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MINING-INDUCED SEISMICITY INVESTIGATIONS USING SEISMIC IMAGING AND SOURCE MECHANISM TECHNIQUES

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Abstract

The paper will describe two case studies where an integrated interpretation of field data from tomographic imaging and mining-induced seismicity experiments, has provided important insights into the in situ correlations between seismic velocity, stress and seismicity. Seismic tomographic imaging has been carried out in Canadian hard-rock mines for several years in an attempt to delineate rockburst prone rock masses. The redistribution of stress due to mining results in measurable differences in seismic velocity and this has been used in conjunction with induced seismicity for rock mass characterization. The two case studies highlight the potential of the technique.

In the first case study, a 2D seismic tomographic imaging survey was carried out around a mineralized fault zone at Falconbridge's Lockerby Mine, Sudbury, Canada in April, 1989. The tomographic image showed two distinct and significant P- wave velocity anomalies: a low velocity zone at the source region of a M_N 2.3 mining-induced tremor recorded in 1985 and a high velocity zone at the source region of a M_N 2.6 mining-induced tremor recorded in 1988. Analysis of mining-induced microseismicity showed that the high velocity zone was the focus for seismic activity prior to and after the 1988 tremor, in contrast to the low velocity zone which remained aseismic for the same period. The seismic anomalies were diamond drilled following the tomographic imaging, to verify the physical characteristics of the zones. The seismically active high velocity zone showed severe core disking, indicative of a highly stressed strong rock, while the low velocity zone was characterized by extensive fracturing and failed rock. The results showed that the 1985 tremor and rockburst sequence resulted in a major failure of the rock mass in the source region of the event, and stress was redistributed and concentrated in the source region of the 1988 tremor. The 1988 event and rockburst sequence did not result in failure of the source region which therefore remains a seismically active high velocity zone with a potential for significant seismic energy release and further rockbursting.

In the second case study, a 3D imaging survey was carried out at Mines Gaspe, Quebec, Canada in June 1991. Although the resolution of the 3D survey is much less than the 2D survey, similar interpretations can be made for these images. A low velocity anomaly in the image is shown to be essentially aseismic in response to mining, while the major high velocity anomaly in the image is also the most seismically active. Source parameters were also computed for the mining-induced seismicity, and the relationship between energy release, stress drop and P- wave velocity anomalies are described.

The interpretation for both these case studies suggests that aseismic low velocity anomalies are areas of low rockburst potential, while regions of high seismic velocity and high seismicity are potentially rockburst prone. The correlations between velocity and seismicity appear to indicate that mining-induced microseismic events are concentrated in the regions of high stress gradient. The study has highlighted a correlation between P-wave velocity structure and induced seismicity which can be used to characterize highly stressed rock masses in underground mines.