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TECHNICAL NOTE TN-19

EM34-3 MEASUREMENTS AT TWO INTER-COIL SPACINGS TO REDUCE SENSITIVITY TO NEAR-SURFACE MATERIAL

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EM34-3 MEASURED AT TWO INTER-COIL SPACINGS TO REDUCE SENSITIVITY TO NEAR-SURFACE MATERIAL

In Geonics Limited Technical Note TN-6 "Electromagnetic Terrain Conductivity Measurement at Low Induction Numbers", operation of ground conductivity meters in both the horizontal and vertical dipole modes is described in some detail. It is shown that in the vertical dipole mode (coils horizontal coplanar} the relative response is zero for near-surface material, increasing with depth to become a maximum at depth approximately 0.4 intercoil spacings, and decreasing slowly thereafter. This behaviour is described by the function $\phi_V(z)$, which is shown here as Curve 1 in the accompanying figure. Conversely in the horizontal dipole mode (coils vertical coplanar} the response is a maximum to near-surface material, decreasing monotonically thereafter as shown in Curve 2. Thus by making measurements in both modes it is possible to determine whether the conductivity is increasing or decreasing with depth.

Now when using the EM34-3 there are advantages to operating in the horizontal dipole mode. For example, since the secondary magnetic field is in maximum coupling with the receiver coil the measurement is relatively insensitive to misalignment of the two coils. Furthermore since the depth of exploration is not as great as in the vertical dipole mode the indicated apparent conductivity stays linear with true conductivity to much higher values of halfspace conductivity, as shown in Technical Note TN--8 "EM34-3 Survey Interpretation Techniques". This feature is of particular importance when making measurements in very conductive regions, such as in mapping soil salinity.

A disadvantage of operating in the horizontal dipole mode is the high sensitivity to near-surface conductivity since variations in this conductivity can mask changes at greater depths. Fortunately there is a simple and effective way of altering the response with depth; the technique requires only that the ground conductivity be laterally uniform to a radial distance of the order of the largest intercoil spacing used.

To employ the technique one simply makes measurements at each survey station in the horizontal dipole mode using intercoil spacings of either 10 and 20 m or 20 and 40 m, depending on the survey depth that is to be achieved. Suppose for example that 20 and 40m are used, and let $\sigma_{a,20}$ and $\sigma_{a,40}$ be the apparent conductivity measured at each spacing respectively. At every measurement station a new apparent conductivity

$$\sigma_{an} = 2\,\sigma_{a,40} - \sigma_{a,20}$$

is calculated and plotted along the profile. It is a relatively simple matter to show that the result of taking this difference is to alter the depth response curve from $\Phi_H(z)$ (Curve 2 in the figure) to $\Phi_N(z)$ (curve 3) which resembles $\Phi V(z)$ in that it is zero at zero depth, now becoming a maximum at 0.25 intercoil spacings which is, in this case, 0.25 x 40 = 10 m since the horizontal scale is now depth divided by the larger of the intercoil spacings. If the measurements were done at 10 and 20 m spacings we would calculate $\sigma_{an} = 2\sigma_{a,40} - \sigma_{a,20}$ and the response would occur at a depth of 0.25 x 20 = 5 m.

The recommended survey procedure is as follows, assuming that 20 and 40m spacings are used. Make the measurements at 20m intervals, and let the stations be at 0, 20, 40, 60, 80 ...m respectively. With the Tx at Station 0 locate the Rx at Station 20 to make the measurement of $\sigma_{a,20}$; move the Rx to Station 40 to obtain $\sigma_{a,40}$. With the receiver location unchanged, move the transmitter to Station 20, measure $\sigma_{a,20}$; move the receiver to Station 60 to obtain $\sigma_{a,40.}$ Now move the Tx to Station 40, and so on down the line. It is recommended that the data of σ_{an} be plotted every 20m at the mid-point of the Tx/Rx array.

In the event that spacings of 10 and 20m are employed, measurements are made every 10m and the same procedure used to locate the measurement sites.

In fact an even more desirable practice (again assuming that measurements are made at 20 and 40m spacings) is to plot two profiles, one of $2\sigma_{a,40} - \sigma_{a,20}$ and the other simply of $\sigma_{a,20}$. Then the relative depth responses will be given by curves (3) and (4) in the figure; we see that the data of $\sigma_{a,20}$ gives us the behaviour of conductivity at depths less than = 0.2 x 40 = 8m whereas the data of $2\sigma_{a,40} - \sigma_{a,20}$ essentially gives conductivity below 8m.

A quick scan of the tabulated data of $\sigma_{a,20}$ and $\sigma_{a,40}$ tells us whether the more conductive regions are shallow or at depth, depending on the relative size of $\sigma_{a,20}$ and $\sigma_{a,40}$. For example, if $\sigma_{a,20}$ is of the order of twice $\sigma_{a,40}$, $\sigma_{an} \cong 0$ and the conductive material is very close to surface. If $\sigma_{a,20} \cong \sigma_{a,40}$ the conductivity is uniform with depth, and finally if $\sigma_{a,20} < \sigma_{a,40}$ the conductivity is of course increasing with depth.

In summary, it is anticipated that the use of this "two-spacing" technique will greatly improve survey data when changes in conductivity of the near-surface material are masking changes in conductivity at greater depth.