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A numerical comparison of 2D resistivity imaging with 10 electrode arrays

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ABSTRACT

Numerical simulations are used to compare the resolution and efficiency of 2D resistivity imaging surveys for 10 electrode arrays. The arrays analysed include pole-pole (PP), pole-dipole (PD), half-Wenner (HW), Wenner-α (WN), Schlumberger (SC), dipole-dipole (DD), Wenner-β (WB), γ-array (GM), multiple or moving gradient array (GD) and midpoint-potential-referred measurement (MPR) arrays. Five synthetic geological models, simulating a buried channel, a narrow conductive dike, a narrow resistive dike, dipping blocks and covered waste ponds, were used to examine the surveying efficiency (anomaly effects, signal-to-noise ratios) and the imaging capabilities of these arrays. The responses to variations in the data density and noise sensitivities of these electrode configurations were also investigated using robust (L_1-norm) inversion and smoothness-constrained least-squares (L_2-norm) inversion for the five synthetic models.

The results show the following. (i) GM and WN are less contaminated by noise than the other electrode arrays. (ii) The relative anomaly effects for the different arrays vary with the geological models. However, the relatively high anomaly effects of PP, GM and WB surveys do not always give a high-resolution image. PD, DD and GD can yield better resolution images than GM, PP, WN and WB, although they are more susceptible to noise contamination. SC is also a strong candidate but is expected to give more edge effects. (iii) The imaging quality of these arrays is relatively robust with respect to reductions in the data density of a multi-electrode layout within the tested ranges. (iv) The robust inversion generally gives better imaging results than the L_2-norm inversion, especially with noisy data, except for the dipping block structure presented here. (v) GD and MPR are well suited to multichannel surveying and GD may produce images that are comparable to those obtained with DD and PD. Accordingly, the GD, PD, DD and SC arrays are strongly recommended for 2D resistivity imaging, where the final choice will be determined by the expected geology, the purpose of the survey and logistical considerations.

INTRODUCTION

DC electrical resistivity surveying is a popular geophysical exploration technique because of its simple physical principle and efficient data acquisition. Traditional resistivity measurements are carried out on the earth's surface with a specified array in order to obtain apparent-resistivity sounding curves, apparent-resistivity profiling data or apparent-resistivity pseudosections, all of which qualitatively reflect the vertical or horizontal variations in subsurface resistivity. This technique is widely used in groundwater, civil engineering and

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