Seismic Reflection and Mineral Prospecting

R.G. Nelson
South Australian Department of Mines and Energy
Parkside, South Australia

Prospecting for minerals becomes increasingly difficult when targets lie at depth, or where basement expression is masked by thick sedimentary cover. Geophysical techniques such as gravity and magnetics are generally used as aids in reconnaissance, but rarely yield unambiguous solutions, while electrical methods suffer because the often highly conductive overburden limits current penetration. Recent advances in extending the resolving power of the seismic reflection method suggest that it is appropriate now to consider its use in mineral prospecting. Its applications can include indirect ore-detection methods such as: tracing intrabasement horizons; qualitative interpretation of zones, using or adapting ideas of seismic stratigraphy; mapping structural features such as faults or folds; interpolating between or extrapolating from existing drill holes.

Direct detection may also be possible by using "bright" or "dim spot" techniques, or because some orebodies have characteristic reflection and diffraction responses.

In contrast with petroleum exploration, where variations in velocity are taken as a guide to reflection response, the evidence indicates that density contrast is more likely to be the governing factor. Thus, for example, increasing substitution of pyrrhotitic ore into a country rock consisting of siltstone does not substantially alter an intrinsic rock velocity of 5.5 km/sec. The density, on the other hand, may change from 2.7 to 4.5 ton/cu m. This is in agreement with the known relationship between velocity, density and mean atomic weight. Therefore, in metamorphic, igneous or mineral-bearing rocks, where porosity is low and exists mostly as microcracks, it is the variations in density which occur in predominantly monomineralic layers which may contribute to a significant reflection response. The thicknesses of such bands, the relative sizes of the targets and the degree of resolution sought of structural features requires the use of high resolution techniques and the recording of frequencies in excess of 200 Hz.

Modeling of the responses of known orebodies confirms the notion that some may have characteristic seismic response. It is a useful approach which assists in the design of field surveys, particularly when one seeks to avoid spatial aliasing problems in areas of steep dip and structural complexity. Processing techniques suitable for a particular area may also be examined using modeling techniques.

The use of common-depth-point stacking is inappropriate in structurally complex areas. However, as some form of stacking is necessary to yield adequate levels of signal above noise, the application of so-called slant-stacking techniques should be considered. These also alleviate problems associated with offset-dependent waveforms and reflection coefficients. Examples from various areas in Australia illustrate these concepts.