Application of moment tensor inversion for the evaluation of failure components of induced microseismicity

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Abstract

The evaluation of the volumetric and shear failure components at seismic event locations is carried out using the moment tensor inversion of observed seismic displacements (e.g., Strelitz, 1978; Jost and Hermann, 1989). Applications based on mine induced seismicity offer valuable additional information for the design and planning of mining operations. The methodology employed in these applications is based on the quasi-automatic evaluation in the time domain of the observed low frequency displacements as a combination of squared displacements and velocities with first polarities attached (Trifu et al, 2000; Trifu and Shumila, 2001, 2002).

At Kidd mine (Ontario, Canada), a sill pillar at depth is investigated in connection to associated increased stress levels and the generation of microseismicity. Although critical for hauling operations at this open stop mine, the pillar appears to pose an imminent danger and the mine is evaluating its controlled destruction. However, failure analysis of the seismicity occurred within this pillar outlines a mechanism characterized by a major tensile component (72-76%), seconded by minor pure-shear (15-20%). This typical crack opening mechanism supports the conclusion that the pillar only exhibits incipient bursting conditions, as serious deterioration would be characterized by pure-shear fractures. Instead, pure-shear failures tend to locate outside this pillar, within highly fractured rock mass. The pillar was consequently maintained and continued to be used, although kept under control.

For a similar mining operation at Darlot (Western Australia), the question is raised whether the microseismicity is associated with the mapped faults or the mining stops. The mechanism results outline the presence of a large pure-shear failure component (up to 60%) and a significant volumetric component (20-40%). The mine geological model permits the evaluation of the smallest divergence angle between the orientations of either of the two nodal planes of the pure-shear component and that of the closest elemental fault cell, as well as that of the average fault. The results show significant divergence angles of 30–60^o. Since synthetic tests show that the mechanism solution is retrieved to within 10–15^o even under up to 30% amplitude variance simulating unaccounted attenuation effects, these results support the conclusion that the microseismicity at Darlot mine is primarily influenced by local stope and mining sequence.

At Ridgeway mine (New South Wales, Australia), a sub-level caving, the mechanism analysis supports the finding that the distribution of microseismicity provides a leading assessment of the caving front from the top of the loosened zone to the cave back, a zone that extends over approximately 20 m. Failure mechanisms show the presence of a high percentage of pure-shear (> 50%), together with a considerable amount of volumetric failure (~ 40%). In order to cave in, the rockmass adjacent to the cave must be essentially fractured. The large amount of shear exhibited by the above mechanisms is in agreement with the presence of a highly fractured rockmass. Additionally, the tension axes tend to align to the caving front as defined by the distribution of microseismicity. These results helped the successful tracking of the cave to surface, where it broke without incidents in early October 2002.

References

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