

# Bingham Canyon Mine monitoring system

## 9 Layers of protection



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1. Trained eyes everywhere (800+)
2. Regular documented inspections of all areas of mining activity
3. Prism network (220+) and Skyboxes (4 robotic theodolites - RTS)
4. Extensometers (6)
5. Time Domain Reflectometry (TDR)
6. Microseismic array
7. Slope Stability Radars (3)
8. IBIS Radar system (3)
9. Geographic Information System (GIS) data display

The Bingham Canyon Mine monitoring system demonstrated 9 layers of protection to ensure employees' safety before, during and after the slide on April 10, 2013.

### Results

- All personnel safe and out of harm's way
- Early warning of Manefay movement
- Monitoring and planning preceded failure
- Relocation of people from buildings near fault area
- Upgraded secondary access road for egress
- Pit evacuation drill
- Over 1000 employees kept safe

## 1. Trained eyes everywhere

All mine personnel trained in identifying geotechnical hazards during annual MSHA refresher.

Hazards reported to supervisor or Production Control. Information passed to geotechnical team for investigation.

Rock fall spotters used during active failures.



## 2. Regular documented inspections of all areas of mining activity

Inspections by shift supervisor prior to the start of each shift.

Periodic inspections by geotechnical engineers or as requested.

Potential hazards to identify during inspections include loose rock in the pit wall, tension cracks on catch bench, rolling rock & dust clouds, and rock fall on catch bench.



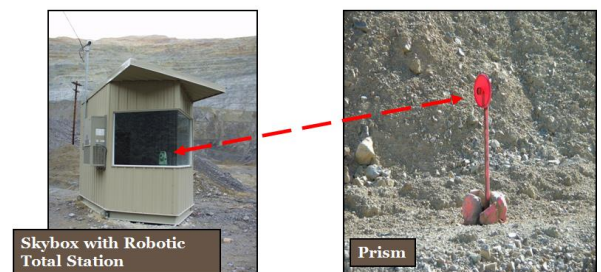
## 3. Prism network (220+) and skyboxes (4 RTS)

Kennecott has an extensive slope monitoring system that utilizes both simple measuring devices and a variety of sophisticated instrumentation.

Robotic Theodolites and electronic extensometers provide a regular update of slope movement information from hundreds of monitoring points throughout the Bingham Canyon Mine.

Prisms are scanned every hour, and extensometer readings are taken every 10 minutes. Prism and extensometer movement is captured 24/7 giving geotechnical engineers valuable insight into areas of instability.

Warnings are provided in areas where visual observations may otherwise not be available.



## 4. Extensometers (6)

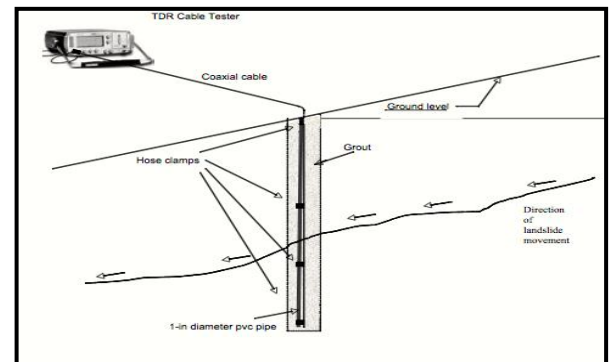
Wire line cable under tension extends between a supply spool and an anchor to measure tension crack displacement in open pit slopes.



## 5. Time Domain Reflectometry (TDR)

TDR cable system is used to detect and monitor movement of known and potential landslides. It is a subsurface monitoring device.

The apparatus detects discontinuities or damage in electric cables. The apparatus will show changes compared to the signal obtained originally when the cable was undamaged, allowing determination of the depth, progression, and general magnitude of movement.



## 6. Microseismic array

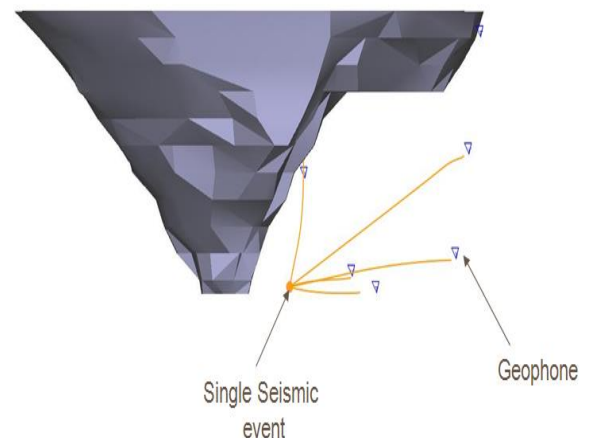
Movement in the subsurface will cause fractures to grow in the rock. Intact rock breaking will create a "noise" in the ground.

This noise is a microseismic event, and may be detected with a microseismic installation.

Geophone arrays installed in boreholes drilled into the open pit mine detect events and record the arrival times of seismic waves.

The data is transmitted to a central office computer where processing software determines the location of the event based on arrival times and a pre-computed 3-D seismic wave velocity model of the pit.

The data is transmitted offsite automatically for periodic interpretation by geophysicists specializing in micro seismic monitoring.



## 7. GroundProbe- Slope Stability Radars (3)

The slope stability radar depends on advanced survey technology and detects movements by comparing successive slope scans.

Scan time depends on the size of the area, but typically range from 4-10 minutes

The advanced analysis tool allows detection of both short and long term slope movement.

The radars are programmed with specific, adjustable alarm settings. If the alarm is triggered, then mine personnel are notified of the movement, allowing rapid evaluation of the surface deformation.

GroundProbe radar's accuracy level is up to 1/10th of an inch and has a range of 10,000 feet. Data resolution and quality is improved at closer range, and ideally it is operated within a few thousand feet of the moving area.



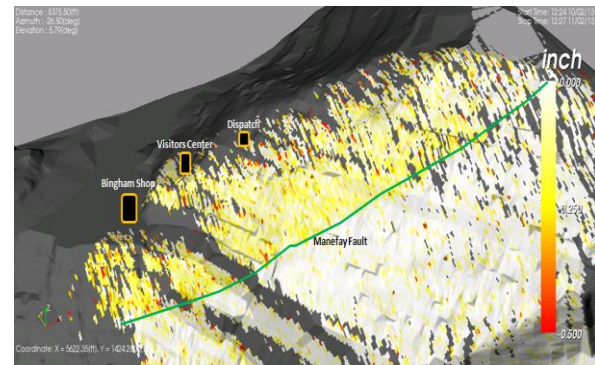
## 8. IBIS Radar System (3)

IBIS radar system also incorporates advanced survey technology to monitor slope movement in open pit mines.

The radar scans a portion of an open pit in six to eight minutes. The effective accuracy level of IBIS radars is at least 1/10th of an inch and range up to 10,000 feet.

IBIS radars are also equipped with alarming capabilities, notifying the mine personnel of detected movement in open pit slopes.

IBIS radars are capable of monitoring mine pit slopes in adverse weather conditions and during low visibility. The mine is purchasing a 4th IBIS radar.



## 9. Geographic Information System (GIS) data display

Customized by KUC staff.

Captures multiple data sources

Accessible by wireless technology

Allows quick system status checks

Visual display of changing conditions

Quick links to instrument charts

