Relative Stress Conditions in an Underground Pillar, Homestake Mine, Lead, SD

D. F. SCOTT†
T. J. WILLIAMS†
M. J. FRIEDEL‡
D. K. DENTON†

One of the basic problems in hard-rock mining associated with deep (> 2000 m) underground deposits is high stress, which frequently results in failure, both gradual and violent, of the rock mass. Violent failure of rock in areas where miners are present is a severe safety hazard. Personnel from the Spokane Research Center, a division of the National Institute for Occupational Safety and Health (NIOSH), have been investigating the use of three-dimensional seismic tomography to detect hazardous ground conditions and monitor the mechanical integrity of a rock mass. This technique was used to determine relative stress in an underground pillar on the 7400 level (about 2256 m below the surface) of the Homestake Mine, Lead, SD.

The time needed to conduct a survey, including site preparation, collection of data, data analysis and graphics preparation, is about 150 h for a pillar measuring 228 m long, 137 m wide and 50 m high. Capital investment for equipment, including a 24-channel seismograph, 24 geophones, seismic spread cables, a 486 computer and software, is about $58,400. Leasing a seismograph, geophones and seismic cables is estimated to be about $1000/day or about $2000 for a survey of a 2 million cubic meter rock mass.

The high schistosity of rocks in the Homestake Mine tends to inhibit violent seismic activity, but creates squeezing ground conditions, which cause damage to the skin of mine openings. On the 7400 level, low velocities, which are interpreted as identifying areas of low stress, were associated with boreholes, segments of haulageways, and the corner of an adjacent pillar. High velocities, which are interpreted as identifying areas of high stress, were identified in the northeast part of the pillar. High stress can result in enough seismic activity to cause unsafe conditions for miners, such as ground falls.

The importance of identifying highly stressed areas in a pillar is that engineers can evaluate the mining cycle and determine the best approach to excavating such areas, or use distressing or preconditioning techniques to relieve the stress. In the field of rock mechanics, the benefits of using three-dimensional seismic tomography to identify high stress are that (1) the technology is noninvasive, (2) it is reliable, (3) it allows a series of surveys to be conducted over time, (4) it is less expensive than conventional methods, (5) it is time efficient, and (6) it allows researchers to evaluate and monitor a large rock mass (as much as 2 million cubic meters of rock).

Keywords: seismic tomography; stress; underground pillars; ground control

†Spokane Research Center, National Institute for Occupational Safety and Health, Spokane, WA 99207, U.S.A.
‡Lakeville, MN, U.S.A.

Characterization of *In Situ* Stress Conditions at Depth—Homestake Mine, Lead, South Dakota

J. M. GIRARD†
R. W. McKIBBIN†
J. B. SEYMOUR†
F. M. JONES†

Determining the magnitude and orientation of *in situ* stresses is one of the most critical factors in designing underground excavations and choosing ground support systems. Generally as mining progresses deeper, *in situ* stress plays a significant role in design considerations. In an effort to further characterize the rock mass in the deep levels of the Homestake Mine, researchers from the Spokane Research Center have completed overcore, i.e. stress relief, measurements using the Bureau of Mines-developed borehole deformation gage. The Homestake Mine geology is comprised of three main geologic formations (Homestake, Ellison and Poorman) each with distinct material properties. The best estimate of an *in situ* stress field would occur when strain relief measurements were taken in solid and mechanically similar rock. However, field conditions generally preclude the reality of such an occurrence. In this particular study, a strong geologic contact was crossed and two very distinct rock types were encountered. Even though variability in geology raised some preliminary concerns, a reasonable stress estimate was calculated based on extensive laboratory tests of the rock, empirical estimates and historical data. The importance of geologic structure was emphasized when the stress state computed along one of the drill holes showed that a 23-in [58 cm] quartz inclusion was carrying more load than the Homestake formation on either side of the inclusion.

Knowledge of the principal stress directions, coupled with geology and locations of current mine openings, is a key to designing safe underground excavations. Through comprehensive programs including materials property testing, instrumentation, numerical modeling and field testing, the *in situ* stress field may be predicted for similar geologic structures. This paper examines the effects of variable geology on stress determinations, and compares these recent stress measurements and field observations with other *in situ* measurements collected in previous research investigations at the mine.

Keywords: *in situ* rock stress; drilling; field tests; stress measurement; borehole deformation gage; biaxial chamber; strain; stress; rock properties; homestake

†Spokane Research Center‡, National Institute for Occupational Safety and Health, East 315 Montgomery Avenue, Spokane, WA, 99207, U.S.A.

Stratigraphic Subunits and Control of Ground in the Revett Formation, Coeur d'Alene Mining District, Idaho

J. K. WHYATT†
B. G. WHITE†

This paper describes recent progress in identifying geologic factors that influence the spatial distribution of ground control problems in deep, hard rock mines of the Coeur d'Alene Miningh District of northern Idaho. Falls of ground and rock bursts have presented longstanding hazards to miners in this district. This hazard has been particularly evident in the Revett Formation, which has hosted 75% of district production and is known for its intensely seismic response to mining. This work grew from recognition that three mechanically distinct rock types could be defined throughout the district based on the relative presence of fine quartz grains and sericite, and that mappable stratigraphic subunits (20–70 m thick) could be identified by predominant rock type within the Revett Formation. This insight proved to be the key to understanding the spatial distribution of rock bursts and seismicity in three case studies. The first case study examined unusually concentrated rock bursting and seismicity that were encountered in driving a crosscut in a vitreous quartzite subunit, at a site where an overcore stress measurement found an unusually concentrated and rotated *in situ* stress field. A second case study examined the spatial distribution of seismicity encountered during driving of development openings and found that the majority of seismic activity was encountered in two zones located in a vitreous quartzite subunit. A third case study examined a set of large (>2.5 M_l) rock bursts that were caused by vertical slip of remnant pillars where a vitreous quartzite subunit abutted the vein. In this case, observed offsets and seismic first-motion patterns were consistent with concentration of stress in the plane of a vitreous quartzite subunit. These case studies show that stratigraphic subunits have an important influence on the spatial distribution of ground control hazards in the Revett Formation.

Keywords: rock bursts; *in situ* stress; ground control; mine safety; mining at depth; rock properties; anistropy

†Spokane Research Center, National Institute for Occupational Safety and Health, Spokane, WA 99207, U.S.A.