Induced Polarization Effects in Time Domain EM Data

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The strong EM pulse used in some time domain electromagnetic transmitters can induce sufficiently large current flow in the earth that a conductor can be electrochemically polarized.

If the body is strongly polarizable, the effects are generally observable as an anomaly of reversed sign. However, the normal transient EM response must decay away to be smaller than the induced polarization response.

Examples from ground TDEM surveys show a measurable EM-induced IP response over weakly conductive sphaleritic zones, which also responded strongly to traditional direct current IP, and weakly to HLEM. A conductive graphitic argillite also responded, and the different magnitude responses from different transmitter loops illustrates the dependency on the strength of the polarizing current.

In an example from Central Newfoundland (data courtesy of Noranda), the EM-37 survey acquired data along the same line from two different transmitter loops. The conductor is a long, formational graphitic argillite in resistive crystalline host rocks. Line 7700N was surveyed from two loops, loop E5 very close to the conductor, and loop E4 almost 300 m away. The close-in loop (E5) energized the conductor sufficiently to polarize it, such that in mid-to-late time (1ms after the end of the ramp) the anomaly reverses (Figure 1), as the current flow reverses. The data from the loop farther away (E4) shows no observable reversal. The current flow induced by the loop was insufficient to significantly polarize the conductor.

The polarization builds up under the influence of the galvanic currents flowing in the conductor parallel to the (vortex) currents induced in the host halfspace by the transmitter. These galvanic currents generate the strongest response in early time. As the galvanic and induced currents in the conductor decay in strength, they are overpowered by the polarization current flowing in the reverse direction.

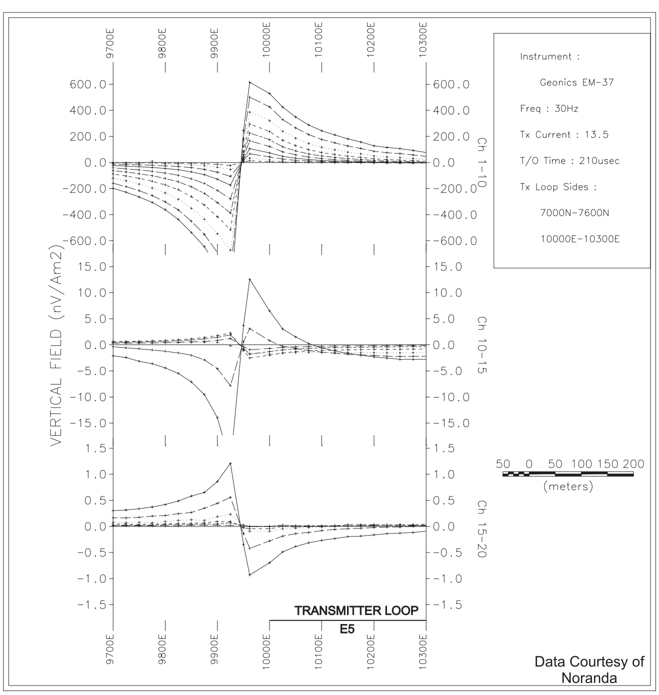

Figure 1: *Mid- to late-time anomaly reversal fronm polarizble body energized by transmitter coil close to the body (Data courtesy of Noranda).*

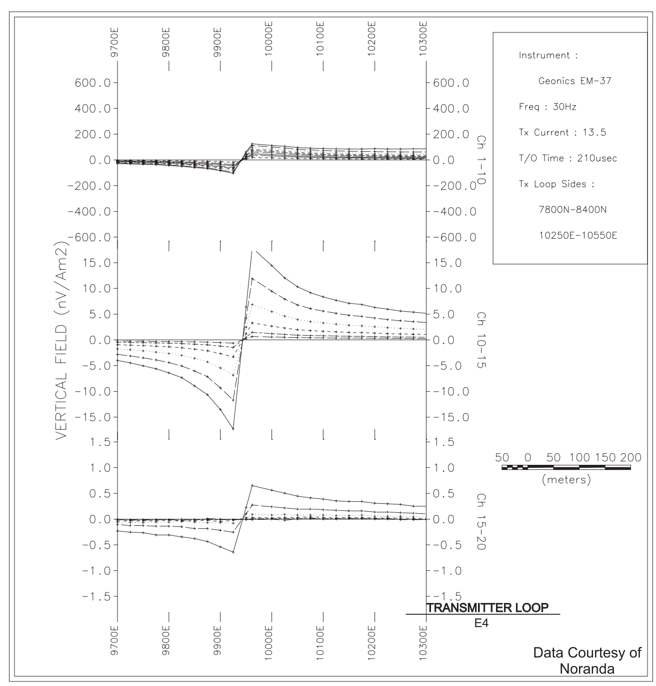

Figure 2: *Same survey line. but with the transmitter loop further away.*

In "Proceedings of Exploration 97: Fourth Decennial International Conference on Mineral Exploration" *edited by* A.G. Gubins, 1997, p. 565–566

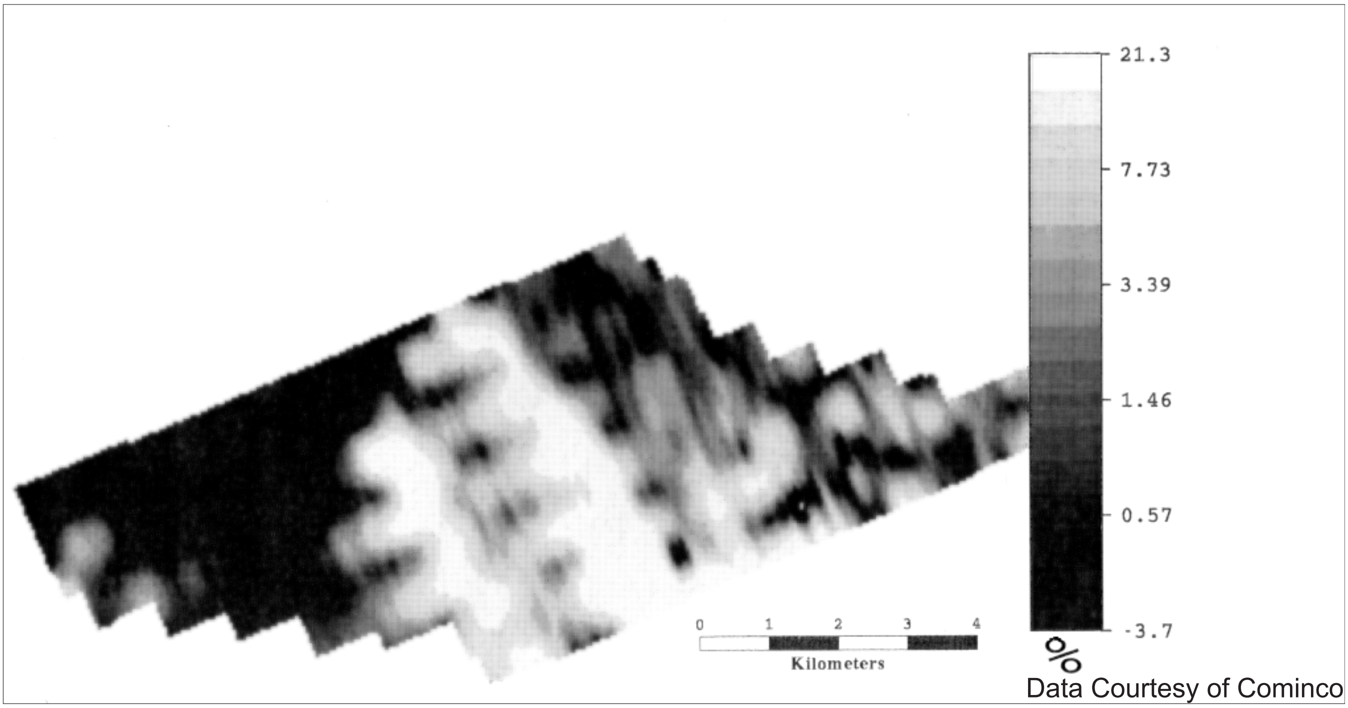

Figure 3: *GEOTEM data showing polariztion effects. (Data coutesy of Cominco)*

For the sign reversal to become evident, the transmitter loop must be close enough to induce strong early time currents sufficient to polarize the conductor, and the decay must be fast enough to allow the reverse currents to dominate.

The effect can be observed on both horizontal (X) and vertical (Z) field components. Only the vertical component is shown here.

An example of this IP response in GEOTEM data indicates that the effect is not confined to ground systems. The data shown in Figure 3 (courtesy of Cominco) shows two zones where the response reverses sign. In this figure, the EM data has been used to estimate the polarizability of the near surface material. The larger zone to the right of the figure coincides with a shale unit which is prospective because of known mineralization along strike. The polarizable zone to the left was not mapped by the geologist, but because its signature is similar to the right zone it is also prospective.

While observations of this effect have been limited to special cases, its effect on interpretations, particularly on conductance calculations from decay constants, may be common.