone of Chandi Formation in the surrounding areas. A thick band offers conditions favorable for the occurrence of groundwater. The dug wells tap both shale & limestones, while the bore wells generally tap the limestone's deeper aquifer. The average depth of water level in open wells ranges from 6 to 10m below ground level.

2.2. Availability of Water Resources

The region delineated for the proposed new city's location is water bodies in the form of lakes, ponds, rivers, and irrigation canals. Water from the three lakes Kumhari, Pirdaon, and Kurud can be tapped

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