Geophysical Research Abstracts,
Vol. 10, EGU2008-A-09300, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-09300
EGU General Assembly 2008

Early-warning microseismic systems applied to the management of post-mining large-scale ground failures: calibration by a geophysical field experiment of blast swarms

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In the Lorraine region of Eastern France, decades of iron ore mining have left extensive underground cavities beneath or in the vicinity of urban areas. As a consequence of major post-mining collapses that occurred in the 1990s, a strategy of post-mining risk management, supervised by national and local administrations, was set up. For the most hazardous areas, it relies on real-time monitoring systems to ensure public safety whenever appropriate risk treatment is precluded. For this purpose, INERIS tested and validated the microseismic monitoring technique as a volumetric method capable of detecting acoustic activity of underground ruptures before general collapse of the geologic overburden.

Although no major collapse has occurred in any of those monitored areas yet, and most of these have proved to be rather quiet, small microseismic events are however recorded as underground noise level. Usually recorded by single 3D probes, associated seismograms show very low amplitude, corresponding roughly to negative magnitudes at mine level. This raises some issues for reliable automatic analysis, especially source location, a fundamental parameter for any appropriate analysis and understanding of stability analysis.

In this context a specific field experiment was launched in 2005 for six instrumented zones. It consisted of sequences of numerous small blasts in underground mine pil-

lars accurately controlled in terms of location, orientation and energy of the explosive source. An exceptional database composed of more than 1200 seismograms was recorded during this experiment.

This unique database of underground artificial microseismic events was then used as a reference data set to test, reset or calibrate different parameters. It contributes to quantifying the sensitivity of the monitoring systems as well as to improving and validating the processing tools. The results benefit from the referenced database composed of the 1200 “induced-blast” seismograms. The data processing allowed to : (1) validate the polarization analysis tool ; (2) calculate P-waves velocity models of each site and characterize some geophysical properties of the main geological strata ; (3) optimize and validate the 3D localization tool ; (4) construct an empirical but accurate source energy and wave propagation laws for the different but geologically similar experimental sites including comparison tests.

Beyond the aim of determining geophysical properties for correct estimates of microseismic sources, the final objective of this experiment is to improve the quality and reliability of the operational real-time monitoring and thus make more reliable expertise during microseismic crisis at the French National Monitoring Centre for Ground and Underground Risks (CENARIS) of INERIS. The developed tools improve and generalize the operational procedures for the characterisation of post-mining instabilities microseismic swarms. Furthermore, the developments will improve decision-making aid for crisis management.