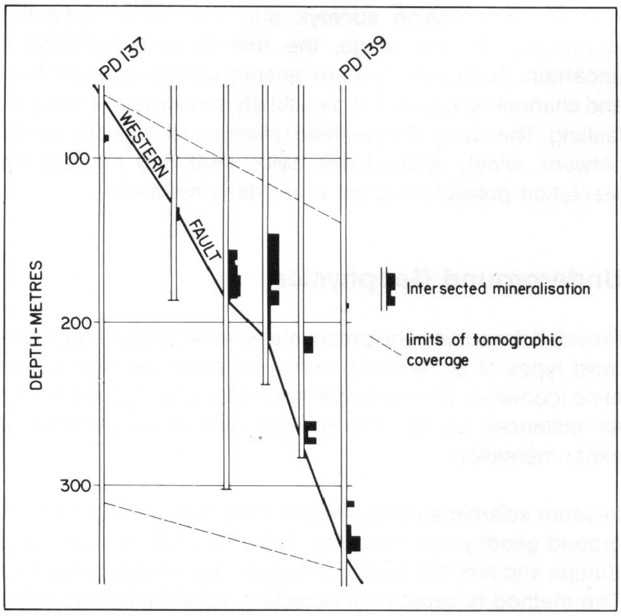

FIGURE 5
Location of mineralisation and faulting between hole pair #1.

zone associated with the Western fault. The low velocity regions at the boundaries of the tomogram are due to the effect of anisotropy. For comparison purposes, the geological information available from drilling is shown in Fig. 5.

In addition to tomography, analyses of anisotropy, spectral ratio, tube waves, and dynamic physical properties were performed to provide a better understanding of the mineralisation and host rocks.

The results indicate that:

- mineralisation can be identified by strong velocity contrasts with the surrounding strata.
- anisotropy occurs in both horizontal and vertical planes, possibly indicative of different structural geology and stress conditions.
- a fractured region exists between Holes PD137 and PD139, at 180 m below surface.
- lithological boundaries and potentially weak strata have been identified between Holes PD182 and PD185.
- water cavities suspected near Hole 182 should be smaller than the limits of resolution of the survey (5 metres).

S-waves were not detected in the data. This could be due to the fact that the detector was not coupled directly to the wall of the boreholes. This may be overcome by using a clampable detector currently under development, together with the appropriate processing software.

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COAL MINING AND THE NEED FOR INNOVATIVE GEOPHYSICS

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Introduction

Coal is Australia's biggest export earner. To retain its competitive position in the world, the industry is embarking on a course of increased mechanisation in all areas of operation. Operations are necessarily capital intensive and mines must perform as designed for economic operation. An outstanding opportunity exists for geophysics to help the industry meet these needs.

Most geophysical techniques have been applied at some stage to a coal mining problem. The degree of success has been variable. Failures often arise because of a lack of familiarity with the problems and because of lack of innovation.

Seismic techniques are generally most useful because of their capability for high resolution. Methodologies such as high resolution seismic and in-seam seismic reflection methods are well described in the literature. However, numerous other innovative techniques are possible. Some of these are discussed in this paper. An underlying theme is that while geophysics can do much to aid coal mining, considerable work is required before this potential can be realised.

The Coal Miners Problems

Australian coal mining is at the stage where the emphasis is on exploitation rather than exploration. All mines are needing to improve the efficiency of their operations. Few new mines are planned.

In the open cut mines, efficiency is tied in with effective removal of overburden. The mines are seeking to operate at depths greater than originally planned and to achieve this, the overburden must be broken up with the minimum amount of explosives and removed with minimal double handling. Bucket wheel excavators and in-pit crushers, which can load conveyor systems, are being introduced to perform initial overburden stripping. The potential for geophysics to assist in the geotechnical evaluation of overburden rocks should be obvious.

In the underground mines, many collieries are either operating or planning to operate longwall equipment which can excavate coal over a face some 200 m in length. The equipment is costly but the method is extremely efficient provided production is uninterrupted. If unexpected geological features such as faults, dykes or washouts are encountered, millions of dollars may be lost through lack of production while the structure is negotiated. The accurate prediction of geological features represents another outstanding problem for geophysics.

Surface and Airborne Geophysics

Most of the conventional geophysical methods fall into this category. Most of them fulfill an excellent exploration roll but fall short of providing solutions to the coal miners problems. High resolution seismic reflection surveys using either the mini-SOSIE or conventional dynamite methods are frequently conducted. They successfully map large scale faults, but smaller faults with throws of about 2 m remain very difficult targets. Such faults need to be identified if surface reflection surveys are to have an application in longwall mining.

Dyke and sill identification is best done with magnetic methods. Problems encountered here are usually associated with noise due to surface features such as power lines, non-magnetic intrusives and the difficulty in predicting the locations of intrusions at seam depth.

In the assessment of overburden rock properties at open cut mines, seismic refraction methods have an obvious application. No special difficulties are encountered in mapping weathering profiles but in assessing rock properties, the thorny problem of predicting rippability from velocity data is raised. This problem still requires much work.

Borehole Geophysics

The drilling of surface boreholes is relatively common in coal mining. The holes fulfill an exploration roll and allow geotechnical and coal quality data to be obtained. As well, they offer geophysicists opportunities for improved access in their surveys.

Borehole logging is now conducted routinely. Many holes are not cored and the geophysical logs provide the only stratigraphic data. Applications in predicting coal quality and rock strength also exist.

Numerous cross-hole and down hole methods are possible. For the open cut miner, cross-hole and down hole P and S wave velocity measurements can indicate Poissons ratio and hence the rock strength. By virtue of being an in-situ determination, these measurements are potentially more useful than the conventional laboratory tests. However, the application has still to be properly developed. Similarly tomographic studies are possible between boreholes but again the usefulness of this application has to be established.

Underground mining problems concerning the location of faults and dykes can be potentially addressed using in-seam seismic transmission surveys and the 'yo-yo' reflection techniques. At this stage, the role of both methods is uncertain. Australian in-seam seismic waveguides are thick and channel waves are not particularly sensitive to small scale faulting. The ability of cross-hole reflection methods to operate between widely spaced drill holes (300–500 m), and the resolution possible has yet to be demonstrated.

Underground Geophysics

Provided the survey equipment meets mine safety regulations, most types of geophysical surveys can be conducted from mine roadways. The horizontal boreholes drilled in coal seams for distances up to 1000 m, can also allow geophysical experimentation.

In-seam seismic surveys are the most familiar of the underground geophysical methods. They are routinely applied in Europe and they are finding increased usefulness in Australia. The method is capable of detecting small faults and dykes up to 500 m ahead of mine workings. The identification of the nature of the reflecting targets and improving resolution are the two main problems currently being faced.

Tomographic surveys around retreat longwall panels by either seismic or electomagnetic means are potentially very useful. Even when a panel has been set up for longwalling, geological anomalies need not have been identified. Washouts many occur in the panel. The seam may thin or split. Such features can halt longwall production and the prediction of their occurrence is of vital importance.

Reflection and tomographic surveys are also possible from long horizontal boreholes. So too is geophysical logging aimed at detecting seam thinning and fault zone intersections. The application of geophysical methods from horizontal boreholes is in its infancy.

Geophysics also has a potential role in underground mining by improving the operation of equipment. In some operations up to 1 m of coal is left in the roof of the coal seam to improve the roof stability. An acoustic method of measuring the roof thickness from a continuous miner is currently under development at ACIRL.

Other potential applications for geophysics underground are in predicting coal outbursts from acoustic emissions and in establishing the internal conditions of coal pillars. Acoustic emission monitoring has been conducted for some time but has yet to find a permanent role. The establishment of pillar conditions is a problem still awaiting a solution.

Conclusion

Coal mining is one of the most significant industries in Australia today. Open cut and underground mining are equally important and both require accurate geological control for efficient operation. In this paper I have outlined some of the areas where there are outstanding opportunities for geophysics.