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The use of downhole geophysical logging in assessing subsidence from abandoned coal mines

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We have used downhole geophysical logging for a number of projects involving abandoned coal mines to assess coal pillar thickness and the effectiveness of mitigation. Traditionally, downhole geophysical logging has been used in coal resource assessment.

The most useful methods include:

- Density (Long and Short spaced) - most common and valuable method. It picks up variations in rock density, with voids and coal having a lower density than the other rock types;
- Gamma – used to assess rock types;
- Velocity – used to help assess material strength in open holes;
- Borehole deviation (Gyroscope in holes with steel casing and magnetic in uncased holes) – Deviation is important since the hole can veer from its intended path during drilling and an accurate location aids in assessing the position of the mine workings with respect to the surface. The survey provides measurement of hole position with depth to an accuracy of ± 2° for the bearing and ± 0.5° for the slant angle.

Downhole geophysical logging allows increased accuracy in accessing coal pillar thickness to evaluate if pillar crushing has occurred or not. The accuracy in "picking" the top / bottom of the coal is approximately 20mm to 50mm. It is an improvement over core drilling due to the potential for loss of coal during drilling, particularly if the pillar is crushed and is a significant improvement over air and / or water flush drilling techniques, which can be influenced by a loss of return and the lag time for cuttings to reach the surface. In addition, partings in the coal seam can also be picked up, which help with the correlation of mined zones in the coal seam.

We have used the method to assess the effectiveness of mitigation where a cement fly ash grout was injected into the mine workings. The method improved the results over just drilling as it provided the density and velocity of the injected material and mine level materials. The density and velocity values helped in the interpretation of zones of loss during drilling. It is also beneficial where the water in the hole has poor visibility and time is not available for settlement of suspended particles for borehole camera viewing.

Potential issues that need to be considered include:

- Availability of the geophysical supplier – In some cases the supplier may be 1 hr to 1 day away from the site; therefore, scheduling is very important to reduce driller standby costs;

- Driller standby for unstable holes – The logging needs to be performed through the drill string in unstable holes or voids and coordination with the supplier is needed to reduce standby time costs;
- Hole depth – The hole needs to be drilled up to 4m below the zone of interest to accommodate the geophysical tools and drilling debris that cannot be removed from the hole;
- Hole diameter – The hole needs to be drilled with HQ size (96mm) or larger tools to accommodate the device; and
- Extra care needed - As the device uses nuclear sources to obtain data, it needs to be retrieved.

Recommendations include further work in assessing the signature of cement fly ash grout and correlation of grout strength with velocity.