

Safety in Mines Research Advisory Committee

Project Summary: SIM 02 03 04

Project Title	Improved seismic locations and location techniques
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Authors:	A Cichowicz, SM Spottiswoode, L Linzer, D Drent, PS Heyns, and MF Handley	Agency:	University of Pretoria
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Category:	Gold and Platinum	Fundamental research	Mine Seismology
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Summary

Seismic locations are the most important information derived from mine-wide monitoring systems. The typical error of location varies from 30 – 100m, mostly depending on the density of geophones in the volume of interest. This location accuracy is sufficient to pinpoint which mining excavations may be damaged by the seismic event (hence providing guidance for a search and rescue effort), and to draw reasonably credible event location – damage distribution correlations. This permits a broad picture of relative seismic hazard mine-wide, but has now reached the limit of usefulness in further improving mine safety. Furthermore, there has been no real improvement in seismic locations in the last 10 years.

There are two ways to improve seismic data:

1. Increase seismic sensor density;
2. Use improved seismic location algorithms.

The first option relies on the notion that the more seismic traces, the better the location. It also means that the sensitivity of the system increases, resulting in a greater processing workload for seismic staff. There is an associated increase in the seismic monitoring system operating and maintenance costs. The latter option provides a means of “getting the best out of existing systems” without any increases in workload or operating costs. It also provides a path towards fully automatic seismic data processing, relieving seismic staff of manual processing and quality control, leaving more time for interpretation and hazard management.

Absolute location methods use some or all the traces from a single event in order to provide a location for that event. Both earthquake and mine seismologists use absolute location methods and manual processing as standard. In contrast, *relative location techniques* use traces from two or more neighbouring seismic events to obtain locations relative to each other. There are many spectacular results from relative location techniques scattered throughout the earthquake seismology literature, while mining seismologists, aside from a few experiments in waveform similarity, are yet to implement these techniques. A literature survey revealed that the double difference location algorithm is

more effective than waveform similarity techniques in the mining environment, because the latter is computationally intensive, hence slow, when large numbers of events must be processed. The summary objectives of the research were to:

1. Investigate weaknesses and strengths of the waveform similarity technique;
2. Identify and quantify sources of noise in seismograms;
3. Determine options for identifying seismic signals in noisy seismograms;
4. Develop relative location software for inclusion in current seismic location algorithms;
5. Review and refine automatic means of P- and S-onset identification;
6. Test improved seismic location techniques;
7. Estimate the error of seismic parameter determination.

Conclusions

The prime objective is to reduce location error by an order of magnitude, since researchers in earthquake seismology had claimed 10-fold error reductions using the double difference method, and a 5-fold reduction in error using the waveform similarity method. This project has achieved a 2- to 5-fold reduction in location errors with minimum operator input and no extra cost. Source parameter estimation errors are reduced proportionately using the standard seismogram-source parameter relationships in seismology. Errors should be further reduced when geophone misalignments and site effects have been quantified and corrected. Methods to achieve this were developed during the course of this work.

Future work involves implementing the results of this work, compensating for geophone misalignments, automating the P- and S-wave pick inconsistency algorithm, and coupling this with an automatic relative location algorithm to produce good seismic locations with a reliability of 99.99%. More work is necessary to develop an automatic means of determining the quality and reliability of relative location results.