rected CSAMT and plane-wave apparent resistivities agree with Maurer's results and are similar to the agreement shown in our reply to Searle's discussion. Note that at frequencies less than 0.1 Hz (periods greater than 10 s), the agreement between the corrected CSAMT and plane-wave apparent resistivities for a conducting basal layer becomes quite good, while on the other hand, the agreement for the less conducting basal layer cases is less than satisfactory.

From our calculations for the collinear configuration we found for the conducting basal layer case that the corrections are reasonable if one ignores the correction near the near-field/far-field transition. However, for the less conducting basal layer case, the corrected CSAMT values are substantially different from the

that when one uses the apparent resistivity calculated from the real part of the impedance function following Spies and Eggars (1986), the agreement between corrected and plane-wave values is similar to those shown by Maurer for both the broadside and collinear configurations.

We agree with Maurer that our correction scheme does not give universally good agreement with plane-wave values. If the basal layer is more conducting than the surface layer, then our correction scheme gives reasonable results for both the broadside and collinear configurations. On the other hand, if the basal layer is less conducting than the surface layer, then our correction scheme only gives reasonable results for the broadside configuration over a limited frequency range and should not be

**DISCUSSION**


A growing number of papers are being published on the CSAMT-MT curve transformation, which — as the authors state — allows a simpler magnetotelluric interpretation of the corrected CSAMT curves. The concept of near-field corrections is based on electromagnetic relations over a homogeneous earth, and the effects of subsurface layers or lateral inhomogeneities are usually neglected. Bartel and Jacobson (1987) especially suppress the bounds of the near-field correction: After presenting several near-field correction curves over a homogeneous earth in their Figure 2 (which includes an idealistic demarcation line instead of a gradual change between near-field and far-field regions), they simply add that "... for a layered earth a similar demarcation occurs between the far- and near-field regimes." Further, the problem of lateral inhomogeneities is not mentioned in the paper. Such a description might lead to an oversimplification. I should like here to underline both limitations.

Over layered earth structures the correctness of the near-field transformation strongly depends on the character of layering. For example, the work of Yamashita and Hallof (1985, personal communication), contains a few comparisons not only for the homogeneous earth but for two-layered cases also. In the case of a conductive basement (when its conductivity is about ten times larger than that of the upper layer), a closer agreement was found between corrected CSAMT and theoretical MT curves, but Yamashita and Hallof found that "the first-order near-field correction...is not as perfect for the case in which the surface layer is more conductive than the lower layer". Yamashita and Hallof's unpublished figure (printed here as Figure 1) demonstrates a trend between corrected CSAMT and theoretical

![Fig. 1. Theoretical CSAMT apparent resistivity curves with near-field correction and with corresponding plane-wave values for a two-layered structure having high-resistivity bottom (Yamashita and Hallof, 1985, personal communication)]
**Discussion**

| Condition                                                                 | \( |Vr| \)  |
|---------------------------------------------------------------------------|---------|
| \( |Vr| \) \( >> 1 \) (deep zone)                                            | \( |Vr| \) \( \approx 1 \) (intermediate zone) |
| \( |Vr| \) \( < 1 \) (quasi-static zone)                                    |         |

**Table:** MT apparent resistivity ratios at large transmitter-receiver distances \( r \) over a homogeneous half-space and in the extreme cases of two-layered half-spaces as a function of \( |V_r| \). Abbreviation FRS is for "frequency sounding," which is the same as CSAMT (Adám et al., 1983).

MT curves quite different from the trend for a conductive surface layer with very systematic deviations up to about 35-40 percent. In addition to these results, the larger the resistivity contrast, the larger the deviation between the corrected CSAMT and AMT curves.

Figure 3 (here Figure 2) of Adám et al. (1983) constructed after Goldstein and Strangway (1973) shows a relation between grounded dipole CSAMT and MT curves for the homogeneous earth and the two 2-layered limiting cases (FRS is an abbreviation for frequency sounding, which is here exactly the same as CSAMT). In the case of a high-resistivity basement in the intermediate zone (defined by \( |V_r| = 1 \)), the ratio \( \phi_{BR} / \phi_{MT} \) which reflects near-field and far-field geometric coefficients, changes quickly. This is a direct consequence of interference phenomena and depends strongly on the transmitter-receiver distance and on the thickness of the upper layer. Elimination of such systematic changes would require a deeper physical approach instead of first-order near-field correction methods.

Some problems that may appear because of lateral inhomogeneities, when making near-field corrections without care, can be easily demonstrated by analog modeling experiments. Our conclusion from many CSAMT model measurements carried out in our laboratory is that all anomalies are produced mainly by inhomogeneities near the receiver or near the transmitter. In other words, the contribution to the anomalous value is largest from structures lying close to the transmitter or to the receiver. According to our experience when calculating impedance instead of a separate interpretation of electric and magnetic components, the influence of the transmitter region is less than that of the receiver region, but the effect of the transmitter region remains significant. The different physical situations in near-field CSAMT and MT investigations again impose a strong limitation on the applicability of near-field corrections.

Bartel and Jacobson (1987) demonstrate in their Table 1 the usefulness of their near-field correction technique for a 3-D situation. It should be added that (1) the resistivity of the 3-D model was 10 times less than that of the surroundings, and (2) a CSAMT-MT near-field correction really can give better results for 3-D structures than for 2-D structures, because in a 3-D synthetic case, the transmitter can be placed in a homogeneous environment; thus, the transmitter region has no influence on the anomaly. However, some 2-D MT problems can be modeled by 3-D CSAMT measurements, as done by Adám and Szarka (1985).

Fortunately, the case history presented by Bartel and Jacobson (1987) avoided the problems mentioned above because their transmitter was in a homogeneous environment and they had low basement resistivities, but what they wrote generally on the possibilities of near-field correction may mislead other CSAMT appliers.

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**References**


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**Reply to L. Szarka by the authors**

We welcome the opportunity to respond to comments by Szarka on our recent paper. The main points he raised are essential to our near-field correction scheme for controlled-source audio-frequency magnetotelluric (CSAMT) data are the application of the correct scheme and the near-field/far-field demarcation in the presence of layers and the application in the presence of electrical structure beneath the transmitter location. In our paper, we addressed the application for three-dimensional electrical structure beneath the receiver location with the transmitter over a homogeneous half-space. In this reply we wish to clarify these points and point out possible limitations of our correction scheme.

We wish first to address application of our correction scheme to the layered-earth case. In this reply we only consider the two-layer case for brevity. Figures 1-4 show calculated apparent resistivities versus frequency for two-layer and homogeneous earth cases. We show the results for the CSAMT, plane-wave corrected CSAMT, and plane-wave apparent resistivities. The solid curves in all the figures represent the apparent resistivities for a homogeneous half-space. In Figures 1 and 2 the basal layer is more conducting than the surface layer, while in Figures 3 and 4 the basal layer is less conducting than the surface layer.