Synopsis of mapping buried waste with IP effects

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Although induced polarization (IP) effects measured over landfills were first discussed in a 1974 article in the journal *Science* (Angoran et al. 1974), it was assumed at the time that the primary source of the IP effect was metallic debris in the waste. For almost 20 years now, we have used the IP method regularly as a detailed mapping tool on more than 50 landfills in various environments and of differing types, including municipal solid waste (MSW), construction waste, green waste, and hazardous waste. Many of these projects were very extensive: 95 lines of dipole-dipole IP and resistivity data were acquired at one landfill alone. Although our work has been primarily in "applied" mode (as a mapping tool) rather than in "research mode" (to develop a better understanding of the IP effects), there are interesting, significant results from this very large data set.

Field techniques

IP surveys have been used in mineral exploration surveys for many decades in both time domain and frequency domain (also called phase domain), in a variety of geometries and arrays dependent on target depth and environment. Environmental applications were less common until the 1990's, since budgets for environmental geophysics were significantly smaller than for resource exploration, of course, and IP data are typically more time-consuming (i.e., more expensive) to collect for various reasons than other electrical properties such as resistivity. With the development of back-packable, battery-powered multichannel receiver systems with multiplexers, combined with flexible field logistics, however, the economics of acquiring IP improved tremendously. In order to maximize economic efficiency for environmental budget constraints, most of the landfill surveys summarized here were run in the time domain, usually using dipole-dipole arrays, measuring IP as the "Newmont Standard" chargeability, adjusted for a repetition rate of 0.5 Hz instead of 0.125 Hz (to increase survey speed).

Summary of results

One early result after comparing IP data with drilling and trenching results from numerous landfills was that the IP effects were not solely the result of metallic debris in the landfills as originally thought in 1974. The strength of the IP anomalies was not necessarily an indicator of metallic content, and eventually, several cases were evident where valid IP anomalies were measured despite the fact that little or no metal was present in the landfill. In one case, a buried "green waste" landfill containing vegetation waste (such as trees, branches, yard clippings, etc.) clearly exhibited an IP anomaly in good agreement with the landfill footprint from the historical records. In another case, trenching (and eventual clean-up) located little metallic waste, but IP anomalies appeared to be correlatable to plastic waste. At a different site, where asbestos from old demolished buildings was segregated from MSW and disposed of separately, a very weak but valid IP effect was detected over the buried asbestos. From a comparison of IP results over landfills comprised of different materials, it became evident that there are likely multiple potential sources of the IP effect at work, including metallic debris, fine-grained clays, wood or vegetable matter, some plastics, and possibly the biodegradation decay processes themselves.

Another particularly interesting overall result was the change in the strength of the IP anomaly over an old, buried landfill after an accelerated degradation process was used for four years. In this case, air and water were circulated in the subsurface waste to increase the speed of the normal decomposition. In the semi-arid desert environment where this landfill was located, the decomposition time was reduced from an estimated 100 years to approximately 5 years.

Accelerating this process is beneficial because it allows more control over ground subsidence and methane production. IP and resistivity data had been acquired over this landfill prior to the start of the accelerated degradation, and several lines of data were re-acquired after four years of the process, using the same survey parameters, equipment type, and data processing programs. The decrease in the strength of the IP anomaly over four years was very strong (see Fig. 1). The change in IP response was not completely uniform, however, suggesting that IP surveys could be used to monitor these degradation processes, helping to identify areas of the landfill where the degradation process is hindered due to poor circulation of air and water, for example.

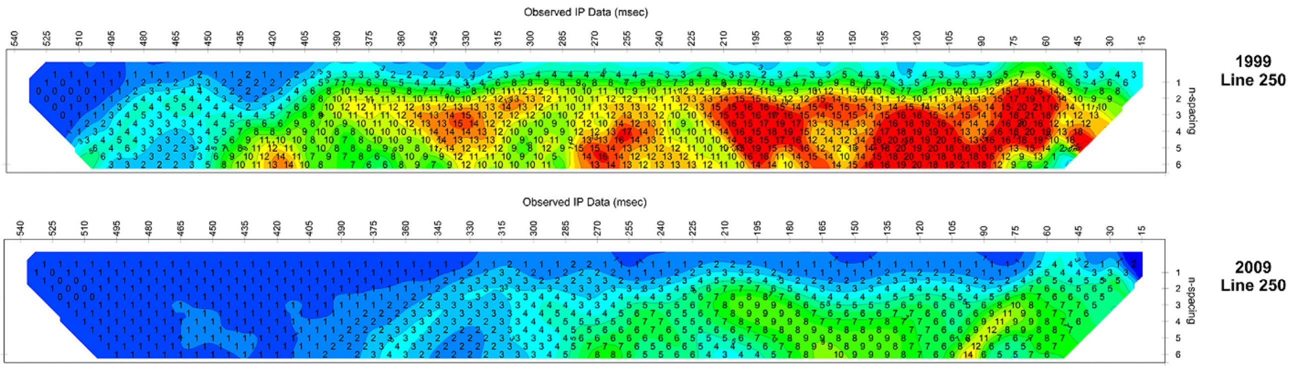

Fig. 1: Raw IP data in traditional pseudosection format, prior to modelling, showing the change in IP effects after four years of accelerated biodegradation of an old, buried, municipal solid waste landfill. Posted values are chargeability in milliseconds.

Summary

Although not acquired as research data *per se*, examination of hundreds of lines of IP and resistivity data over dozens of different landfills in a variety of environments has been useful in that it clearly illustrates that there is no single mechanism as the source of IP effects, and that differences in IP effects may in fact be useful in differentiating the types of waste in the subsurface at a given landfill. The IP method also shows promise as a tool for monitoring the accelerated biodegradation processes being developed now for landfill remediation.

Reference

Angoran, Y.E., Fitterman, D.V. and Marshall, D.J., 1974. Induced Polarization: a geophysical method for locating cultural metallic refuse. *Science,* 184, 1287-1288.