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Preliminary numerical modeling results - cone penetrometer (CPT) tip used as an electrode

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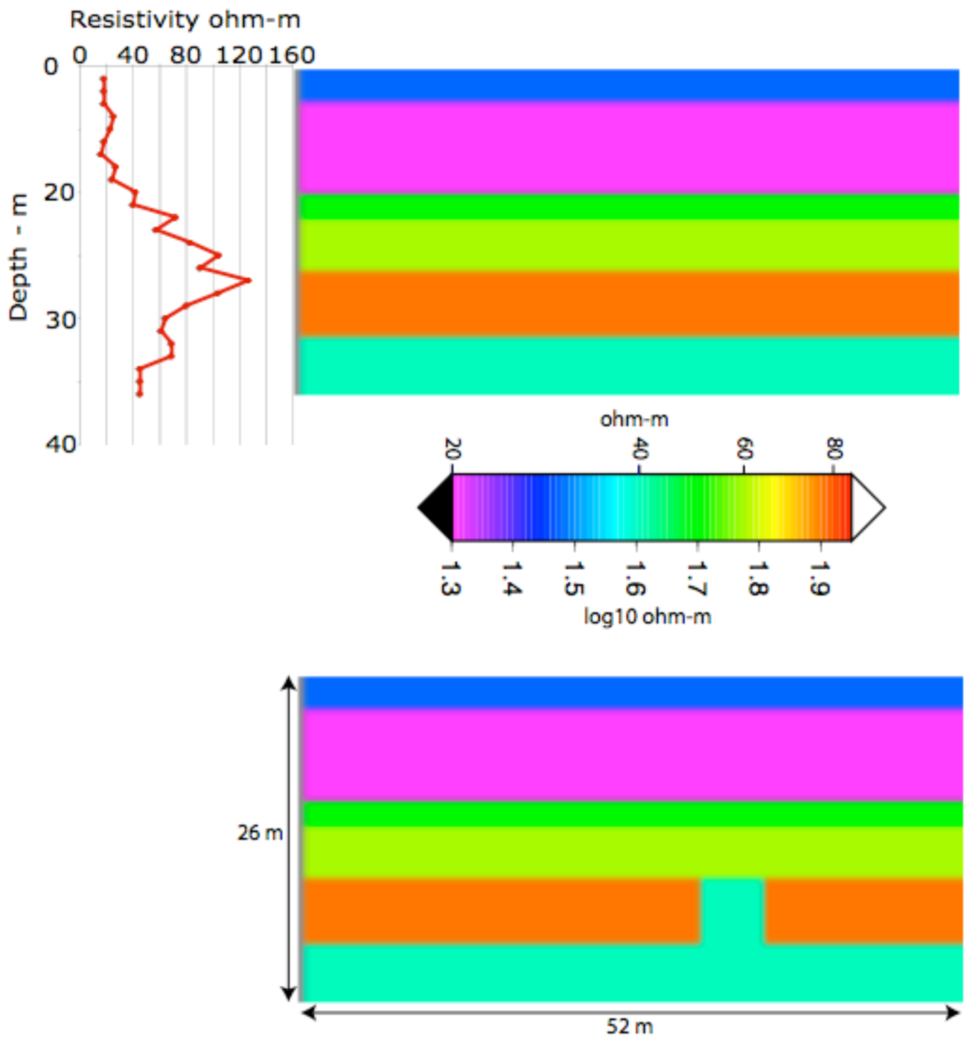

Figure 1 shows the resistivity models considered in this study; log10 of the resistivity is shown. The graph on the upper left hand side shows a hypothetical resisitivity well log measured along a well in the upper layered model; 10% Gaussian noise has been added to the well log data. The lower model is identical to the upper one except for one square area located within the second deepest layer.

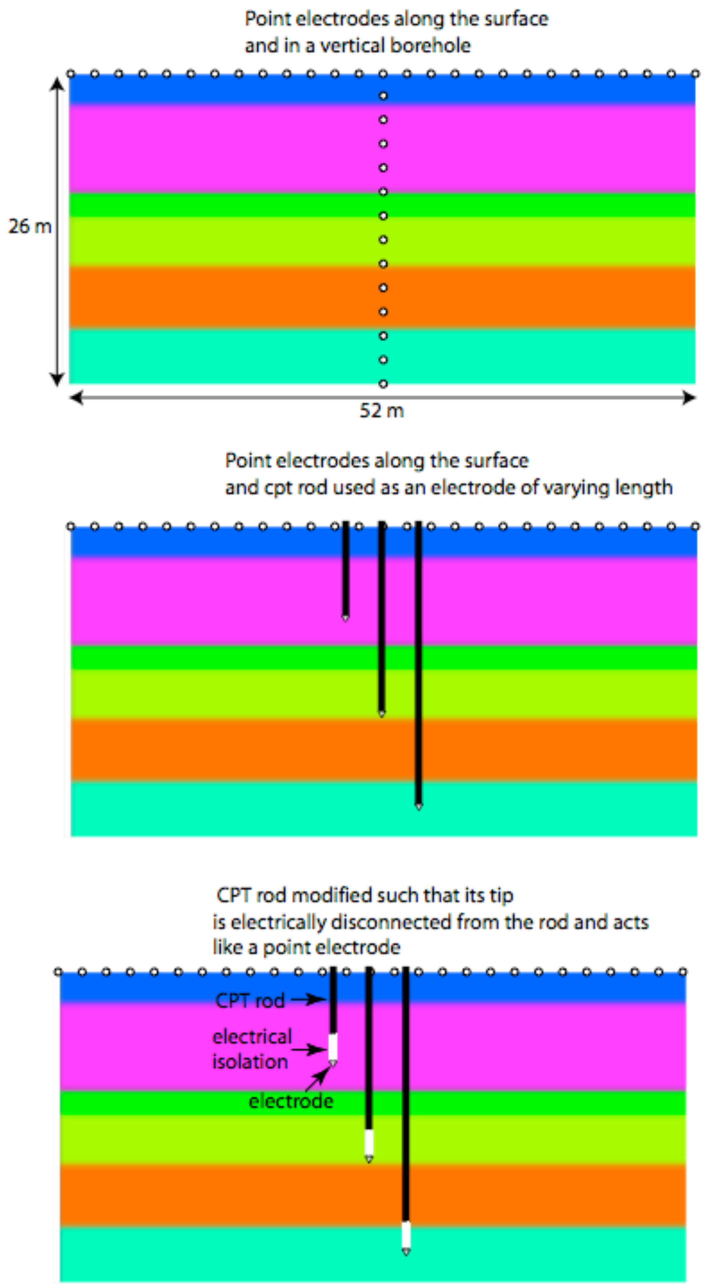

Figure 2 shows the electrode configurations considered. The "reference" case (upper frame) considers point electrodes located along the surface and along a vertical borehole. The "CPT electrode" case (middle frame) assumes that the CPT tip serves as an electrode that is electrically connected to the push rod; the surface electrodes are used in conjuction with the moving CPT electrode. The "isolated CPT electrode" case assumes that the electrode at the CPT tip is electrically isolated from the pushrod. Note that the separate CPT push rods in the middle and lower frames are shown separated to clarify the figure; in reality, there is only one pushrod that is changing length as the probe advances.

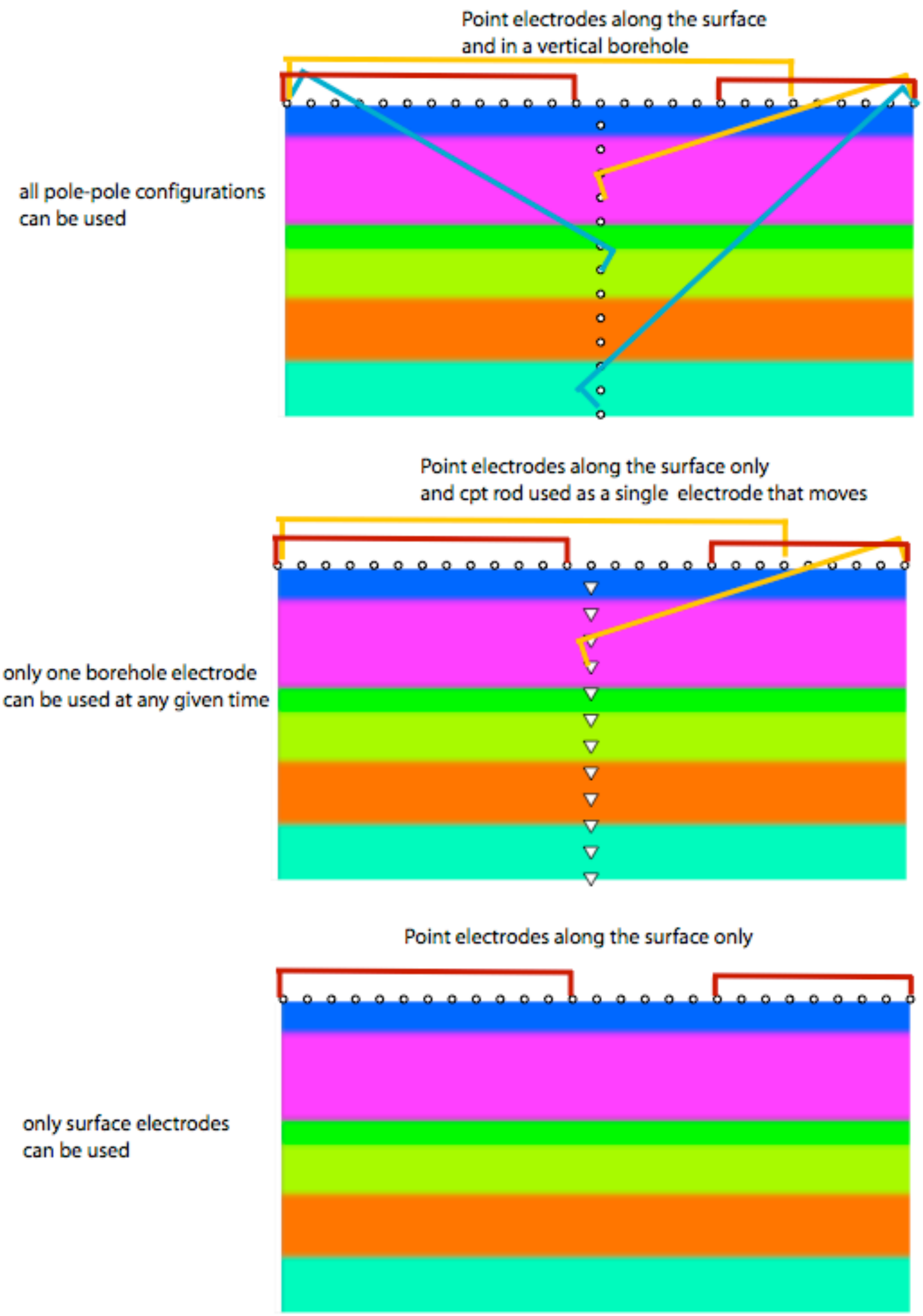

Figure 3. Three pole-pole measurement schemes were considered; in all cases, the "get lost" electrodes were the leftmost and rightmost surface electrodes. The top frame shows the reference scheme where all surface and borehole electrodes can be used. The middle frame shows two possible configurations available when a CPT mounted electrode is used. Note that only one of the four poles can be located along the borehole at any given time; electrode combinations such as the one depicted in blue (upper frame) are not possible in this case. The bottom frame shows a sample configuration where only the surface electrodes are used.

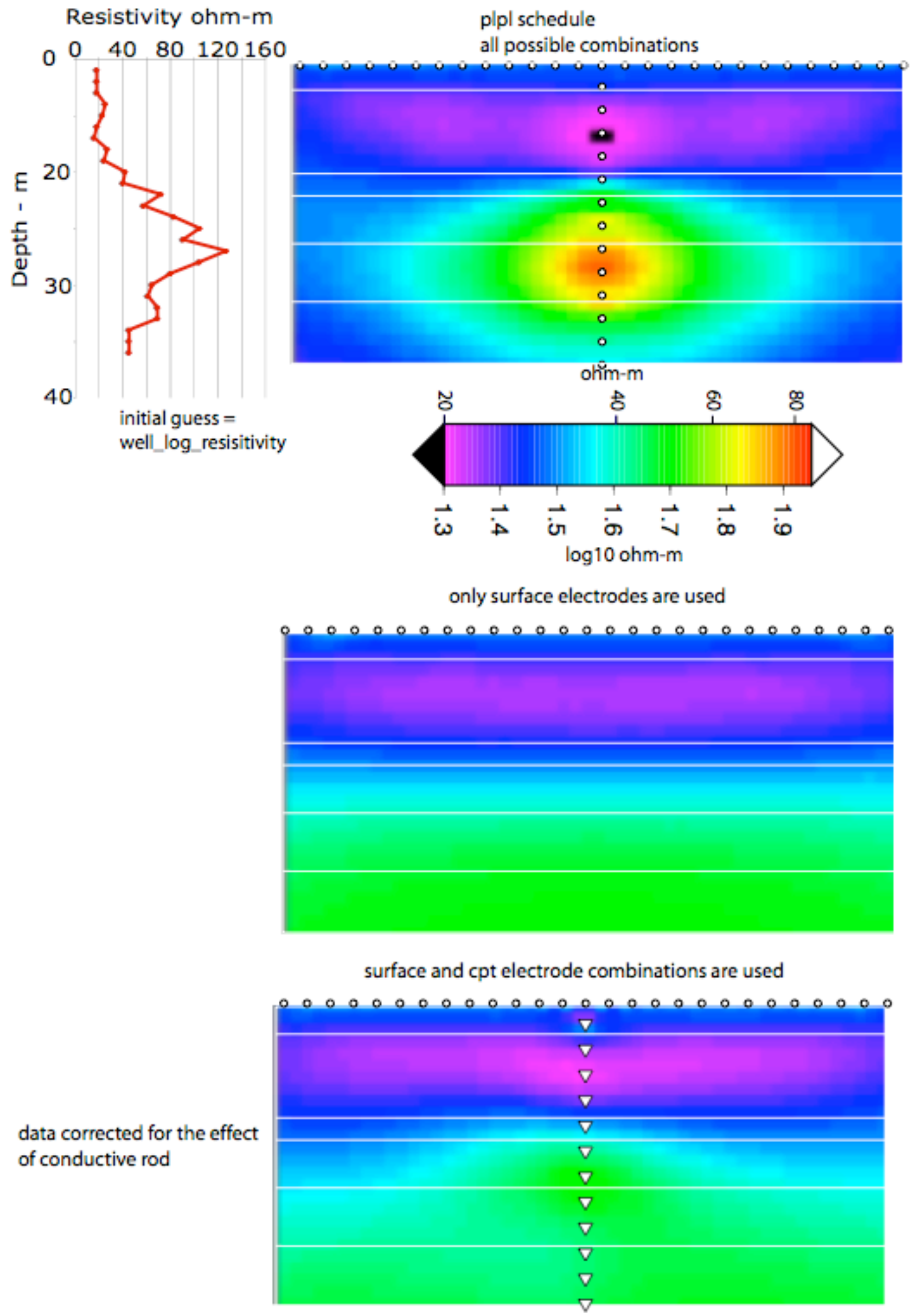

Figure 4 shows the results obtained for the various measurement schemes. The white lines show the outline of the true model (shown in Figure 1, upper frame). The starting initial model for these inversions is based on the electrical resistivity log shown on the upper left. The results in the lower frame show what would be observed if the data collected by the CPT electrode have been corrected for the effects of the push rod.

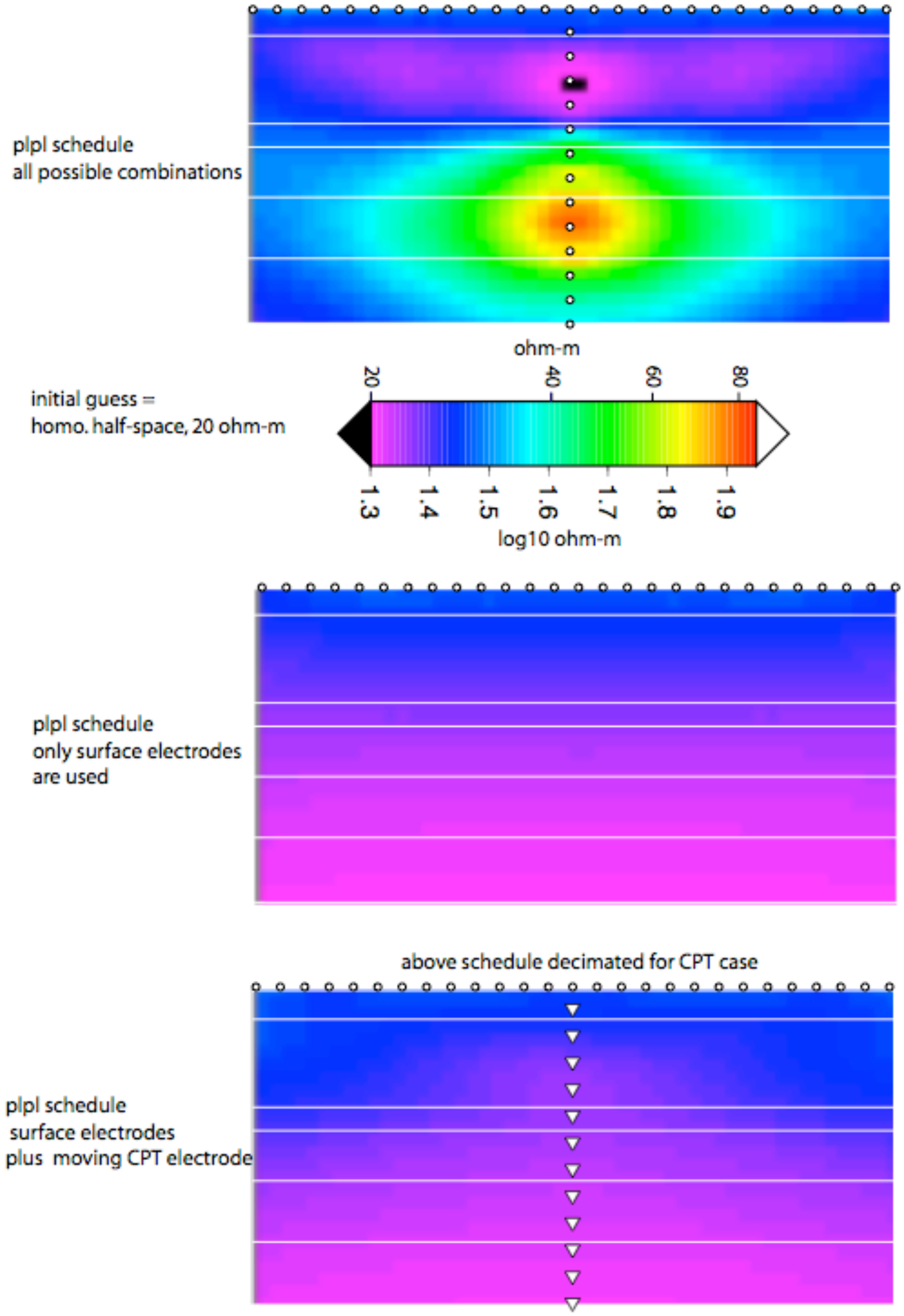

Figure 5 shows the results obtained when the starting initial model is a homogeneous half-space with a resistivity of 20 ohm-m. This figure can be compared with Figure 4 to see the effect that different starting models have on the inversion.

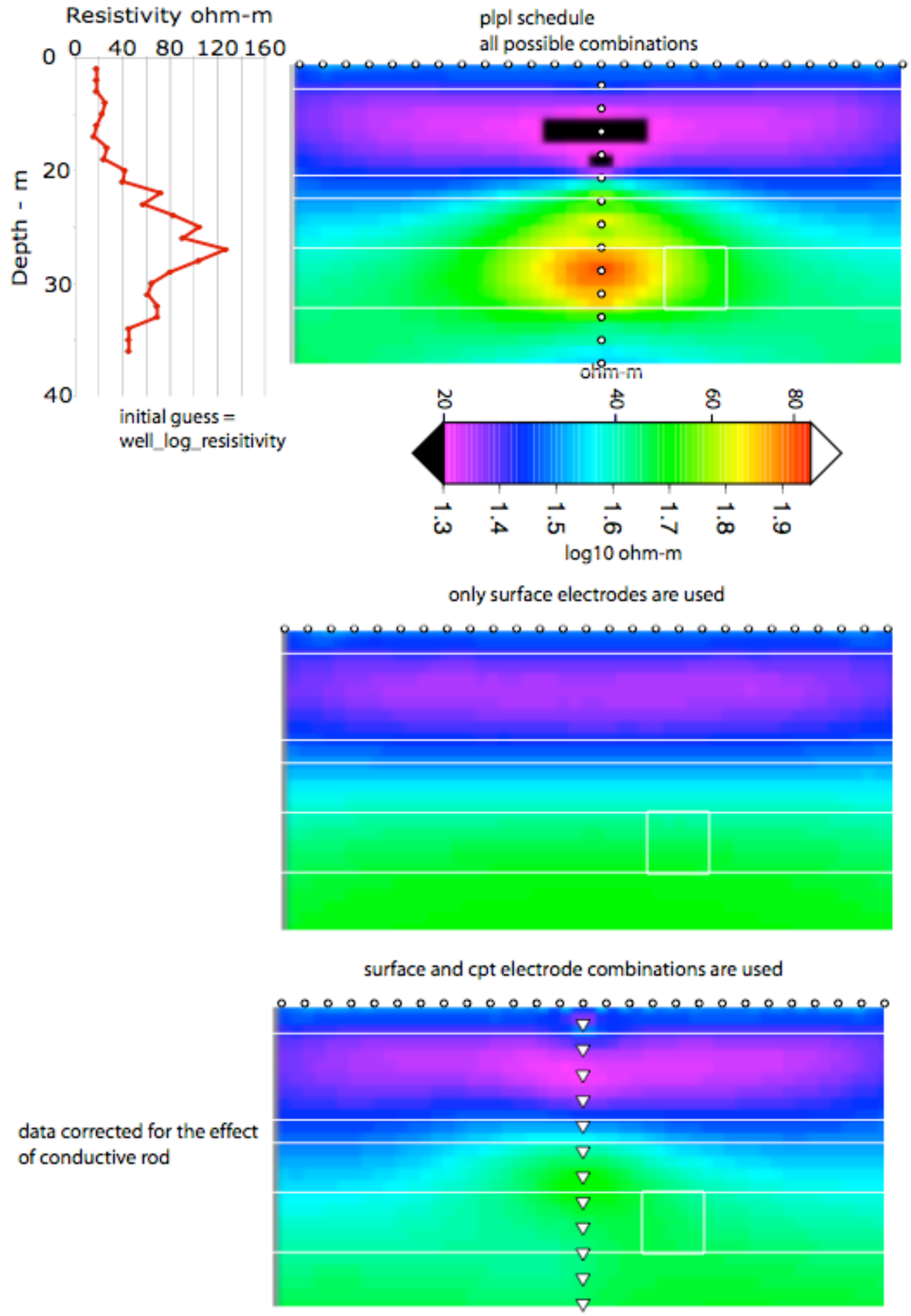

Figure 6 shows results that are analogous to those in Figure 4. In this case, the true model is the one shown in the lower frame of Figure 1.

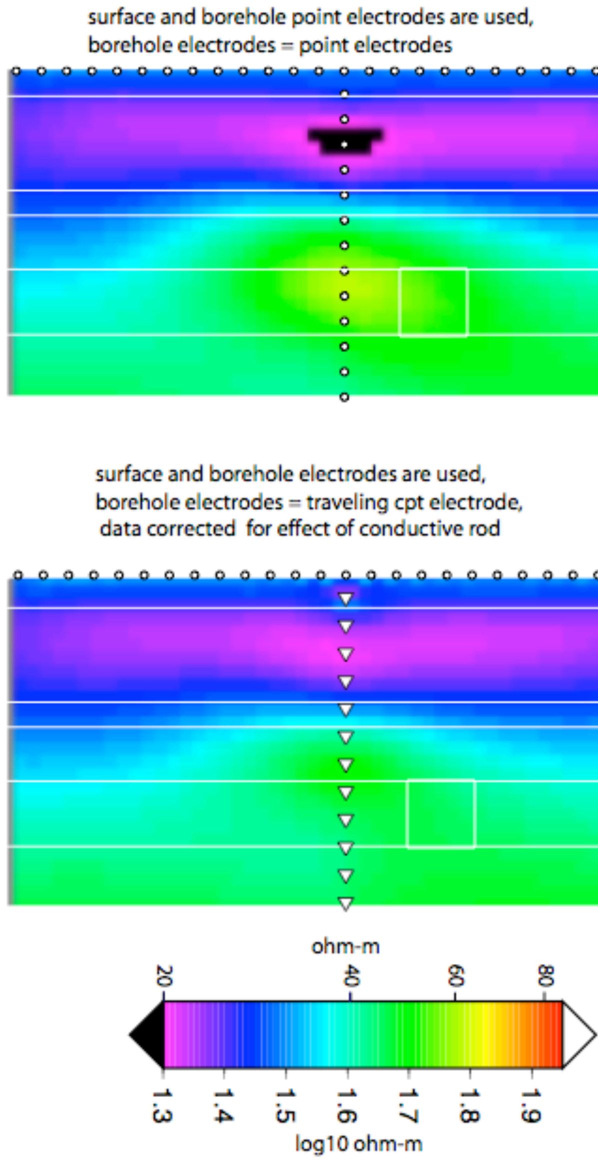

Figure 7 compares corrected and uncorrected results. Both results only used data that can be collected when CPT electrodes are used. The top frame shows results when data is collected with point electrodes (no correction used). The bottom frame shows results when data is collected using a CPT electrode; a correction was applied to remove the effects of the electrically conducting pushrod.

We have considered two approximate approaches that can be used to correct for the effects of the electrically conducting pushrod on measured transfer resistances.

$$R_c \approx \frac{R_{h,p}}{R_{h,cpt}} R_{meas,cpt}$$

or

$$R_c \approx \frac{R_{wl,p}}{R_{wl,cpt}} R_{meas,cpt}$$

<u>where:</u>

R_c =*corrected* transfer resistance
$R_{h,p}$ = transfer resistance calculated for point electrodes in a homogeneous half-space
$R_{h,cpt}$ = transfer resistance calculated for electrodes that are attached to the tip of an electrically conducting push rod and embedded in a homogeneous half-space.
$R_{meas,cpt}$ = *measured* transfer resistance using electrode attached to the tip of a push rod that is electrically conducting

$R_{wl,p}$ = transfer resistance calculated for point electrodes in a layered medium; the resisitivity of the layers is obtained from an electrical well log.
$R_{wl,cpt}$ = transfer resistance calculated for electrode attached to the tip of a push rod that is electrically conducting and is embedded in a layered medium; the resisitivity of the layers is obtained from an electrical well log

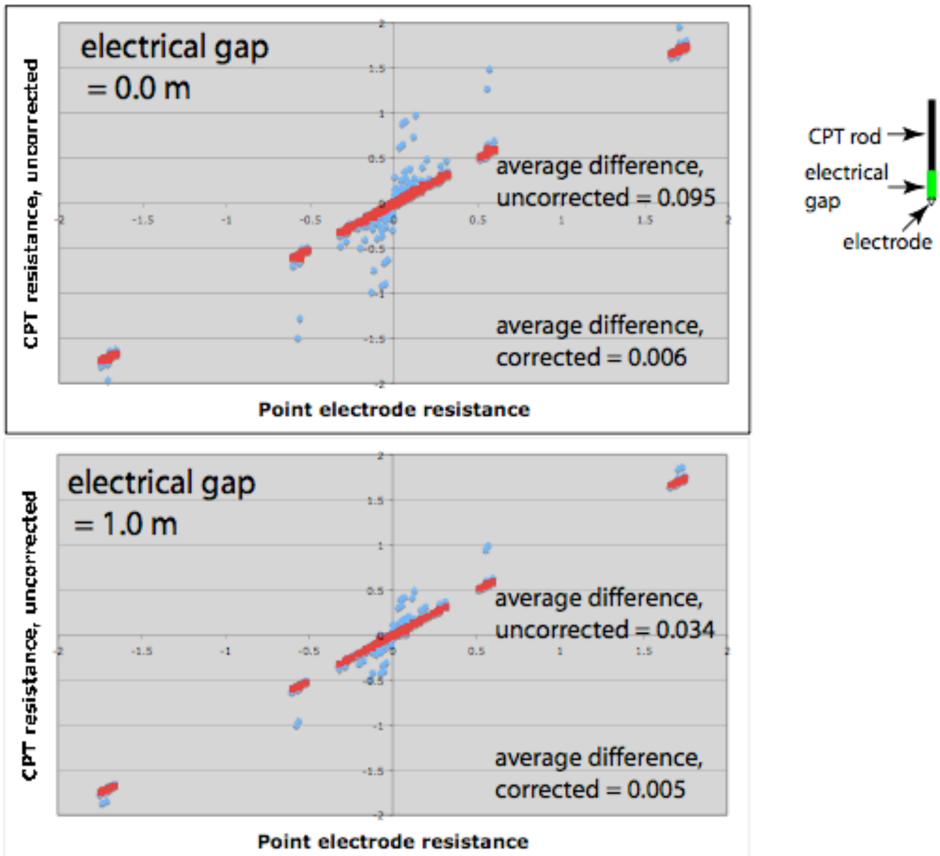

Figure 8 compares data collected using the CPT electrodes to data collected with point electrode. The blue diamonds represent the uncorrected CPT data and the red squares represent the corrected CPT data. The top frame (electrical gap = 0.0 m) corresponds to the case where the CPT electrode and the pushrod are connected together thorigh the metal. The bottom frame corresponds to the case where the CPT electrode and pushrod are separated by a 1.0 m gap; the electrical connection between rod and electrode is through the soil.