Microseismic Monitoring at the Troy Mine

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April 2014
Introduction

- Background
- December 2012 events
- MBMG – Regional seismic monitoring
- NIOSH instrumentation
- ESG geophones
- System expansion
• What is a seismic event?
  – Sudden release of energy within the earth’s crust which creates seismic waves, i.e. earthquakes

• What is a microseismic event?
  – Very small scale seismic event commonly heard by miners working underground
• Rock noise has long been seen as a warning of changing or unstable ground conditions.

• Researched by the US Bureau of Mines beginning in the 1930’s.
• Range of applications including mining, oil & gas, and exploration

• Underground applications:
  – Geotechnical analysis
  – Seismic hazard
  – Rock burst monitoring
  – Peak particle velocity / acceleration
  – Block cave mapping
• Increased rock noise reported by miners
• Suspend operations, begin monitoring audible noise from safe locations
• Events recorded by MBMG
Regional Seismic Monitoring

- Maintained by the Montana Bureau of Mines & Geology
- Confirm on-site observations
- Detect large events
- Limited number of stations in Northwest Montana
• Increased seismic activity prevented personnel from going underground
• The decision was made to install a microseismic monitoring system
Dr. Pete Swanson installed two seismographs on Dec 21, 2012.

- Decreasing trend over the following weeks
- Quantitative measurement of microseismic activity levels within the mine
- Initial estimate of effected areas and seismic velocity

Photo by Dr. Pete Swanson
Recorded Seismic Events per Hour

Date & Time (MST)

Number of Events Per Hour
• Data Acquisition
  – Sensors
  – Paladin
  – Telemetry
  – HNAS
• Determine area of interest
• Work with ESG to optimize array design
  – Sensor spacing
  – Try to surround area of interest with a 3D array of sensors
    • Limited by location of mine workings
  – Determine route from geophones to surface
Geophone Installation

- Finding a safe location for sensors
- 120V power required at each paladin
- Set-up
  - ESG field technician available to provide training and assist with installation
  - Determine triggering parameters
• Event Triggering
  – What constitutes an “event”
• Trigger Parameters
  – Amplitude threshold triggering
  – Number of sensors
  – STA/LTA triggering
• Defines the event
  – When
  – Where
  – Magnitude

• Dependent on seismic velocity
  – Requires initial calibration blasts

• Automatic vs Manual
• Events are automatically processed in real time

• Software determines P-wave arrival times based on STA/LTA algorithm
  – Typically less accurate than manual processing
  – Does not pick S-wave arrivals
• Various event types
  – Fracture style events
  – Rock fall
  – Blasts
  – “Noise”
• Remove noise events caused by mining
• Go through each event individually to determine locations
• Process blasts
Manual Processing
• ESG SeisVis Software
  – Uses colors / shapes / sizes to differentiate magnitude and event type
• Allows visual comparison of event locations with the mine workings
• Daily monitoring by engineering, mine, and safety departments
• Training personnel to differentiate between equipment noise and (micro)seismic events
• Remote desktop allows users to log in from anywhere with an internet connection
• All events are tracked in a spreadsheet
• Daily event processing
• Event frequency graphs generated regularly
• Determining background seismicity
  – What is “normal”
  – Audible noise vs measured seismicity
  – Work with geotechnical consultants to determine working and monitoring protocols
• Additional uses
  – Monitor cycle times
  – Improve practices / procedures

• System expansion
  – Modular design
System Expansion
• Improved regional seismic network
  – Worked with the MBMG to install a regional seismograph near the Troy Mine tailings facility
  – NIOSH researchers working to install a permanent station above the mine workings
    • Difficult terrain
    • Logistical issues
    • Data transmission (telemetry)
Acknowledgements

• Dr. Pete Swanson, NIOSH / OMSHR
• Mike Stickney, MBMG Earthquake Studies Office
• ESG Solutions Training Documents
• Troy Mine seismic data