SHORT NOTE
COMMENTS ON SOME EMPIRICAL RESISTIVITY INTERPRETATION METHODS

*by S. A. Greenhalgh**

Attention is directed in this note towards certain empirical methods of resistivity sounding interpretation which have gained acceptance in many engineering applications, especially in the United States.

The methods in question, the Barnes Layer Method (Barnes, 1952) and the Moore Cumulative Method (Moore, 1945) are entirely without theoretical support. They have been criticised by Muskat (1945) and Mooney (1954), who showed that the interpretations reduce to a Gish-Rooney technique (Gish and Rooney, 1925), because depths are equated to electrode spacings. In Moore's method, though, there is possibly some advantage through smoothing, since the cumulative curve serves to minimise the effect of purely local surface anomalies and errors of measurement. The work of Muskat and Evinger (1941) has shown that there is no simple relationship between depth and electrode spacing, but depends on the resistivity contrast. Depth determinations by these empirical methods are therefore considered erroneous. However, in a surprisingly large number of field tests, the Barnes Layer Method and the Moore Cumulative Method have been reported to have given reasonably satisfactory results (Ruedy, 1945; Happ, 1946; Shepard, 1949; Moore, 1952, 1957, 1961; Barnes, 1954; Malott, 1966 and others) and their continued use has been partly justified on the basis that resistivity interpretation must be considered pragmatically. More commonly, though, failure to reject such methods is because oversimplified theory and empirical analyses are purveyed in sales brochures and the like and then used by those not specialised in resistivity interpretation. To evaluate the two methods, over one hundred, two and three layer, theoretical resistivity curves covering a fairly wide range of conditions were used as accurate known solutions against which to test the validity and range applicability of the Barnes Layer and Moore Cumulative Methods. The theoretical curves (Orellana & Mooney, 1966, 1972) were computer reduced and interpreted by both methods and then compared with the model from which the resistivity values were calculated. The following brief summary of conclusions reached will be discussed in detail in a forthcoming paper.

BARNES LAYER METHOD

1. The Barnes Layer Method yields the correct configuration of increasing/decreasing layer resistivities for 2-layer cases and 3-layer A type and Q type cases. However, for 3-layer H type and K type cases, the interpreted second layer resistivity largely fails to attain the true minimum or maximum value respectively. In some cases, where the theoretical intermediate layer is thinner than the first layer, it is missed altogether in the interpretation, and only a two-layer situation is inferred.
2. Errors in calculated depths are generally much greater than 70%.
3. Errors in computed layer resistivities at electrode spacings corresponding to the true depths in each model, vary from 50% to 350%.

MOORE CUMULATIVE METHOD

1. The Moore Cumulative Method only gives the correct trend of relative resistivity values for 2-layer cases and A type and Q type 3-layer cases. H type cases are falsely interpreted as Q type cases, or occasionally as A type cases. K type cases are normally misinterpreted as A type cases, or sometimes as Q type cases.
2. If the depth in question is known, it is always easy to find two tangents to the cumulative curve which will intersect to be a correct solution, with an accuracy of 10% or less. However, most cumulative curves exhibit gentle curvature rather than taking the form of a straight line, so, in actual field tests where depths are unknown, the method must be used with caution.
3. In nearly all cases, there exists more tangent intersection points than theoretical model discontinuities. There is no way of differentiating true discontinuities from those which are fictitious and the problem arises of trying to assign geological significance to only some of the intersection points.

Because of excessive errors in the interpreted resistivity configuration and in the actually determined depths and layer resistivity values, it is concluded that the use of these methods could result in highly misleading assessments of site conditions.

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REFERENCES:
Barnes, H., 1952. Soil investigations employing a new method of layer value determination for earth resistivity interpretation. Bull. 65, **Highway Research Board,** pp. 20-36.
Barnes, H., 1954. Electrical subsurface exploration simplified. **Roads and Streets,** May, pp. 8185.
Gish, O., and Rooney, W., 1925. Measurement of resistivity of large masses of undisturbed earth. **Terrestrial Magnetism & Atmospheric Electricity,** Vol. 30, pp. 161-188.
Happ, S., 1946. Electrical resistivity investigations of levee foundations near Kansas City. Bulletin, **Geol. Soc. Am.,** Vol. 57, p. 1200.
Malott, D. F., 1965. Application of geophysics to highway engineering in Michigan. **Highway Research Board,** Rec. 81, pp. 20-41.
Mooney, H. M., 1954. Depth determination by electrical resistivity. **Min. Eng.,** Vol. 6, pp. 915-918.
Moore, R. W., 1945. An empirical method of interpretation of earth resistivity measurements. **Public Roads,** Vol. 24, No. 3, pp. 75-82.
Moore, R. W., 1961. Geophysics efficient in exploring subsurface. Journal of Soil Mechanics Division, **Proc. Amer. Soc. Civil Engrs.,** Vol. 87, No. SM3, pp. 69-98.
Muskat, M., 1945. The interpretation of earth resistivity measurements. **Trans. Am. Inst. Min. & Metall. Engrs.,** Vol. 169, pp. 224-231.
Muskat, M., and Evinger, H. H., 1941. Current penetration in D.C. prospecting. **Geophysics,** Vol. 6, pp. 297-427.
Orellana, E. and Mooney, H. M., 1966. Master tables and curves for vertical electrical sounding over layered structures. Interciencia, Madrid, Spain. 159 pp.
Orellana, E. and Mooney, H. M., 1972. Two and three layer master curves and auxiliary point diagrams for vertical electrical sounding using Wenner arrangement. Interciencia, Madrid, Spain. 43 pp.
Ruedy, R., 1945. The use of cumulative resistance in earth resistivity surveys. **Can. Jnl. Res.** 23A, pp. 57-72.
Shepard, E. R., 1949. Subsurface exploration by geophysical methods. **Proc. Amer. Soc. Testing Materials,** Vol. 49, pp. 993-1009.