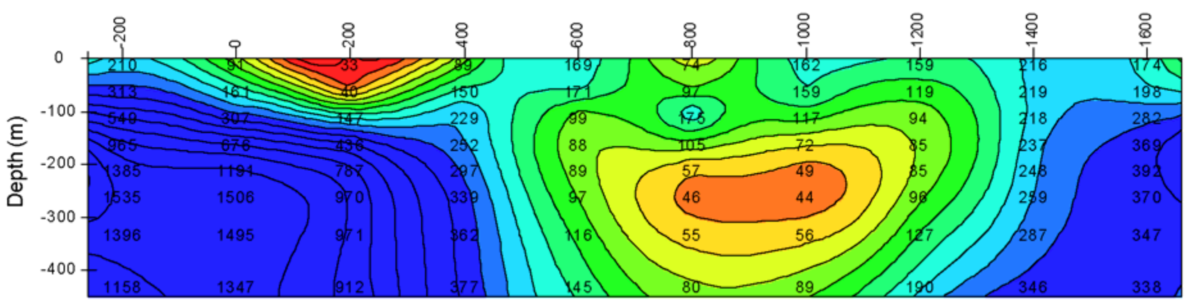
Wadi Almarsad Project
Line 10

Comparison of Dipole-Dipole IP/ Resistivity and CSAMT Results

Two-Dimensional Smooth-Model Inversion Results
200 meter Dipole-Dipole Resistivity (ohm-m)



This project highlights two important points: 1) the very good agreement of results between IP and CSAMT survey methods, and 2) the excellent comparison between the inversion models from the two survey methods. Both data sets were acquired by the same field crew, using the same GDP-16 receiver and GGT-10 transmitter equipment.

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Introduction

Dipole-dipole IP/ resistivity and Controlled Source Audio-magnetotellurics (CSAMT) are two very different electrical methods. One is a galvanic method, while the other is a far-field electromagnetic technique. Both methods provide apparent resistivity information, but each has distinct advantages: dipole- dipole IP/ resistivity provides both resistivity and induced polarization information, while CSAMT provides better lateral resolution, greater depth of investigation and is logistically more efficient.

The two methods are often used in a complimentary fashion on projects, but in the past, correlation of the two resulting data sets has occasionally been confusing because of the difficulty in interpreting geometric effects in the dipole- dipole data. Two-dimensional smooth-modeling of dipole-dipole data now provides a much more realistic presentation of the data, and allows a more direct comparison of the results when used in conjunction with CSAMT.

The following example shows the dipole-dipole data and the CSAMT data that were acquired along the same line during a training session at Wadi Almarsad in the Kingdom of Jordan. The line is on relatively flat ground, crossing a narrow valley. The alluvial fill material is of an unknown depth, but expected to be less than 200 meters, except in the center of the valley.

It is important to note that both data sets were acquired using the same GDP-16 receiver and GGT-10 transmitter. The dipole-dipole data were acquired one day, and the CSAMT were acquired the following day. In order to change to CSAMT operation, a magnetic field antenna was necessary.

Dipole-Dipole Data

The dipole-dipole data were collected using 200 meter dipoles, in order to obtain a depth of investigation of approximately 400 meters. A larger depth would require larger dipoles, resulting in a loss of resolution; in order to obtain better lateral resolution, smaller dipoles (both transmitter and receiver) would be necessary, resulting in shallower depths. The data were gathered in frequency domain, at 0.125 Hz, using a standard seven-electrode transmitter array.

Figure 1 shows the results of the dipole-dipole survey. Figure 1a shows the apparent resistivity data in standard pseudosection format, Figure 1b shows the calculated 2-D inversion results in pseudosection form (for comparison to 1a, the observed data), and Figure 1c shows the smooth-model inversion results in cross-section form with stations across the top and depth in meters down the side.

Figure 1a

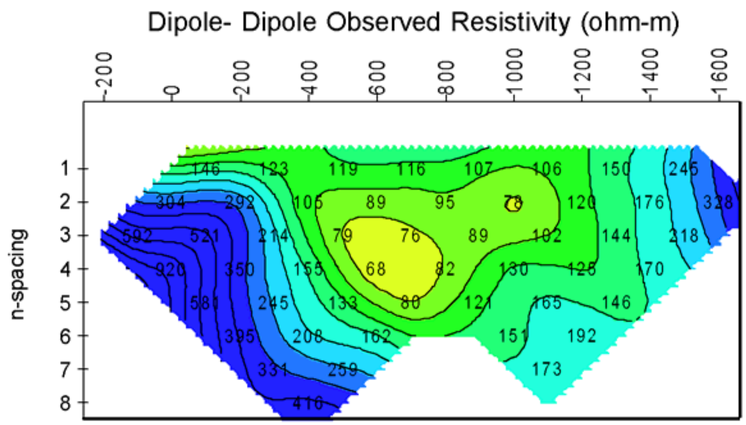
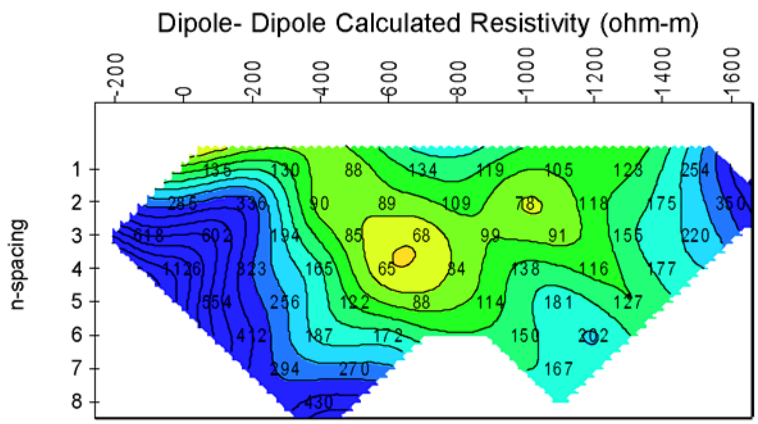


Figure 1b



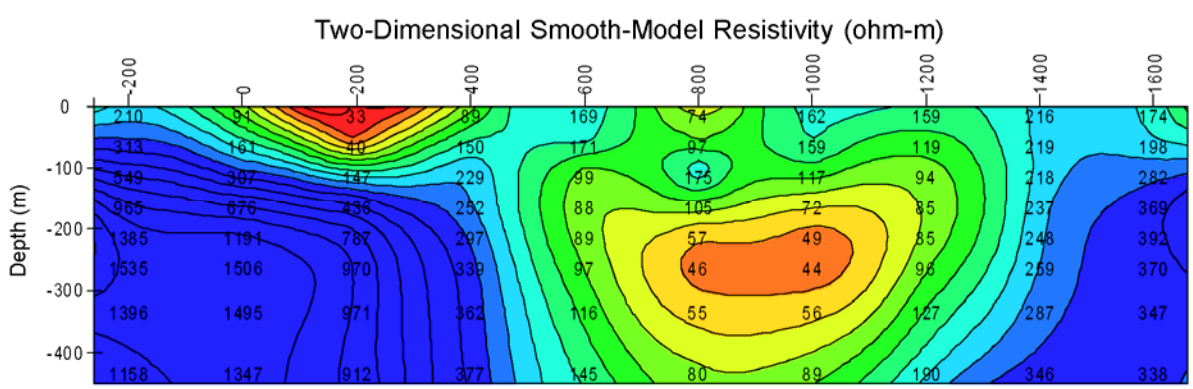


Figure 1c

Figure 2a

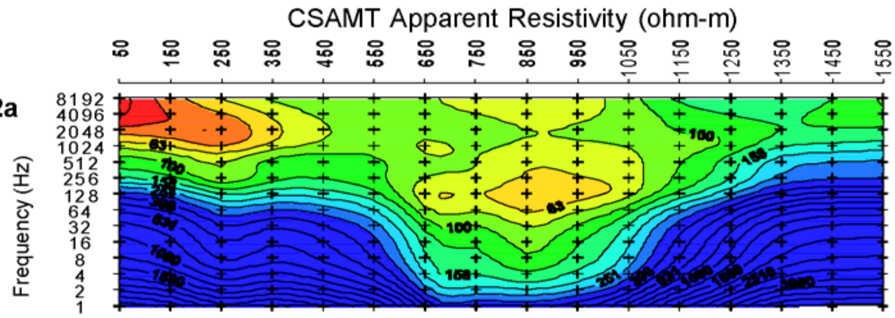


Figure 2b

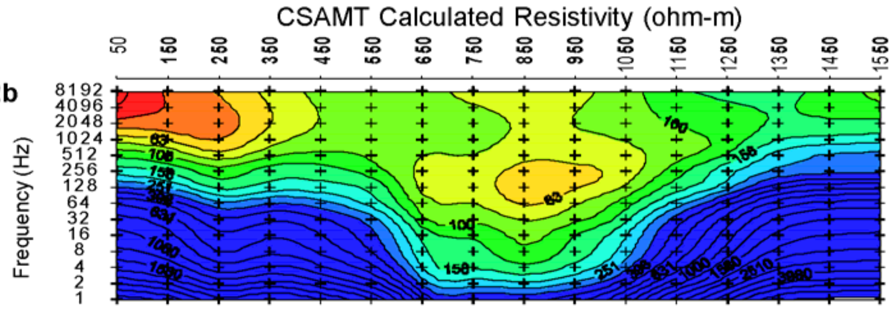
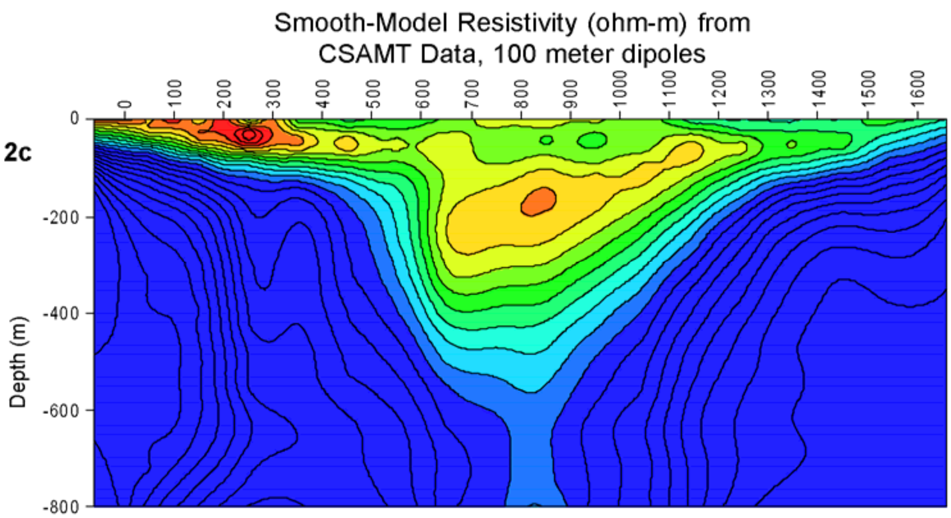


Figure 2c



CSAMT DATA

The CSAMT data were collected using 100 meter electric-field dipoles in scalar mode, with one magnetic field measurement for every four electric-field dipoles. The frequencies acquired were 1 Hz through 8192 Hz, and the transmitter was approximately 6 km from the receiver line. In order to obtain deeper information, it would only be necessary to read lower frequencies, with no changes required in the receiver dipole or transmitting dipole or distance (assuming all far-field data). To obtain better lateral resolution, the receiver dipole size need only be reduced, without making any changes to the transmitter size or location.

Figure 2 shows the results of the CSAMT survey. Figure 2a shows the apparent resistivity data, plotted in standard pseudosection form. Figure 2b shows the calculated 1-D inversion results in pseudosection form (for comparison to 2a, the observed data), and Figure 2c shows the smooth-model inversion results in cross-section form with stations across the top and depth in meters down the side.

Comparison of Results

Examination of the apparent resistivity pseudosections (Figure 1a and 2a) show only a general agreement in overall resistivity values and structure. The CSAMT data clearly have better resolution, both vertically and horizontally, and are easier to interpret. A small, shallow conductor is evident in the CSAMT data in the vicinity of station 200, but is not present in the dipole-dipole data, and the difference in the slope of bedrock on each side of the valley is much clearer in the CSAMT data.

After smooth-model inversion, however, the two data sets look very similar (Figures 3a and 3b). Both methods indicate the bedrock on the west slopes more steeply than on the east, and both now indicate a shallow conductor near station 200. Even a weak, surface low at station 800 is seen in both data sets. The CSAMT data still provide better resolution, but the correlation between the two data sets is very good.

Each method has distinct advantages. The CSAMT method provides better resolution and is normally much more efficient in the field. CSAMT results provide much deeper information, without the time and effort to change dipole sizes or location.

On the other hand, the dipole-dipole method provides induced polarization information, shown in Figure 3c. The IP data indicate that the shallow conductor at station 200 is not polarizable, and thus would not be considered an attractive target if the goal of the survey was to locate sulfide mineralization. Note also that the IP data show that at depth the west side of the valley has a higher IP response than in the east, suggesting a difference in bedrock material.

In one typical exploration scenario, CSAMT would be used to map resistivity structures in this valley, determining depth to bedrock, locating faults and resistivity anomalies (such as at station 200). Using the same equipment, dipole-dipole IP (which is slower and thus more expensive) would then be used only in specific areas to add IP information to the data set. The dipole sizes for the IP survey can be determined in advance, eliminating expensive testing, since depth of specific targets would already be known from the CSAMT results.

Figure 3a

Two-Dimensional Smooth-Model Inversion Results
200 meter Dipole-Dipole IP (ohm-m)

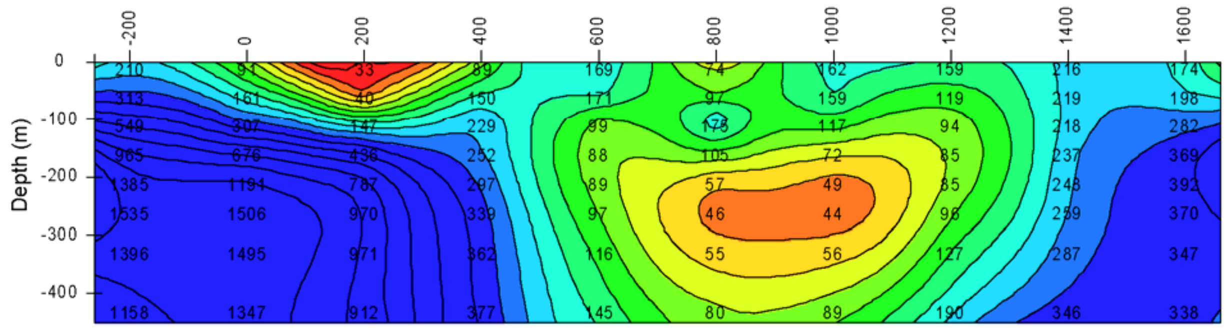


Figure 3b

Smooth-Model Resistivity (ohm-m) from
CSAMT Data, 100 meter dipoles

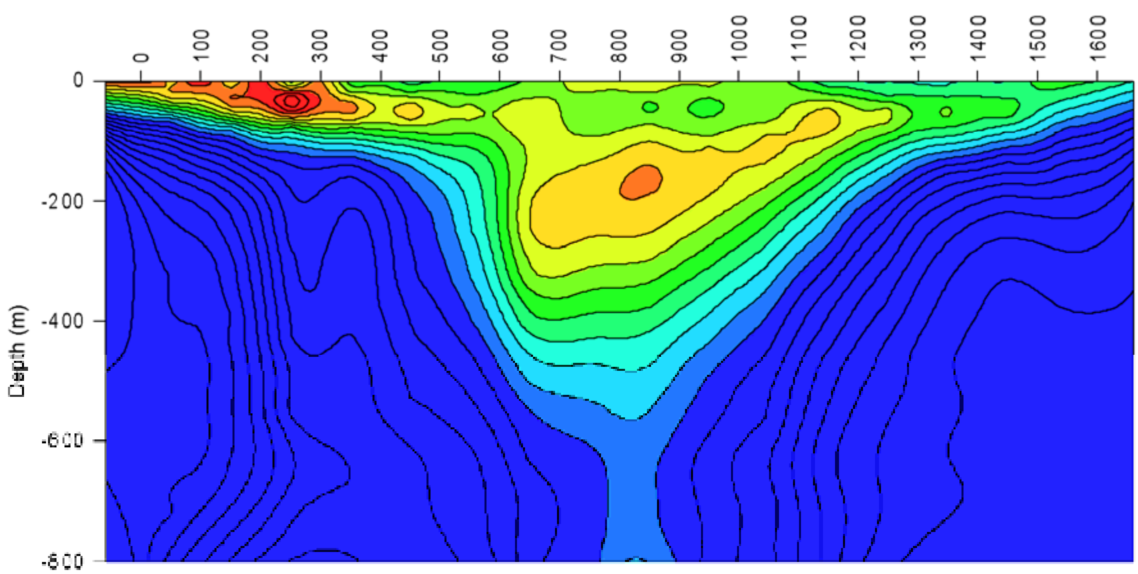


Figure 3c

Two-Dimensional Smooth-Model Inversion Results
200 meter Dipole-Dipole IP (milliradians)