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Werner Method for Buried Spherical Sources Depth Determination from Residual SP Data

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***Abstract*—Self-potential method is an electrical method that involves measurements of naturally occurring potentials, commonly associated with the weathering of sulfides ore bodies. Werner Deconvolution method developed primarily for magnetic and gravity data have been adapted to electrical SP data. Validity of this method is tested by applying synthetic data with and without random noise. This method has also been applied to field Self potential data collected from India. Moreover, the depth obtained by the proposed approach is found to be in a very good agreement with the depth obtained from drilling information.**

***Keywords*— Self-potential Data, Synthetic Data, Field Data, Werner Deconvolution, Simple Shape Anomaly, India**

I. Introduction

Self-potential (SP) is called also spontaneous polarization and is a naturally occurring potential difference between points in the ground. SP depends on small potentials or voltages being naturally produced by some massive ores. It associates with sulphide and some other types of ores. It works strongly on pyrite, pyrrohotite, chalcopyrite, graphite. SP is the cheapest of geophysical methods. The self-potential associated with an ore body is called its "mineralization potential." Self-potential (SP) anomalies across ore bodies are invariably negative, amounting usually to a few hundred mill volts. We applied the Werner method described by Werner, 1953. Werner method developed primarily for gravity and magnetic data have been adapted to electrical SP data. The validity of the method is tested on synthetic data with and without noise and a field data from India. Field studies indicate that for a self-potential anomaly to occur its causative body must lie partially in a zone of oxidation. A widely-accepted mechanism of self-potential1 requires the causative body to straddle the water table (figure 1). Below the water table electrolytes in the pore fluids undergo oxidation and release electrons which are conducted upwards through the ore body. At the top of the body the released electrons cause reduction of the electrolytes. A circuit thus exists in which current is carried electrolytically in the pore fluids and electronically in the body so that the top of the body acts as a negative terminal. This explains the negative SP anomalies that are invariably observed and, also, their stability as the ore body it undergoes no chemical reactions and merely serves to transport electrons from depth. As a result of the subsurface currents, potential differences are produced at the surface.

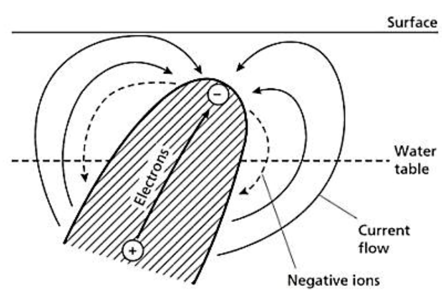

Fig1: The mechanism of self-potential anomalies (Kearey and brooks, 2002)

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II. WERNER DECONVOLUTION

The self-potential anomaly expression produced by some simple polarized geologic structures can be represented by the following approximate continuous function1:

$$V = M\left[\frac{x_i \cos\theta + Z \sin\theta}{(x_i{}^2 + h^2)^q}\right] \quad i = 1, 2, 3, \ldots N \qquad (1)$$

Where h is the depth to the centre of the body, x_i is a discrete point at which the anomaly is located, θ is the polarization angle, M is the electric dipole moment, and q is the shape factor whose value is 1.5 for sphere (figure 2).

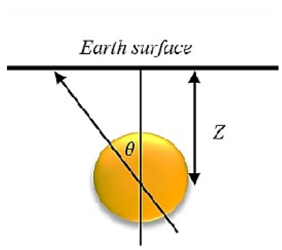

Fig2: A sphere model buried at depth Z with polarization angle θ

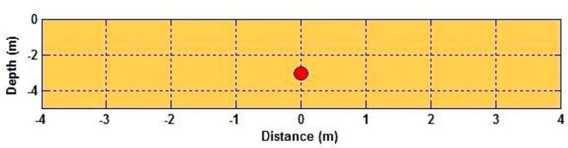

Fig3: Solution from the Werner method is marked as red circle (synthetic spherical model)

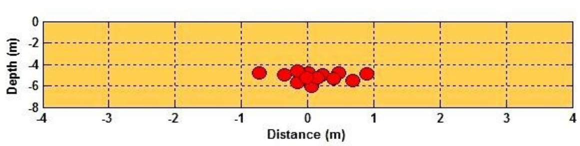

Fig4: Solution from the Werner method is marked as red circles (Synthetic spherical model with Noise random)

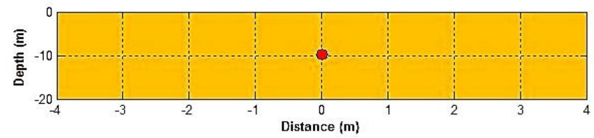

Fig5: Solution from the Wernermethod is marked as red circle (Synthetic spherical model)

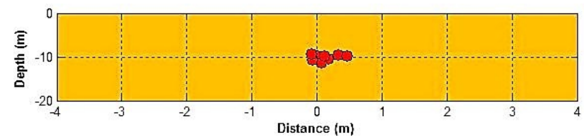

Fig6: Solution from the Wernermethod is marked as red circles (Synthetic spherical model with Noise random)

The Werner deconvolution (Werner, 1953) technique is very useful and simple for preliminary interpretation of potential field data for isolated bodies. This technique is based on the assumption that the source is vertical thin dike, but it can be applied for other type of bodies. Werner deconvolution is a 'sliding window' technique. We move the operator along the profile and continually solve for the unknowns.

III. EXPERIMENTAL AND REAL DATA

We compute a theoretical SP anomaly of a sphere (q = 1.5, Z = 5 and 10 unit, K = -100 mV, and θ=40°) at 10 points with spacing of 1 m (figure 2). The method correctly locates sphere very accurately, as can be seen (figure 3 and figure 5). Next, random errors of 5% were added to the SP anomaly to simulate noisy data. The results are shown in figure 4 and figure 6.

As a test case, we apply Werner method to analyses the SP data acquired from Hyderabad area, India. SP anomaly measured over a graphite ore is shown in figure 7. Map of upward continuation is presented in figure 8. The results showed that a buried spherical model located at a depth of 20.35 m probably approximates the source of this anomaly (figure 9). Results and corresponding RMS errors $(RMS =$

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$\sqrt{\frac{\sum_{i=N}^{N}[Y(x_i)-V(x_i,z,q)^2]}{2N+1}}$); Y = observed anomaly and V = calculated anomaly) is shown in table 1.

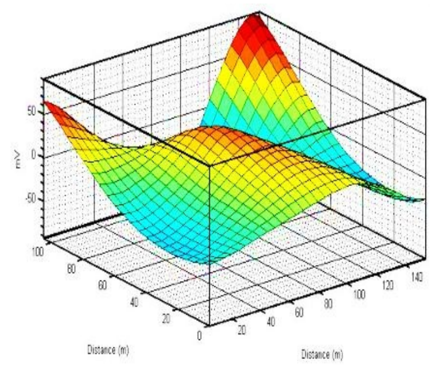

Fig7: 3-D Map of SP anomaly over a graphite ore

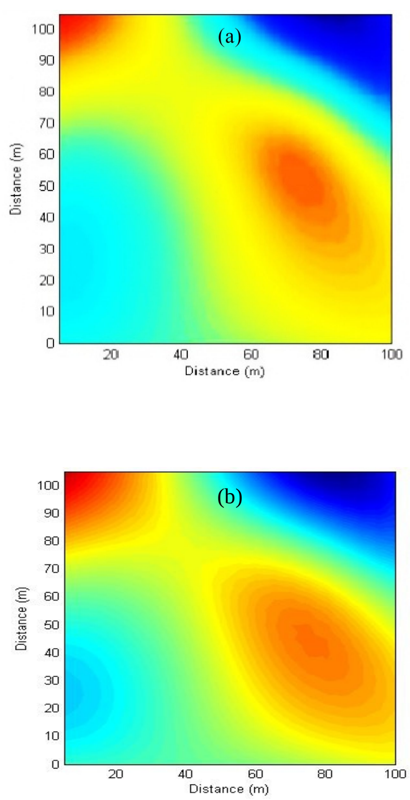

Fig8:2-D Map of upward continuation: (a): 10 m and (b): 20 m

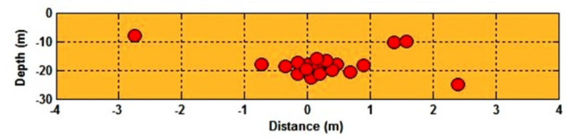

Fig9:Solution from the Wernermethod is marked as red circles

Table 1: Results and Corresponding RMS Errors

Depth (m)	RMS
19.56	8.2365
19.36	8.2536
19.38	8.2365
20.35	**7.3589**
23.36	8.3658
21.36	8.3698
22.33	8.3659
22.35	9.3760
22.56	9.5636

IV. CONCLUSIONS

A fast and precise method, based on the Werner method has been introduced for the interpretation of SP data profiles. The method uses the sphere model. Its sensitivity to random noise and to interference was tested on synthetic data. The method was also applied to SP data from India.

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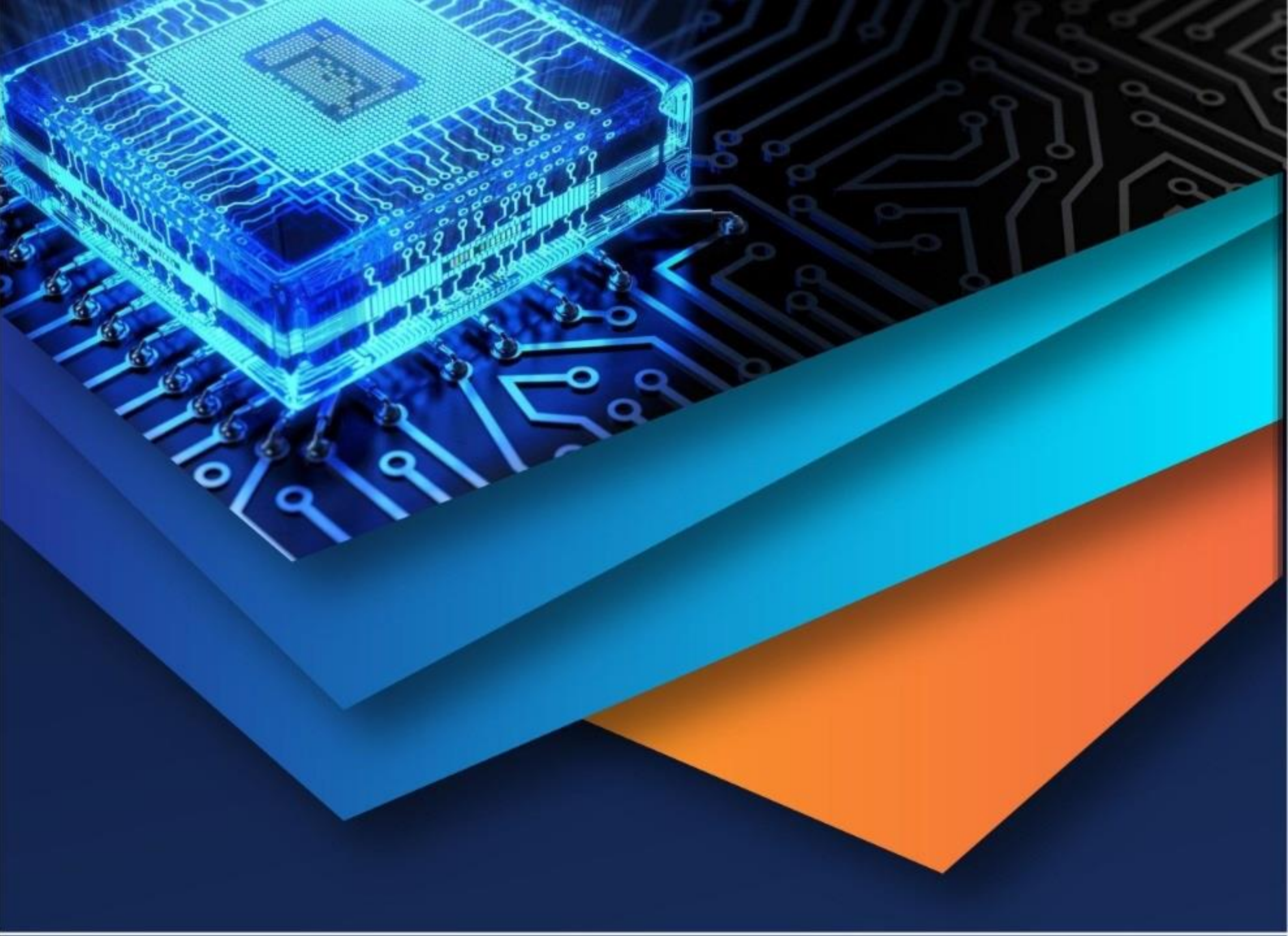

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