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# Detection of Cavity Using Electrical Resistivity Tomography (ERT) at Patherdih, Jharia Coal Field, Dhanbad, India

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**Abstract** Geophysical survey for cavity detection is one of the most common near surface application. The usage of resistivity methods are also very straightforward for the air filled underground voids, which should have theoretically very high resistivity in the ERT image, whereas the water filled cavities have low resistivity in Electrical Resistivity Tomography (ERT) image. Three different geoelectric arrays Wenner, Schlumberger and Dipole-dipole are applied for detecting cavities. The survey results suggest that ERT is a viable geophysical tool for the detection and monitoring of mining voids and other subsurface cavities. The resolution capacity of joint Wenner-Schlumberger, Dipole-dipole array for the detection of cavity is greater than that of the individual one. Using the ERT survey in Patherdih Thana Basti village (Jharia coal field), a number of air filled cavity or water filled mining voids are detected at around 25-30m of below the ground level at different profile distance of 630m profile length along the road that extending S-E to N-W direction.

**Keywords** Jharia Coal Field, Patherdih Coal Field (stratigraphy), Electrical Resistivity Tomography (ERT), Underground Cavity

## 1. Introduction

Electrical Resistivity Tomography (ERT) method is useful for subsurface imaging and detecting different underground voids such as corridors (i.e. underground buildings), crypts (underground burial chambers), cellars (any types of underground rooms), caves (natural underground chambers) etc. These voids can be empty, full or partly water-filled or filled with different kind of stuff. Different prospecting techniques have been employed to detect underground voids. Success depends on their ability to reach the target depth with the appropriate resolution for each problem. ERT method aims to characterize the variations of the physical parameters (ground resistance vs. depth) of underground formations. It measures a set of data in which various parameters (apparent resistivity, conductivity, depth etc.) are measured. Each of these parameters is related to one or more physical properties of the subsurface. ERT is a popular choice due to the low costs of the survey and the high resistivity contrast that exists between the air-filled cavity and surrounding formation. The cavities are partially or completely water filled and can have a resulting electrical conductivity ranging from very conductive to relatively resistive depending on the host rock (Barakar formation).Besides, cavity detection by ERT, clear picture of coal fire is also imaged on that shallow subsurface.

## 2. Geology of Patherdih Area

Patherdih coal basin is belongs to Gondwana basin (Verma et al.1979), part of the Jharia coalfield is located in the Singhbhum craton extends for about 38 km in an east–west direction and maximum of 18 km in north–south direction, and covers an area of about 456 km$^2$ (Fig.1). The general stratigraphic succession (Chandra, 1992) is illustrated in Fig.1. In general, beds of Patherdih coalfield is dipping southerly (10°). The formations generally follow the boundary of the coalfield, striking E–W and NW–SE and dipping towards the center of the coalfield. The sedimentary succession, unconformable overlying the Archaean gneissic basement, starts with Talchir Formation followed upward successively by the Barakar, Barren measures and Raniganj Formations (Dasgupta, 2008), deposited within an intra cratonic extensional setting (Ghosh and Mukhopadhyay, 1985). The coal seams of the present study belong to Barakar Formation of Permian age, which does not show any evidence of high intensity tectonic deformation except normal gravity faults of different magnitudes: both, minor (thrown less than 10m and major [thrown 10m to greater than 100m ](Ghosh and Mukhopadhyay, 1985 );( Sengupta, 1980)

## 3. Location

The study area is situated in eastern part of India near North-West of Chasnala Coal Mine in Dhanbad district, Jharkhand. The area is situated about 20km in southward direction of Dhanbad town. Actual position of the study area is in Patherdih Thana-Basti village just in the eastern bank of Damodar River and left side of Dhanbad-Adra railway track, from Patherdih -bazar just in the western field. The area lies within the geographical coordinates between 23°47'34"N to 23°47'53"N latitude and 86°21'59"E to 86°22'16"E longitude.

## 4. Methodology

The choice of the place is along the bare road of Patherdih-thana Basti village as there is land subsidence, coal mine fire, wide-space and no disturbance. Just beside the coal mine fire and along the road a 630m long straight profile is made. Every 10m spacing along the profile of 630m, arrangement of electrodes in the ground surface is done, then the connection of every electrode with cable wire is done and finally setting up of flashRES-UNIVERSAL instrument is completed with pouring salted water at the position of the electrode location for the good conduction of current). ERT instrument take data in different array like Wenner-array, Schlumberger array and Dipole-dipole arrangement**.** Surface electrical resistivity tomography surveying is based on the principle that the distribution of electrical potential in the ground around a current-carrying electrode depends on the electrical resistivity and distribution of the surrounding soils(i.e. red soils, grains, small particles etc.) and rocks (that is the geology of the sub-surface and underground formations).The usual practice in the field is to apply an electrical direct current (DC) between two electrodes implanted in the ground and to measure the difference of potential between two additional electrodes that do not carry current. Usually, the potential electrodes are in line between the current electrodes, but in principle, they can be located anywhere. The current used is either DC, commutated direct current (i.e., a square-wave alternating current), or AC of low frequency (typically about 20 Hz). All analysis and interpretation are done on the basis of direct currents.

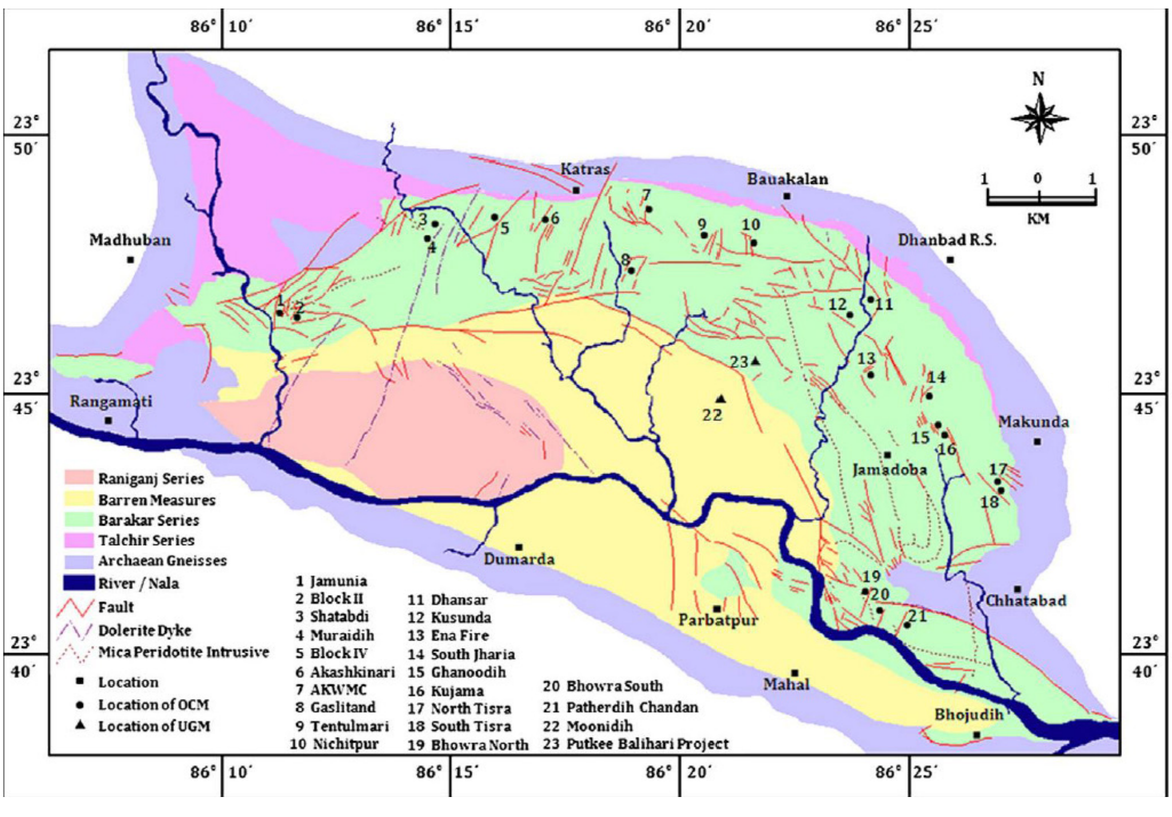


**Figure 1.** Geological map of Patherdih area with stratigraphic succession (Chandra, 1992)

## 5. Detection of Cavities

Subsurface cavities most commonly occur as solution cavities in carbonate rocks. They may be empty or filled with soil or water. In favorable circumstances, either type may offer a good resistivity contrast with the surrounding rock since carbonate rocks, unless porous and saturated, usually have high resistivities, whereas soil or water fillings are usually conductive, and the air in an empty cavity is essentially non-conductive. Wenner or Schlumberger arrays may be used with horizontal profiling to detect the resistivity anomalies produced by cavities. The probability of success by this method depends on the site conditions of Sandstone/clay stone/shale etc. (in wetted area, wide space for the ERT cable, no hard rock for the disturbance of the electrodes and no electrical disturbance area, success is more) and on the use of the optimum combination (current and potential electrode array combination should be in proper) and of electrode spacing and interval between successive stations. Many of the unsuccessful surveys are done with an interval too large to resolve the anomalies sought

## 6. Results and Discussions

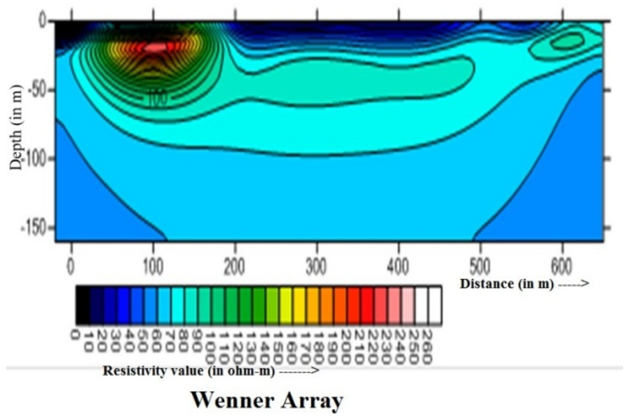


**Figure 2.** Plot of Wenner Array

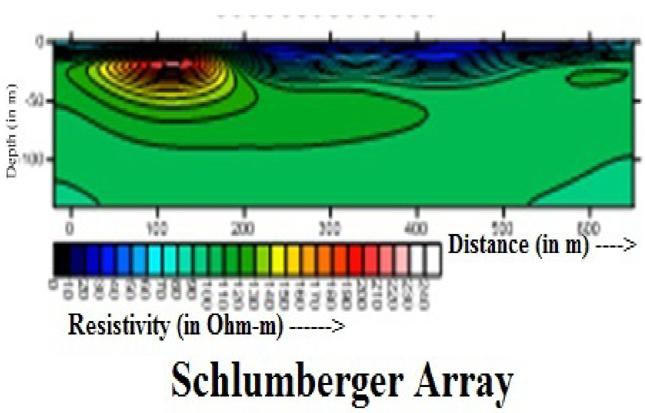


**Figure 3.** Plot of Schlumberger array

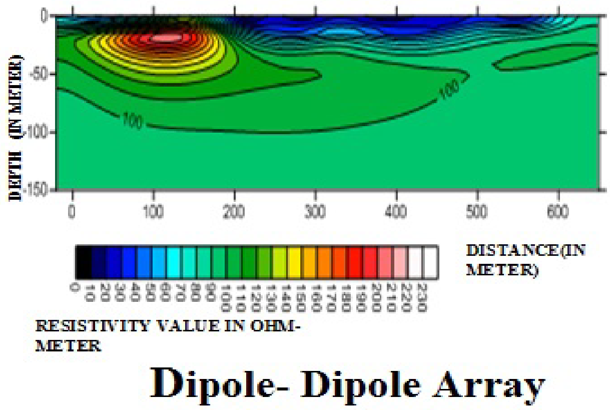


**Figure 4.** Plot of Dipole-Dipole Array

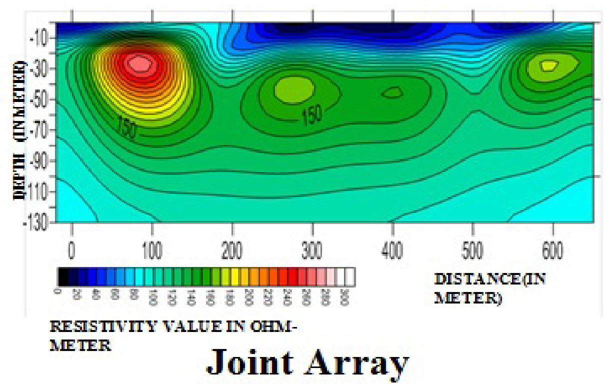


**Figure 5.** Plot of Joint Array

Fig.2. Interpret the Wenner array and clearly seen that profile distance about 630m along the horizontal axis and depth varies from (0-130m) along the vertical axis of fig.2, the resistivity value is 10-240ohm-m. The red deep colour represents air filled cavity as the resistivity value is high at 25-30m depth at $10^{th}$ electrode position from starting point. At about 600m along the profile, there is another small water-filled cave at depth 25m from surface. In Schlumberger (fig.3) array the resolution is better than Wenner array but here resistivity value ranging between 10 ohm-m to 230 ohm-m. In this case also cavity location is same i.e. the exact location of the cavity is 105m from the starting point and the actual depth of the cavity is 30m in nearly below position of 10th electrode location from starting point i.e. from north -west position of the road. In 600m of the profile length i. e to the south-eastern part of the road once again we see the water filled cavity and its exact location from surface about 25m.

While in dipole-dipole array (fig.4) the resolution is better than the rest two methods. The resistivity value varies from 10-220ohm-m. In this figure also seen clearly the coal seam fire position, in deep blue colour, represents coal seam fire distribution.

The beauty of ERT is that it collects data simultaneously and called it joint array (fig.5) of Wenner, Schlumberger and dipole-dipole array. Here the resolution is more and better than the previous three modes. Here resistivity varies from 20-280/290 ohm- m. Here, interpretation shows more two water filled cavities, circular one in 290m from zero point and another small one in 400m from starting point along the profile. In this array, clearly getting the structure of shallow surface up to 130m. It distinguish the coal fire, air filled and water filled cavities, lithologies of Patherdih area.

# 7. Conclusions

The survey results suggest that electrical resistivity tomography is a state-of-the-art geophysical tool for the detection and interpreting of the mining voids and other subsurface cavities.

The resolution capacity of joint inversion of Wenner Schlumberger and dipole-dipole array data for the detection of cavity is suitable than that of the individual one.

Using the electrical resistivity tomography survey in Patherdih Thana Basti village a number of air filled cavity or water filled mining voids are detected at around 25-30m depth at different profile(100m-600m) distance of 630m profile length along the road that extending S-E to N-W direction.

Besides, cavity detection by ERT, clear picture of coal fire is also imaged on that shallow surface.

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