GEOPHYSICAL DETECTION OF ABANDONED MINE TUNNELS[1]

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Abstract: This project is developing equipment and methodology for locating voids and faulting in Rock Springs, the area in Wyoming that has experienced the greatest problems. This involves testing and calibrating high-resolution seismics (HRS) and ground-penetrating radar (GPR) over air-filled, rubble-filled, grout-filled, water-filled cavities, and as yet unmined coal beds. Calibration is furnished by coordinating with drilling results of engineering companies that are carrying out the remediation efforts in Rock Springs. As we develop these geophysical imaging techniques, we have also taken economic and environmental acceptability of operation into consideration. High Resolution Seismics. High-resolution seismics (HRS) is based on seismic reflection methods at relatively high frequencies (greater that 100 Hz). These techniques are highly dependent on field data acquisition which is site-specific, depending on the nature of the surface weathered zone. HRS profiles are presented for McKinley Street, Lincoln Street, Cody Street, and the water tank in Rock Springs where mined area are at depths around 100 to 120 feet. Ground truth is provided by drilling at Lincoln and McKinley streets. An HRS profile over shallow (50-60 feet) mined areas at Alder Street is not presented because the data was degraded by high-velocity noise propagating along sidewalks. here useful information was, however, obtained from GPR. The Lincoln Street HRS profile runs along most of the profile and a void was interpreted in the seismic profile and confirmed by drilling. The HRS profile along McKinley Street is calibrated by projecting from drilling about 50 feet off the profile. A coal horizon, at 120 feet, was imaged and a void with roof collapse encountered at 97 feet is marked by a change in the reflection signature. Possibly a grouted void was also seen. The shallow roof-collapse zone indicates the kind of complication in seismic signature that must be further calibrated by drilling. The Cody HRS profile is located in a vacant lot southeast of Cody Street but has not been drilled. Based on amplitudes, we interpreted a mined zone at about 100 feet depth. We are using further processing, analysis and comparison with known voids to provide more support for the interpretation. An HRS profile was run at the new water tank located off the South Side Beltway. The mined coal horizon is imaged and two voids are interpreted. No drilling information is available. We are conducting further processing and analysis of this data. New field techniques are being developed that may provide better data quality and that allow us to operate successfully along surfaced roads. Better field equipment has also been developed. Ground Penetrating Radar. Ground penetrating radar (GPR) has been tested with a number of problem areas at Rock Springs including a sink hole, faulted coal beds, grouted cavities, air shaft, and a tunnel. The application of GPR is affected by nearby metal objects and the nature of the soil zone so that, in several cases, results were degraded by reflections from metal at the surface, and apparently by some conductive soil zones. The GPR system, however, works well on bedrock and provides depth coverage from the surface down to about 60 feet, the depth range where HRS is slower and less satisfactory. The GPR is extremely fast, simple, and environmentally compatible, providing a real-time image of the subsurface. Faulted coal beds were imaged down to a depth of about 20 feet and the faults themselves were directly imaged by the GPR. Along the Beltway, we were directed to a sinkhole that had been backfilled. The GPR image of sinkhole area shows the sinkhole, a buried topographic ridge, and interference from three overhead wires. The sinkhole and buried ridge are imaged nicely; the cavity underlying the sinkhole may be revealed by a gentle depression, but its presence is complicated by the arcuate interference, caused by overhead wires. Such interference effects were noted by the operator in the field. At Alder Street, we profiled over voids that had already been grouted at depths of about 50 feet. Here two grouted areas were detected at slightly different depths together with a water-filed cavity. Arcuate bands are reflections and diffractions at the top of both grout-filled drill holes and likewise with the water-filled cavity. Because the GPR signatures may appear similar, more work (like looking at true amplitude) needs to be done to improve interpretation. Future study involves developing a better understanding of subsurface signatures and solving the problem of surface interference and attenuation. Along this

line, recent GPR profiling was completed across adits for abandoned coal mines, and the GPR section provides a distinctive signature for the adit at depths of 30 to 50 ft. New software to sharpen GPR images has been developed.

Additional Key Words: High Resolution Seismics (HRS), Ground Penetrating Radar (GPR)

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