The Use of multiple-gradient array for near-surface electrical resistivity tomography

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Abstract

The use of most conventional (e.g. Wenner, Schlumberger, dipole-dipole, pole-dipole and pole-pole) arrays in practical near-surface electrical resistivity tomography (ERT) surveys is time consuming and labour intensive. Thus, data acquisition teams are often tempted to compromise the data density so as to speed up field operation and reduce survey cost. But this can significantly degrade the quality and resolution of the resulting inverse models. Non-conventional arrays (Stummer et al., 2004) may be used to conduct fast and cost effective ERT without necessarily compromising the data density. Multiple-gradient array, proposed by Dahlin and Zhou (2002; 2004; 2006), is one of such non-conventional arrays. In this array, the injecting current electrodes are separated by $(s+2)a$, where a is the minimum electrode spacing and s is the maximum number of potential measurements for a given current injection. The potential differences between the potential electrodes are measured sequentially with spacing a. This presentation evaluates the practical applicability of multiple-gradient array for conducting rapid and cost effective ERT survey in a study site located in Covenant University, Ota, southwestern Nigeria. 2D ERT survey was conducted along two traverses with an ABEM Terrameter (SAS 1000/4000 series) using multiple-gradient and Wenner arrays. Traverse 1 was conducted along north – south direction with a profile length of 450.0 m, while Traverse 2 was in the west – east direction with a profile length of 500.0 m. The same basic survey parameters (profile length, minimum electrode spacing a and data level) were used for each traverse and for both arrays. Also, four Schlumberger soundings were conducted along each of the traverses with maximum half-current electrode spread (AB/2) ranging from 180.0 m to 240.0 m. The observed apparent resistivity data were inverted with the aid of RES2DINV inversion code (Loke and Barker, 1996) which uses a nonlinear optimization technique that allows the 2D model resistivity distribution to be determined from the measured apparent resistivity.

Although both smoothness constrained least-squares and robust inversion techniques were used to invert the data sets, only the smoothness constrained inverse model for Traverse 1 is presented here (Fig. 1). The subsurface features in the resistivity images for both arrays are very much similar but with slight variations due to differences in the geometry of the arrays. The resolution and quality of the inverse models for the array are comparable to those for Wenner array. The image resolution and the target definition of the inverse models for the multiple-gradient array provide more detail of the subsurface features than those of Wenner array and the geoelectric parameters of the resistivity soundings. Furthermore, the effective depth of penetration observed for multiple-gradient array is much greater than that of Wenner array. The geoelectric layered parameters delineated from the soundings present an approximate picture of the subsurface electrical resistivity distribution. The practical applicability of using multiple-gradient array for rapid 2D ERT is demonstrated. Multiple-gradient array is fast, cost effective and suitable array for conducting ERT surveys. The array has the advantage of measurement logistics and improved image resolution over Wenner array. Multiple-gradient array is well suited multi-electrode surveys and is particularly easy to use for manual data acquisition since only the measuring potential electrodes are moved during data measurements.

Keywords: Electrical Resistivity Tomography; Non-conventional arrays; Multiple-gradient array; Near-surface characterization.

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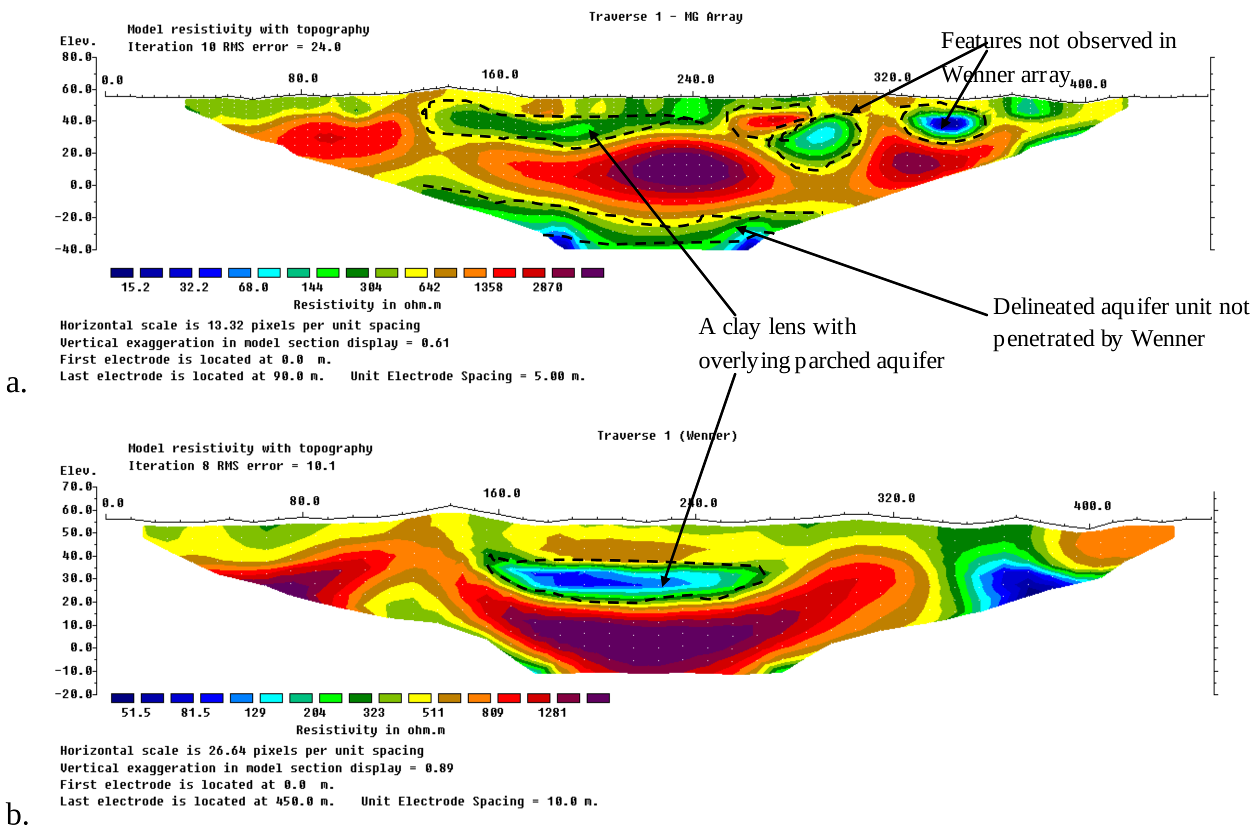

Figure 1: Inverse model resistivity of Traverse 1 for: (a) Multiple-gradient array, and (b) Wenner array. The aquifer unit delineated agrees with Schlumberger soundings results.