Applications of Microseismic Monitoring in China’s Underground Coal Mines

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Outline

• Microseismicity
• Seismic Systems
  – Intrinsically Safe and Explosion Proof Seismic System
• Case studies:
  – Gas Drainage Optimization
  – Fault Identification
• Conclusion
Seismic Event

- Occurrences in which energy is released in the rockmass creating a series of seismic waves propagating throughout the rockmass
- Can cause a Fall of Ground or CoalBurst

Factors creating Seismicity:
- Mining at Depth
- High stress zones
- Major geological structures
- Mining practices and strategies
- Mining activities i.e. drilling and blasting
Seismic Waves

Two types are mainly used in seismic processing:

- Primary wave (P-wave)
- Secondary wave (S-wave)

- P-wave velocity is often 1.73 times faster than S-wave velocity
Seismic System Architecture

- **Surface systems** (for monitoring Seismic or larger magnitude events)
- **Underground systems** (For monitoring Microseismicity or smaller events)
- **Combined architecture**
Advances in Technology

- Transition from First Arrival based systems to continuous 24 bit resolution data recorders over the past 30 years
Intrinsically Safe MSHA-certified seismic system configuration

Seismic recorders must be located in ventilated, fresh air areas
The IS barriers are installed inside explosion proof junction boxes, which allow seismic recorders to be located in non-ventilated areas.
Sensor Array Design

- To evaluate the type and sensitivity (minimum magnitude detection) of the sensor array
- To determine sensor array configuration for minimum cost and optimum performance
Sensor Array Design

Challenges

• Loss of high frequency signals in coal which is softer than hard rock with lower wave velocities
  – Install geophones rather than accelerometers

• Most coal mines have a sub-horizontal working level that moves forward rapidly
  – Utilize a few triaxial sensors in addition to uniaxial sensors
Geophone array at Wudong coal mine

- 12-ch system
- 150 m spacing between sensors
- To monitor magnitude between -1.5 to 2
Monthly seismicity and blasting data at Wudong coal mine

September to December 2011

3-D Seismic Viewer
Case Study 1

- Methane Gas Drainage optimization using microseismic monitoring in Xinzhuangxi coal mine
Seismic clustering pattern identifies a circular shaped fracture zone in the Xinzhuanzi coal mine, matching the O-shape circle theory of Yuan and Liu (2003).
Gas drainage rate and purity after optimization

- Gas drainage rate improved from 3-8 to 5-15 m³/min
- Gas purity improved up to 50% without additional drilling costs
Case Study 2

- Identifying geological structures using microseismic monitoring in Xinzhuangxi coal mine
A two-dimensional survey indicates the presence of two faults at Xinzhuangzi mine.
2010.4.29 Seismic Event at Xinzhuangxi Coal Mine
Accumulated seismicity up to May 3\textsuperscript{th}

From 29/4/2010 to 3/5/2010 Seismic Event at Xinzhuangxi Coal Mine
Up to May 10th

To 10/5/2010
To 16/5/2010
Up to May 18th

To 18/5/2010
Seismic Active Area

Up to May 20th

To 20/5/2010
To 24/5/2010
Seismic moment density evaluated from microseismic source parameters for events in the areas of the Fa and F10-5(10) faults at Wudong coal mine.
Conclusion

• Seismic monitoring in coal mines can be challenging due to the limited mining elevation, and softer rockmass
• The advances in technology, seismology theory and powerful computers better allow recording and analysing seismic events in challenging media
• Seismic monitoring over time can help better explain the rockmass reaction to mining activities
• The history of data can be used to identify high stress zones, unknown or seismically active geological structures, and gas concentration zones