Journal of Scientific & Industrial Research
Vol. 63, November 2004, pp 927-930

Multielectrode resistivity imaging technique for the study of coal seam

K K K Singh*, K B Singh, R D Lokhande and A Prakash
Central Mining Research Institute, Dhanbad 826 001

Received 06 April 2004; accepted 05 July 2004

The multielectrode resistivity imaging method has been used to study the coal seam located in the northern part of Jharia Coalfield of Dhanbad district. This method has been applied on experimental basis to know the efficacy of this technique. The improvement of resistivity methods using multi-electrode arrays led to an important development of electrical imaging for subsurface surveys. Such surveys are usually carried out using a large number of electrodes, i.e., 48 or more, connected to a multi-core cable. Apparent resistivity measurements are recorded sequentially sweeping any quadripole (current and potential electrodes) within the multielectrode array. As a result, high-definition pseudosections with dense sampling of apparent resistivity variation at depths are obtained in a short time. It allows the detailed interpretation of 2-*D* resistivity distribution in the ground. In this experimental study, Syscal Junior Switch-48 electrode resistivity meter is used for the exploration of the coal seam at east Basuria colliery of Jharia coal field, Dhanbad. Pole-dipole configuration of the multielectrode resistivity survey has been carried out along two traverses R1 and R2, which were selected over developed workings of coal seam II at an incline mine of the east Basuria colliery. These traverses lie in dip-rise direction with station interval of 2.5 m. Coal seam is delineated having high resistivity values ranging more than 989 to 1632 ohm.m at depths varying 10 to 31 m from the surface.

Keywords: Multielectrode resistivity, Imaging technique, Coal seam

IPC Code: Int.Cl.^{7}: G 01 N 3/38

Introduction

Inundation is the main causative factor for coal mines disaster in India. Generally, it occurs due to puncturing of thinned coal barrier under water pressure which is not shown accurately on the plan. In most of the cases, one side of the barrier is old waterlogged unapproachable workings, whereas other side is current workings. The position of the coal barrier in the active mine (current workings) can be surveyed accurately whereas other side with unapproachable old waterlogged workings can not be surveyed physically. Therefore, it was felt necessary to locate the position of coal seam either from the surface or from the old waterlogged unapproachable side for the safe mining and to check disaster in coal mining areas.

Electrical resistivity methods have been widely used for shallow and deep investigations. Several researchers have proved the suitability and effectiveness of these methods by studying the response of diverse structures, such as faults[1-3], dykes[4-6], contact[7-9], in the laboratory and in the field. So far the problem of detecting coal seams has not yet been studied adequately, even though it has immediate application in coal mining. Verma and Bhuin[10] have carried out a study of this problem in Jharia Coalfield. They found that the coal seams are having high resistivity with respect to the surrounding formation and its values vary from few hundred ohm.m to a few thousand ohm.m. Their results suggest that this method can be applied to detect coal seams. However, there is a need for studying the applicability of resistivity methods under different geological conditions, because the natural and physical environment of coal seams vary considerably from area to area.

Multi-electrode resistivity system, which is advance version of the old four electrode resistivty system, is used here on experimental basis to know the efficacy of this system over the surface for the delineation of known coal seam in an incline mine of East Basuria colliery of Jharia Coalfield.

*Author for correspondence
Tel: +91-326-2203010/2203070/2203090,
Fax: +91-326-2202429,
e-mail: kkksingh@yahoo.com

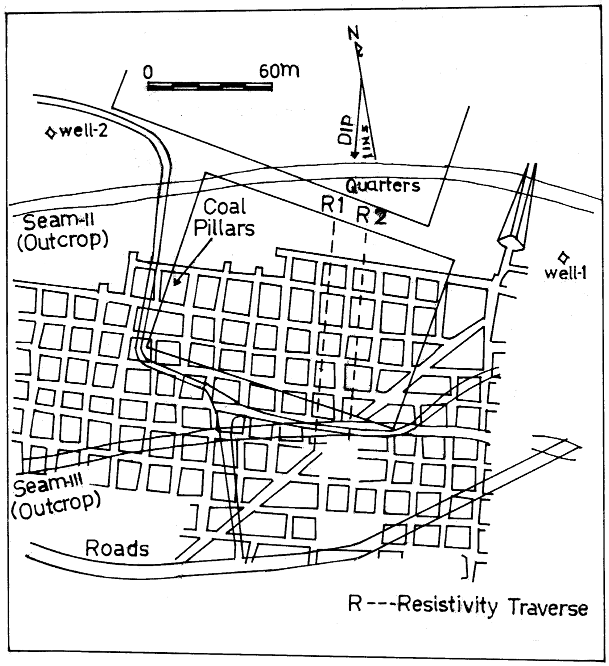

Fig. 1—Location map of resistivity traverses over workings of seam II at East Basuria colliery

Study Site

An incline coal mine of East Basuria colliery was selected for the delineation of known coal seam at known depth. This colliery is located about 11 km west of Dhanbad district of Jharkhand state. The area has an undulating topography with maximum and minimum elevation ranges between 188-219 m. However the natural features have been marred to a great extent due to mining activities resulting in subsidence and dumping of overburden in the area. Two traverses R1 and R2 were selected over developed workings of coal seam II, as shown in Fig. 1. These traverses lie in dip-rise direction with station interval of 2.5 m.

Geology of the Area

East Basuria colliery is located in the northern part of Jharia Coalfield of Dhanbad district. All the working coal seams lie in Barakar formation of Lower Gondwana. Barakar formation consists predominantly of sandstone of varying grain size, intercalation of shale and sandstone, grey and carbonaceous-shale and coal seams. The general strike of the formation is E-W and dip of the coal seam varies from 10-15^{o} towards south.

Methodology

The purpose of electrical surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface. The resistivity measurements are normally made by injecting current into the ground through two current electrodes, and measuring the resulting voltage difference at two potential electrodes. From these measurements the true resistivity of the subsurface can be estimated. The ground resistivity is related to various geological parameters such as the mineral and fluid content, porosity, degree of fracturing, the percentage of the fractures filled with ground water and degree of water saturation in the rock. Electrical resistivity surveys have been used for many decades in hydrological, mining and geotechnical investigations.

The improvement of resistivity methods, using multi-electrode arrays has led to an important development of electrical imaging for subsurface surveys. Resistivity multi-electrode imaging system (an advanced version of DC resistivity four elect-rodes) has been used in this experimental study. Such surveys are usually carried out using a large number of electrodes, i.e., 48 or more, connected to a multi-core cable. A laptop microcomputer together with an electrode-switching unit is used to automatically select the relevant four electrodes for each measurement. Apparent resistivity measurements are recorded sequentially sweeping any quadripole (current and potential electrodes) within the multi-electrode array. As a result, high-definition pseudosections with dense sampling of apparent resistivity variation at shallow depth are obtained in a short time. It allows the detailed interpretation of 2 D resistivity distribution in the ground. It is also being used for the delineation of underground in-homogeneities such as cavities[11,12], fractures[13] and caves[14] . A resistivity meter Syscal Junior Switch is used in the present study with 48 electrodes connected to the meter through a multi-core cable. Pole-dipole array of this system is used in this study.

Results and Discussion

The pole-dipole configuration inverted resistivity section along traverse R1, lying over solid coal pillars and level galleries (Fig. 1), is shown in Fig. 2. A high resistive zone of over 989 ohm.m shows an incline coal seam in black color, which is located at surface position from 30-80 m. The depth of coal seam at this surface position varies from 10-31 m. In this section, level galleries or voids are not delineated due to poor resolution although coal seam is developed i.e., there is alternet voids/galleries of size 2.5 m after 18 m solid coal pillar in the incline mine of the east Basuria colliery.

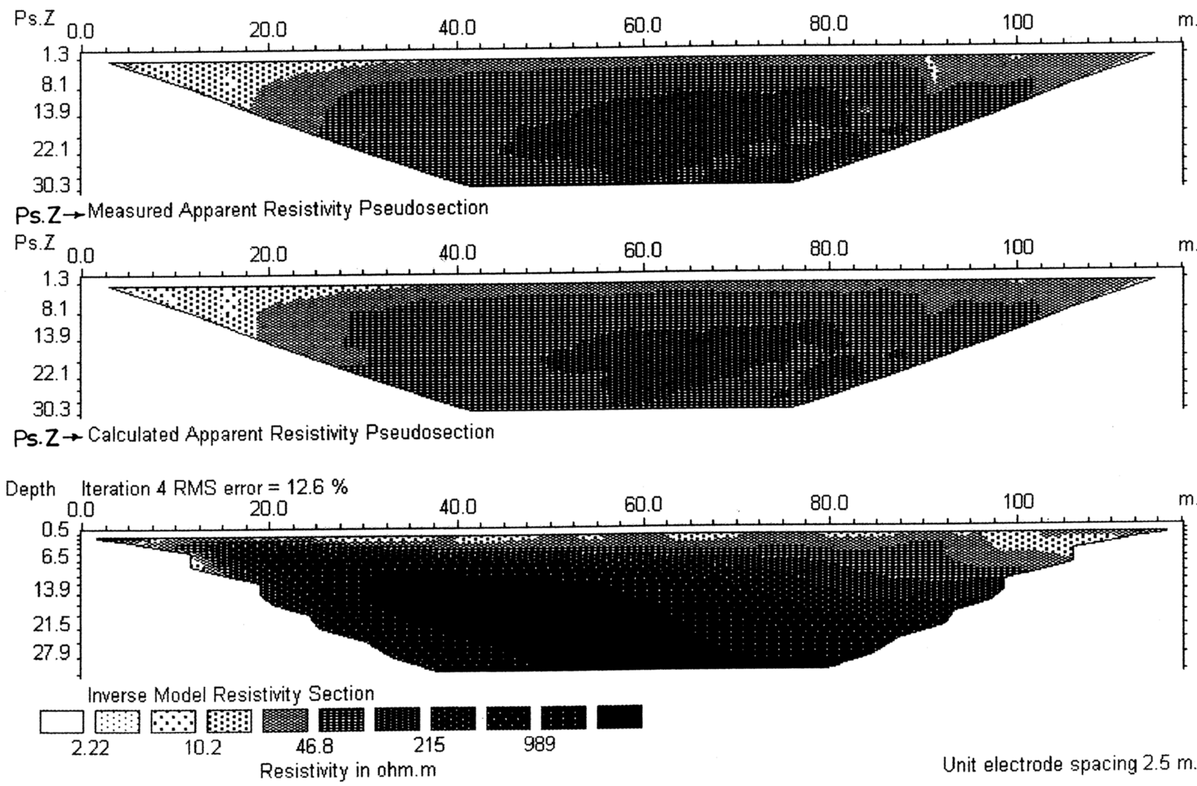

Fig. 2—Resistivity section using pole-dipole configuration along traverse R1 at East Basuria colliery

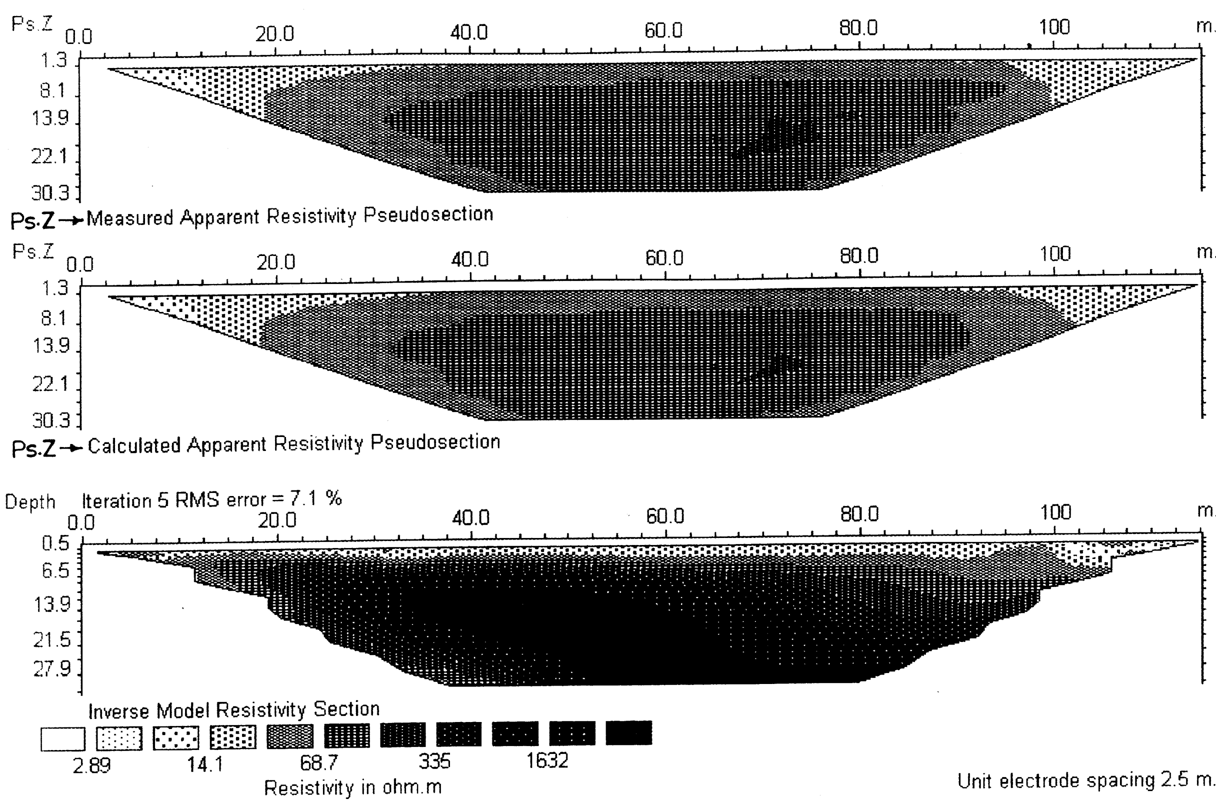

Fig. 3— Resistivity section using pole-dipole configuration along traverse R2 at East Basuria colliery

The pole-dipole configuration inverted resistivity section along traverse R2 lying along dip-rise direction over solid coal pillars and level galleries (Fig. 1) is shown in Fig. 3. It appears that a high resistive zone of over 1632 ohm.m (marked by black color) exists at surface positions 32.5–82.5 m at the depth of 10-31 m. This may be due to the presence of coal seam II. But, voids and coal pillars of lengths 2.5 and 18 m, respectively, are not distinguished in this section due to poor resolution of this method. However, both the traverses (R1 and R2) lie on the same seam II, but the resistivity value obtained along the traverse R2 is greater than the value along traverse R1, which is due to some air filled fractures present along the traverse R2 and air filled fractures have high resistivity values because of high resistivity value of air.

Conclusions

Resistivity imaging conducted at East Basuria colliery of Jharia leads to the following conclusions:

- Coal seam II has been delineated with this system, which depth varies from 10- 31 m and resistivity values vary from more than 989-1632 ohm.m.
- Size of coal pillars and voids could not be delineated very clearly using Resistivity Imaging surveys due to some constraints like resolution.

Acknowledgements

The authors are thankful to Director(Technical), Koyala Bhawan, Dhanbad for providing financial support to undertake this experimental study for the evaluation of barrier thickness at the East Basuria colliery of Kusunda Area. Thanks are also due to Mr R N Singh, Mr S N Rajak and Mr B Pashwan of Central Mining Research Institute, Dhanbad for their kind co-operation during field investigations.

References

1 Long O, Mapping nearly vertical discontinuities by earth resistivity, *Geophysics* (*USA*), **19**(1954) 739-760.

2 Bhattacharaya P K & Patra H P, *Direct current geoelectrical soundings* (Elsevier, Amsterdam)1968, pp 70-91.

3 Apparao A & Roy A, Resistivity model experiments, *Geoexploration*, **7**(1971) 45-54.

4 Zohdy A A R, The use of schlumberger and equatorial soundings in ground water investigations near EI Paso, Texas, *Geophysics* (*USA*), **34**(1969) 713-728.

5 Kumar R, Resistivity type curves over outcropping vertical dyke-I, *Geophys Prospect*, **21**(1973a) 560-578.

6 Kumar R, Resistivity type curves over outcropping vertical dyke-II, *Geophys Prospect*, **21**(1973b) 615-625.

7 Stanley W D, Jackson D B & Zohdy A A R, Deep electrical investigations in the valley geothermal area, California, *J Geophys Res*, **81**(1976) 810-820.

8 Patella D, Resistivity sounding on a multi-layered earth with transitional layers. Part I: Theory, *Geophys Prospect*, **25**(1977) 699-729.

9 Patella D, Resistivity sounding on a multi-layered earth with transitional layers, Part-II: Theoretical and field examples, *Geophys Prospect*, **26**(1978) 130-156.

10 Verma R K & Bhuin N C, Use of electrical resistivity methods for study of coal seam in parts of Jharia Coalfield, India, *Geoexploration*, **17**(1979)163-176.

11 Smith D, Application of the pole-dipole resistivity technique to the detection of solution cavities beneath highways, *Geophysics* (*USA*), **51**(1986) 833-837.

12 Panno S, Wiebel C, Heigold P & Reed P, Formation of regolith-collapse sinkholes in Southern Illinois: interpretation and identification of associated buried cavities, *Environ Geol*, **23**(1994) 214-220.

13 Batayneh A, Haddadin G & Toubasi U, Using the head-on resistivity method for shallow rock fracture investigations, Ajlum, Jordan, *J Environ Eng Geophys*, **4** (1999) 179-184.

14 Batayneh A & Al-Zoubi A, Detection of a solution cavity adjacent to a highway in southwest Jorden using electrical resitivity methods, *J Environ Eng Geophys*, **5** (2000) 25-30.