IN THE
SUPREME COURT
OF THE
STATE OF IDAHO

RONNEL E. BARRET, etal

Petitioners-Appellants.

v.

HELCA MINING COMPANY, etal

Defendant-Respondent.

Appealed from the District Court of the First Judicial District of the State of Idaho, in and for the County of Kootenai.

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VOLUME 2 of 5
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Supreme Court
Court of Appeals
Exhibit 4
EXECUTIVE SUMMARY

1) This report represents Phase 2 of a two-part project aimed at providing predictive modeling of the extraction of the 5300-5900 pillar at the Gold Hunter portion of the Lucky Friday mine. Phase 1 of the project consisted of an initial rock mechanics model calibration study (Board, 2010). In this phase of the project, a three-dimensional (3D) model was used to simulate the creation of the circular 5900, 30 Vein access crosscut pillar at Gold Hunter by mining of the adjacent stopes. The predicted induced stresses, orebody yielding, and hangingwall-to-footwall closure of the pillar were compared to: a) measurements of stress change (IRAD gauges), b) yielding extent observed in adjacent stopes and in pillar observation hole breakouts, and c) vein closure measurements along the 5900 drift. It was concluded that the model provided adequate comparison to these observations and that the rock mass properties and in situ stress state could then be used for simulation of the response of the mining of the 5300-5900 pillar.

2) This current report summarizes the results of a geomechanical analysis of extraction of the 30 Vein pillar remaining below the 5300 level stopes and above the 5900 level stopes in the Gold Hunter portion of the Lucky Friday mine in Mullan, Idaho. This mining block will provide production from the Gold Hunter operation through approximately 2013. Current concepts call for extraction of this reserve by using underhand cut and fill methods, by mining down from the base of the 5300 level stopes to meet up with 5900 stopes which were extracted using overhand cut and fill methods. This remaining reserve will be mined from the 5500 level to the 5700 level. This approach will continue to create a pillar of reducing vertical height (and decreasing width to height ratio) that will concentrate vein-perpendicular stresses within the pillar. This report presents the results of 2D and 3D numerical stress analyses of this mining and examines the stress concentration and failure within the reducing pillar and the surrounding rock mass. Additionally, the stresses along flat, north-dipping footwall faults are determined to estimate the slip potential of these faults and the general likelihood of producing seismic response.

3) The results of the analyses were used to estimate the potential seismic mechanisms that could occur during the pillar extraction. The most likely seismic mechanisms and their timing within the mining sequence are estimated as follows:

- **Fault Slip** – Fault slip on flat north-dipping footwall fault structures within the region bounded by the orebody to the south and out to approximately the outer turnings of the ramp to the north. These events are most likely to occur in the footwall region adjacent to the pillar or below it where the ratio of shear to normal stress along the faults exceeds the estimated Mohr-Coulomb slip condition. Seismicity appears less likely to occur near the top of the pillar and adjacent to the above mined underhand stopes as this orientation tends to promote clamping rather than shear. In other words, due to the orientation of these fault structures, it is expected that the underhand stope would be less susceptible to seismicity (in the footwall) than the overhand stope up to a certain pillar height that both stopes interact. This point is difficult to determine from the results of the modeling. Based on the frictional properties and locations assumed for these faults, seismic events on them are possible in the current time (in fact, they appear to be occurring now) and are expected to potentially occur throughout the pillar mining. Estimation of the possible magnitude of these events from the model is very difficult to make due to unknown fault continuity and topography, but the slipping area
EXECUTIVE SUMMARY
(Page 2 of 4)

would suggest events in the 1.5 M_L range, or slightly higher, are possible. Events to date show that events in the 1.5 to 2.5 M_L range have occurred in this area. As recommended later, a program of structural mapping and classification of the fault orientation and continuity (to the extent possible) as well as the surface characteristics (waviness and infilling) should be made and related to the seismic record in an attempt to define which fault characteristics give rise to seismic response.

- **Pillar Foundation Failure** – Foundation shear failure occurring in the hangingwall and footwall rocks as a result of pillar punching appears possible when the pillar height is reduced to somewhere around 75' in height. The term “punching” means that the pillar itself is stronger than the wall rock and may act as a rigid “punch” that indents into the wall rock under the applied pillar loads. This results in shear fracturing through the wall rock emanating from the pillar edges. The modeling indicates that, for the strength assumptions of the footwall and hangingwall rocks, the pillar is still too wide to induce this type of mechanism with the current stope and pillar geometry. The modeling indicates that this mechanism could potentially result in seismic events due to formation of shear fractures in the wall rock and would occur relatively close to the stope. This is a result of a relatively (relative with respect to the wall rock strength) strong orebody with a squat, strong pillar sandwiched in a weaker, bedded rock mass. This type of failure has been noted in some South African gold mines (COMRO, 1988) as well as deep room and pillar operations.

- **Strain-Bursting** – More common pillar strain-bursting mechanisms, typical in other Coeur d’Alene mines, appear less likely, but are estimated to be possible in siliceous veins if the pillar is reduced to around 50' in height or less. From the current seismic record, it does not appear that this mechanism is currently operating in the 5900 pillar, and would only be expected when the pillar height is sufficiently reduced.

4) Recommendations include:

- **Ground Support** – Conduct a review of the footwall development and stope ground support to determine whether the ground support is within seismic standards for the expected magnitudes and locations of footwall seismic events. These events would be located in the region between the stope and ramp, and have magnitudes from 1.5 to 2.5.

- **Geologic Interpretation of Structure** – Develop a project with the Gold Hunter geology/geotechnical staff to map footwall fault locations, orientations and continuity, as well as surface characteristics. A methodology for relating fault characteristics to seismic potential in mining has not been developed, to my knowledge. However, understanding why certain faults/structures in specific locations at the Gold Hunter are susceptible to seismicity would prove very useful in developing a method for identifying regions where larger events can be expected. Additionally, this would assist in development of numerical tools that can be used to anticipate future locations and timing of events. I would suggest that the Gold Hunter geology staff examine the following types of characteristics of structures and develop some form of classification system for comparison of these features as mapped in stopes, xcuts, ramps, and sublevels:
EXECUTIVE SUMMARY

(Page 3 of 4)

- Orientation (dip, dip direction)
- Continuity (traceable length)
- Surface characteristics (gouge, strong infilling, slickensides, thickness, etc.)
- Surface topography (waviness and amplitude, offsets and splays, etc.)

This classification could then be compared to the seismic monitoring history (see below) and observations of damage and fault offsets underground as a function of time to attempt to relate the fault characteristics to seismic potential.

- **Laboratory Strength Testing** – Conduct a program of laboratory testing to identify the triaxial strength properties of common orebody and wall rock units to better understand potential failure mechanisms. There is currently an inadequate database of strength information on these rocks. The following types and numbers of laboratory tests are suggested:

For each major lithology (argillite, silicic argillite/silty argillite, sericite), conduct uniaxial and triaxial tests as follows:

- Uniaxial compression – conduct approximately 10 UCS tests on each of the above lithologies. For samples with strong cleavage, attempt to choose samples with a variety of angles of the cleavage to the core axis to understand the impact of anisotropy on UCS.
- Triaxial compression – conduct at least 3 triaxial test series on each lithology. A triaxial test series would include strength testing at confining pressures of 5, 10, 15, and 25 MPa.

- **Seismic Monitoring** – Discuss with Dr. Wilson Blake to determine what additional information can be gained from future seismic monitoring. In particular, it would seem useful to determine source mechanisms for the larger events to correlate with the fault characterization program described above, as well as the results of modeling. This analysis—relating the fault characteristics and model predictions of slip location and magnitude—would help to increase the confidence level in predictability of future seismic potential. The types of seismic parameters that would prove useful would be:

  - Source location
  - Magnitude
  - Orientation of slipping structure
  - Slip radius

- **Mining Methods** – Examine alternative mining sequences for removal of the last 75-100’ (approximate) of the pillar. Potential methodologies include:

  - Use of destress blasting in the orebody below the underhand mining front to precondition the orebody and reduce its stiffness. This addresses potential pillar bursting mechanisms and possibly foundation failure, but is unlikely to affect the fault-slip mechanism.
EXECUTIVE SUMMARY
(Page 4 of 4)

Revision of the current method to a narrow vein blasthole-and-fill end-slicing method in which the two current stopes retreat from the center of the span toward the abutments. This approach attempts to progressively push stress concentrations toward the abutments during extraction without increasing pillar stresses. Advantages include a more stable stope geometry and potential reduction of worker exposure. The obvious disadvantage of this approach is the potential dilution from wall rock as well as introduction of a new mining method and equipment. The plan could be optimized to determine size of blasts and re-entry protocols, retreat distances prior to backfill, possible remote controlled equipment, control of stope access to minimize worker exposure, etc. It is recommended that a location be chosen away from the current pillar extraction region, perhaps at the ends of the previous stopes, to test the method. The testing could determine the best methods for slot raise development, maximum open span prior to filling, dilution, and other design parameters.

5) This report provides estimates of rock mass response to mining using the best information available. The resulting conclusions and recommendations are preliminary in nature, with the following limitations:

- There is a small database of laboratory strength properties for the various rock mass lithologies. Additionally, the Wallace Formation is a thinly-bedded material that has highly anisotropic behavior that is complex in its mechanical response. This means that estimates of rock mass strength cannot be made with great confidence without extensive calibration of the models against information including stope and drift deformations. The rock mass strength and material model estimates have a significant impact on numerical results, and thus overall confidence in the conclusions.

- The location, orientation, continuity, and surface characteristics of the faults assumed here are not well understood at present. Assumptions as to the fault characteristics have a direct impact on predictions of slip potential, and location and magnitude, which are, obviously, preliminary in nature.

- Finally, due to the complex nature of rockburst source mechanisms, prediction of the specific locations and timing of these events is inherently an inexact science. The conclusions and recommendations give our best estimates as to the potential for these events.
Exhibit 5
22 March, 2010

Subject: Calibration of 5900 Pillar Numerical Model

1 Introduction

This report reviews calibration of the 3DEC numerical model against stress meter data, borehole and drift stability observations in the 5900 Gold Hunter drift at the Lucky Friday Mine in Mullan, Idaho. The 5900 drift crosses from the Silver Shaft through the 30 and 40 veins to the footwall ramp development and is required to be stable for access to the stopes from the Silver Shaft. A 50’ radius circular stabilizing pillar was left in place through the 30 vein with the 5900 drift at its center. The pillar was created by adjusting the ends of adjacent cut and fill stopes such that a circular shape was created. After driving of the 5900 drift, IRAD stressmeters were installed in short boreholes drilled vertically up and horizontally into each wall of the drift at the orebody intersection. These stressmeters are oriented to monitor stress change resulting from the pillar creation in the vein-perpendicular (roughly N-S) direction. In addition to the stress data, two horizontal observation diamond drill holes were drilled in the sidewalls of the drift down the axis of the vein after the pillar was completed. The core was examined to record initial pillar condition and have been scoped with a digital borescope a number of times to record damage accumulation.

A previous study of the stressmeter data and pillar failure observations was conducted by Pikalnis and Associates (2009). This study utilized an elastic numerical model (MAP3D) to perform a prediction of stress change in the pillar as a function of estimated orientation and magnitude of the in situ stress components. The conclusions of this study was that an E-W major horizontal stress component with a value of 1.5 times the vertical (gravitational) stress provided a best fit to the stressmeter data. Empirical damage criteria, based on the ratio of either the maximum shear stress ($\sigma_1 - \sigma_2$) or the maximum induced stress ($\sigma_1$) to the uniaxial compressive strength ($\sigma_c$), were used to compare to observations of borehole discing, reportedly showing good correlation to the discing.

In this study, the 3DEC model is used to simulate the mining and pillar creation assuming the orebody and rock mass behave as yielding materials. The induced pillar stresses and damage are compared to stressmeter data and borehole observations. The conclusions reached are that the model corresponds reasonably well to the data and observations, and that the major principal stress is at an azimuth of roughly N40W. The conclusion from the analyses indicate that the pillar is yielded around its periphery, but that the interior of the pillar remains at an unyielded, elastic state. It is felt that the pillar stresses will not increase dramatically from the current state. It is still possible to have relatively low-level seismicity occurring around the periphery of the pillar where the stresses are high, but the potentially larger events would occur due to pillar foundation failure or slip on fractures in the wall rocks around the pillar periphery.
Numerical Modeling Approach and the 5900 Pillar Model

The numerical modeling approach used here is the 3DEC program of Itasca (Itasca, 2007). This program is used to simulate three-dimensional mining geometries and is uses a "discontinuum" method. This means that the program is capable of representing the failure of the rock mass (i.e., the general rock mass consists of intact rock and in situ jointing) as well as movement along major fracture or fault surfaces. To represent the rock mass, it is typically subdivided into blocks separated by the major fault traces. The blocks, which consists of intact rock blocks separated by fracture or bedding surfaces, are typically represented by a rock mass failure criterion (that takes into account the weakening effects of the general rock fracturing). Specific, important faults may be represented explicitly as breaks in the model that separate rock mass blocks. In this project, the rock mass is represented without specific fault surfaces, and as a rock mass only. The rock mass is subdivided into a large number of tetrahedral finite difference elements in which the stress state and deformation are determined at each element.

The 5900 pillar and surrounding 30 and 40 vein stoping are represented in the 3DEC model. DXF files of the 30 and 40 veins and the development were supplied by Lucky Friday staff, and these were used to form the numerical model. The 30 vein stopes were subdivided as per the DXF file and extracted stope-by-stope in the actual sequence that occurred in the mine. The stopes that formed the basic circular shape of the pillar were mined in a series of 23 steps (termed Phase I as was used by Pikalnis, 2009), followed by extraction of the remaining ore above and below the pillar in 2 steps, termed Phase II and III. Figures 1 and 2 show large scale and close-up views of the 5900 pillar from the hangingwall. Here, the actual dxf stope outlines are shown in transparent mode with the 3DEC model representation given behind. The infrastructure development is also given showing the correspondence of the model to the actual geometry.
Figure 1  Outer boundary of the model showing 3DEC block structure. The model is about 3300' on a side, with the y axis pointing north. The orientation of the orebody (dip 90°, dip direction 17°) can be seen in the blocks. The 30 vein is located deep inside this model.
Figure 2  Large scale view of the 30 Vein geometry superimposed on the 3DEC model (note, the non-pillar areas of the 30 and 40 Veins are removed from the 3DEC model for visual clarity).
3 Rock Mass Material Model and Properties Estimate

3.1 Material Models to Represent the Major Rock Units

The Gold Hunter rock mass is represented in this calibration model as two material types: the orebody and the footwall and hangingwall argillites. For the level of this analysis, it is felt that the orebody and host rock are not required to be further subdivided into various rock types since we do not have detailed mapping of the variability. However, a sensitivity study is made to look at variability in the ore strength and separate models are run assuming a silicic quartzite and siderite ore.

3.2 Orebody Representation
The orebody, which is composed of vein material and silicified rocks, siderites and quartzites, is represented as a material that is elastic until its peak strength is reached, followed by yielding and reduction in strength to residual strength after failure. This type of model is termed "strain-softening" or "strain-degradation" model in that the strength is degraded with increasing shearing strain after peak strength. The strength of the ore is defined using a standard method using the Hoek-Brown failure criteria (Figure 4).

![Figure 4](image)

**Figure 4** The Hoek-Brown failure envelope is a parabolic function describing the rock mass failure condition in terms of the major principal stress. Stress states below the criteria indicate an elastic rock mass, while stress states on the criteria indicate a failed state. Stress states above the criteria are not possible due to yielding and stress redistribution.

A Hoek-Brown strength criteria defines the peak strength of the rock mass in terms of the principal stresses ($\sigma_1$, the major, or driving, principal stress, and $\sigma_3$, the minor or confining principal stress). During excavation, the stresses in the 5900 pillar will change from the in situ stress, to some other state as a result of stress relief and concentration from the mining. If the stress state reaches the failure condition, yield in that region will occur, and the stresses will decrease based on how much strain occurs in the rock mass. Figure 5 shows a schematic of the stress-strain behavior of the rock mass that is assumed and is typical of strong, brittle rocks such as quartzite. This figure indicates that after peak strength, the rock will yield and strength decays to a residual level over some amount of strain. The "brittleness" (or, violence) of the failure response is governed by how quickly the strength decays from peak to residual strength. If this strength decay occurs over very small levels of strain, the response is brittle and violent, and similar to how glass might behave when fracturing. If the strain over which this decay occurs is larger, the response is more "ductile" in nature and less violent. In the 3DEC analyses, it is assumed that the ore responds as a relatively brittle material which could respond in a seismic nature. This is an assumption based on experience in the Coeur d'Alene rock types.
3.3 Argillite Wallrock Representation

The argillite, on the other hand, is assumed to behave in a ductile fashion in which the response is dominated by the weak cleavage planes which are assumed to strike sub-parallel to the orebody. A material model, termed the ubiquitous joint model, is used in 3DEC to represent a thinly-bedded rock mass like the argillite. This material model assumes that the rock mass has a large number of bedding planes or joints oriented parallel to the orebody, and that these joints are weak (i.e., no cohesive strength—in other words, they can be pulled apart easily, and that the friction angle along them is low as a result of the typical slickensides and chloritic/talcy minerals on their surfaces. This model allows shear to occur in the direction of the cleavage planes, and buckling into the excavations.

3.3 Rock Mass Properties Estimates

As stated above, the Hoek-Brown strength criteria is used to represent the stress level at failure for the orebody. The Hoek-Brown criteria is a parabolic relationship between the major and minor stress at failure (Figure 4). Rock mass properties are estimated by the following approach:

1. The Hoek-Brown failure criteria for intact (laboratory-scale) rock specimens is defined by curve-fitting the criteria to uniaxial (UCS) and triaxial compression data. The HB failure criteria is expressed as follows:
Two parameters describe the failure envelope for intact samples of rock: the UCS ($\sigma_c$) and $m_1$ which defines the amount of curvature of the envelope. In our case, we have little actual laboratory data to describe the various rock types. Currently, a few tests of the UCS (provided by NIOSH) indicate a significant variability in orebody strength based on content of siderite, quartzite and argillite. The UCS of the siderite samples averages around 50 MPa (about 7000 psi) whereas the vitreous quartzite is around 17,000 psi or 115 MPa. To fit the HB envelope to the intact rock sample data, the curvature parameter, $m_1$, shown in the above equation is required. In the absence of triaxial data on these rock types, from which $m_1$ is typically derived, approximate literature values for quartzite are used. Here, a value of $m_1$ of 20 is assumed. It should be noted that the UCS testing conducted for Gold Hunter falls at the lower end of the range for ore types in the Lucky Friday mine as reported by Whyatt, et al, 1996. They present the following average values of mechanical properties for the Lucky Friday mine (Table 1): 

Table 1 Proposed values of rock mass strength and modulus for Lucky Friday Mine (Whyatt, et. al., 1996)

<table>
<thead>
<tr>
<th>Mine, rock type, and sampling site</th>
<th>Compressive strength</th>
<th>Tensile strength</th>
<th>Elastic modulus</th>
<th>Poisson's ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MPa</td>
<td>psi</td>
<td>MPa</td>
<td>psi</td>
</tr>
<tr>
<td>Lucky Friday:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitreous quartzite (FW-4250)</td>
<td>145</td>
<td>21,000</td>
<td>17.2</td>
<td>2,500</td>
</tr>
<tr>
<td>Viscous quartzite (WH-5100, 5200)</td>
<td>161</td>
<td>23,000</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Viscous quartzite (FW-Kellog fracture)</td>
<td>151</td>
<td>21,500</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Seismic quartzite (FW-4750)</td>
<td>314</td>
<td>45,500</td>
<td>17.2</td>
<td>2,500</td>
</tr>
</tbody>
</table>

As seen in this table, the rock UCS values are significantly higher than estimated by Pikalnis. Thus, it is likely that the UCS for vitreous quartzite could be significantly higher than assumed in the Pikalnis report.

2. Obviously, the strength response for small, intact rock samples does not represent the actual strength of the in situ rock mass. The Hoek-Brown approach provides for a methodology for adjusting the failure envelope of the intact rock to in situ values based on the "quality" of the rock mass. This quality is typically expressed in terms of the GSI (Geologic Strength Index) of the rock mass, which is based on the degree of fracturing and the coatings on fractures. Figure 6 shows a chart illustrating the method of determining GSI. Pikalnis (2009) performed an analysis of the GSI for the ore, which was confirmed during my visit to the mine in Feb. 2010. The orebody is typically a good quality material with clean and rough natural fractures, resulting in a GSI.
estimate of around 55 to 60. The resulting estimate of the Hoek-Brown failure
criteria for the orebody base condition is given in Figure 6.
3.4 In Situ Stress

The in situ stress state in the Coeur d'Alene district has been reported by Whyatt, et al. (1995) as given in Table 2. This correlation is based on stress measurements at the 4200 and 5300 levels of the Lucky Friday as well as the 7300 level of the Star Mine. The measurements indicate a $\sigma_1$ direction of about N40W and a ratio of $\sigma_1/\sigma_v$ of approximately 1.5. The

Figure 6 Approximate estimate of range of the GSI for the orebody in 30 Vein. The rock mass is classified in general as a good quality material with block to very blocky conditions and GSI of about 55 to 60.
maximum stress direction is reinforced by numerous observations of breakouts in boreholes, shafts and raises as summarized in Figure 7. Pikalnis (2009) estimated a maximum stress direction of E-W based on a best-fit back-analysis of the 5900 pillar IRAD stressmeter readings. To my knowledge, the available stress measurements and raise breakouts district-wide show a range in \( \sigma_1 \) direction of approximately N20W to N40W (Whyatt, 2000).

The in situ stress state applied to the 3DEC model was varied from N15W to N40W, with the vertical stress component based on 1.2 psi/ft depth and a ratio of \( \sigma_1 / \sigma_v \) of 1.5.

### Table 2  **Lucky Friday Mine In Situ Stress Estimate** (Whyatt, et. al., 1995)

<table>
<thead>
<tr>
<th>Stress component</th>
<th>Magnitude(^1)</th>
<th>Bearing</th>
<th>Plunge</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma_{xx} )</td>
<td>57</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>( \sigma_{yy} )</td>
<td>49</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>( \sigma_{zz} )</td>
<td>35</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>( \tau_{xy} )</td>
<td>-15</td>
<td>-0.6</td>
<td></td>
</tr>
<tr>
<td>( \tau_{xz} )</td>
<td>2</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>( \tau_{yz} )</td>
<td>-10</td>
<td>-0.4</td>
<td></td>
</tr>
<tr>
<td>( \sigma_1 )</td>
<td>70</td>
<td>3.1</td>
<td>N40° W</td>
</tr>
<tr>
<td>( \sigma_2 )</td>
<td>42</td>
<td>1.8</td>
<td>S41° W</td>
</tr>
<tr>
<td>( \sigma_3 )</td>
<td>29</td>
<td>1.3</td>
<td>N68° E</td>
</tr>
</tbody>
</table>

\(^1\) Magnitude is a function of overburden depth.
4 Summary of Model Runs and Analysis

A series of model analyses were run for comparison to stressmeter measurements, discing and borehole breakout observations. These are summarized below:

- **In situ stress variation**
  - Base case model assumes $\sigma_1$ direction of N40W and $\sigma_1 / \sigma_3$ of 1.5
  - Alternative stress model assumes $\sigma_1$ direction of N15W and $\sigma_1 / \sigma_3$ of 1.5

- **Strength variation**
  - Assume base case stress condition
  - Base case assumes a UCS strength for orebody of 115 MPa (16,900 psi) and GSI (or RMR) of 60. This is the “fair to good quality silicified orebody” assumption
  - Alternative case assumes a UCS strength of the orebody 115 MPa, but a GSI of 50, which is a “poor to fair quality silicified orebody” assumption
  - Alternative case assuming a siderite orebody with UCS of 50 MPa (7350 psi) and GSI of 50, representing a poor-fair quality siderite.
The initial in situ stress variations were run for comparison to the stressmeters, followed by variation of the strength for the N40W base case to examine the impact of strength variability of the ore on pillar failure extent and mechanisms.

4.1 Stress Variation

A series of plots showing the evolving maximum principal stress (vein-perpendicular) and the regions of failed rock are contoured through the center of the 5900 pillar are given in Figures 8-10 for the base case stress state and silicified orebody strength. As seen in these plots, the immediate edges of the pillar as well as the back (and floor) of stopes yield in shear and extension as the stopes are mined. This creates a thin “rind” of failed material about five feet thick and pushes the stress concentration into the confined regions of the rock mass. This failure depth corresponds reasonably well with the slabbing observed in the face of overhand stopes which was induced by fracturing in the back of the previous stope. This slabbing is due to both extension and shear and is a result of the stress concentration from the vein-perpendicular stresses that arch over the back. This observation from the model and field provides some minor calibration that the strength properties assigned to the model and the softening response are reasonable. The depth of failure may be somewhat overpredicted, meaning the UCS of the stronger silicified materials may be a bit greater than assumed (115 MPa).

As the mining progresses, the depth of failure within the pillar increases until it reaches a thickness about 15 to 20'. This is essentially the depth of spalling or failure that might be expected at the completion of Phase III. Inspection of the stress state shows that the stresses are more-or-less symmetric on either side of the 5900 drift – in other words, there is not large variation in induced stresses on the east or west side of the pillar, and no large influence of the 40 Vein can be seen.
Figure 8  Base case stress state and failed regions at mining step 14 (11/2006) Stresses are in Pa (1e6 Pa = 147 psi). At this stage, the stress concentrations are mostly near the pillar edges with destressing in the local roof of the 5900 drift. The pillar edges and immediate roof of the 5900 drift are yielding (blue = nonfailed, elastic). Note the stope backs and floor yield to a depth of approx. 5' with these strength properties assumptions.
Figure 9  Base case stress state and failed regions at mining step 23 (5/2007 - end Phase I). Stresses are in Pa (1e6 Pa = 147 psi). At this stage, the stress concentrations have migrated inward from the failed pillar edges with destressing in the local roof of the 5900 drift. Approximately same yielding conditions as previous. Note inner core of pillar is elastic.
Figure 10  Base case stress state and failed regions at mining step 24 (3/2008, end Phase II). Stresses are in Pa (1e6 Pa = 147 psi). The depth of failure in from the edges of the pillar have reached about 10 to 15', depending on location. The greatest stress concentration is formed in a sharp band in from the yielded rim due to the confined nature of the pillar core.
Figure 10 Base case stress state and failed regions at mining step 25 (current, end Phase III). Stresses are in Pa (1e6 Pa = 147 psi). The depth of failure in from the edges of the pillar have stabilized at about 10 to 15', depending on location. The greatest stress concentration is formed in a sharp band in from the yielded rim due to the confined nature of the pillar core.
The predicted stresses for the base case (N40W) and alternative stress case (N15W) are plotted in comparison to the stressmeter measurements in Figure 11. In this figure, the change in stress (i.e., that over and above the pre-existing in situ stress) is plotted as a function of date (i.e., mining step). As seen, the stress is slightly higher (about 1500 to 2000 psi, or about 10%) on the west side of the pillar than on the east side. The range in stress for all three stressmeter locations for the two stress cases are given by the shaded boxes. The base case (N40W) indicates induced stresses at the end of Phase III mining ranging from about 12 to 16,000 psi and about 9 – 11,000 psi for the N15W case. The measured stresses fall in this same range, with the west gauges fitting the range of the N40W case well and the east gauges fitting the N15W case reasonably well. In general, it is felt that this correspondence is actually extremely good, given the typical sensitivity of IRAD stressmeter calibration and results to factors such as:

- Gauge contact area with the borehole wall – the calibration and response of the gauges is highly sensitive to the match of gauge seating platens to the hole wall and the resulting contact area.
- Gauge factor – the calibration factor of the gauges is sensitive to the modulus of the rock mass. The high variability of the rock along the GH boreholes, from siderite to vitreous quartzite results in a high variability of modulus. Depending on exactly where the gauge is installed, the calibration factors could vary significantly. For accurate stress change measurement, the gauges are typically calibrated in the particular rock type by installing the gauges in a large core of the rock and compressing in the laboratory.
- Orientation – the stress monitored by the gauge is sensitive to axis orientation. As demonstrated by Pikalnis, the stress monitored by the stress meter will vary significantly with even a few degrees of rotation of the axis of the seating platen.

For these reasons, the calibration (which was done without attempting to manipulate the estimated in situ stress magnitude) is felt to be very good and lends confidence to the interpretation that a N40W stress provides a reasonable and conservative maximum stress orientation and that the 1.5 max:min stress ratio is also reasonable. I do not think that it makes sense to attempt to make any more detailed assessment of these measurements at this time.
Gold Hunter - Uniaxial Stress Meters - PSI Change

Approx. Range of Prediction of E and W Gauge Induced Stress for N40W $\sigma_1$

Approx. Range of Prediction of E and W Gauge Induced Stress for N15W $\sigma_1$

Figure 11  Prediction of induced stress change at East, West and Top stressmeter locations for two cases of the direction of $\sigma_1$: N40W and N15W. The approximate range of the predictions is given by the shaded boxes.

4.2 Comparison of Model to Observations of Hole Breakout and Discing

4.2.1 Prediction of Failed Regions

The depth of failure given by the base case model can be summarized as follows:

- The failure depth in the pillar reaches a maximum of around 10 to 15' around the outer rim of the pillar and stabilizes after the “Phase II” extraction when the pillar is fully created by mining (Figure 10). Failure is by extension along the outer edge, and shear in the interior confined zone at the rim. Failure in this model would typically mean formation of new fractures and shear on existing fractures. Drilling into this zone would potentially mean encountering poor core recovery and greater core loss.
- Yield zones exist above and below the 5900 drift to a depth of about 5' or so.
- The interior of the pillar remains elastic and is expected to remain elastic.

Further meaning of this failed zone can be determined by examining the level of induced strain in the pillar. Figure 12 shows the base case maximum principal strain induced in the pillar, contoured to a level of 0.05%, which is an approximate level for extensional cracking of
concrete or rock. As seen, this zone of expected new fracturing is approximately the same depth as indicated by the yielded zone. Again, the mean of this zone is that formation of newly-developed fracturing or movement on existing fractures can be expected.

Figure 12 Base case strain levels induced in the pillar. The red region has strain levels exceeding 0.5%, which is the approximate level of extensional strain at which concrete and underground cave mine cracking are observed. This zone roughly follows the yield zone above and is the region where new fractures might be expected.

**Discing and Breakout**

In addition to the damage level observed in the stope backs and floors, damage within the pillar was observed from drilling of the east and west GH holes (Figure 13 and 14). A summary of the hole observations are:
Figure 13 GH West borehole core. Note moderate to strong discing over entire length of the hole, with rubblized and lost core below about 50’ length.
Figure 14 GH East borehole core. Note moderate to strong discing over entire length of the hole, with the exception of the final 10' of hole which is in a mostly-undamaged condition.

- Both holes show moderate to strong discing behavior over much of their length, although the east hole shows no discing for the bottom 10' or so of the hole. However, the end of the hole passes out of the pillar and into the region between the 30 and 40 veins, which appears to be more silicified and stronger (Figure 15).
Figure 15 Plan view of the 5900 pillar and drift showing west and east observation holes. Note that the east observation hole is not centered in the pillar and passes out through the silicified zone between the 30 and 40 veins.

- The bottom 5 to 10' of the west hole is strongly disced and rubblized.
- Both holes remain open and passable to the video camera probe. Video shows that the west hole has breakouts at the top and bottom of the hole for the final half of the hole. The east hole has some breakouts in the hole and joint offset from about 30 to 40' depth, but the remainder of the hole is circular and in good condition.

The conclusion from these above points is that although the west hole shows greater damage in terms of discing and breakouts, both holes (with the exception of the end of the west hole) are open with only local evidence of intense hole failure or squeezing.

A number of researchers have studied the stress state and rock properties that result in discing of core. The most interesting work are laboratory simulations in which diamond drilling was performed into a rock sample subjected to applied biaxial stresses (e.g., Lee and Haimson, 1993). These studies have led to estimates of the stress conditions that lead to discing and borehole breakout for numerous rock types.

Discing

Discing of core stubs occurs when the stress relaxation accompanying the drilling results in extensional failure of the core stub. The thickness of the discs is indicative of the intensity of the stresses. Figure 16 provides a plot of the relationship between the principal stresses that result in discing for granite. To understand the stress state in the stub, computer models were used to simulate the drilling process and estimate the stresses corresponding to tensile failure.
The plot shown in Figure 16 is an approximate relationship for granite and is based on a low tensile strength and brittle behavior. The quartzites and siderites at the Gold Hunter will undoubtedly be different, but this plot provides some basis for asking the question: Is discing expected in the pillar, given the stresses, or is there some other mechanism occurring?

The stresses for an E-W line through the center of the 30 vein (we did not account for the off-center East hole alignment), through the 5900 drift and to the B and W extremities of the pillar were determined and plotted in the form of the discing predictions in Figure 17. As seen in this pillar, the stress conditions in the entire pillar are either in a possible discing condition or borderline condition (with the exception of the area immediately adjacent to the 5900 drift). It is therefore assumed that the character of the observed discing, which, with the exception of the end of the East borehole, is present in most locations, is due primarily to the variability of the rock strength rather than regions of stress which anomalously fall below a discing limit. The bottom line is that the stress conditions in the pillar appear to be conducive to discing over most of its width and are not necessarily related to extensive failure of the pillars.

Borehole Breakout

Spalling of the boreholes, particularly the west borehole, has been observed in the digital borehole video. The spalling has occurred at the top and bottom of the hole, which is consistent with the maximum stress being horizontal and oriented in a vein-perpendicular direction. The relationship of spalling in boreholes to stress magnitude and rock strength is not certain, and some researchers have concluded that there is no unique relationship between stress and breakout. However, Lee and Haimson (1993) performed compression testing of rock samples of granite and limestone with boreholes in the laboratory and defined a range of conditions under which breakout occurred. Figure 18 illustrates the relationship of the major and minor stresses in the plane perpendicular to the borehole axis under which spalling was observed for granite and limestone. The stress state predicted for the base case along a horizontal line across the 5900 pillar in the 30 Vein was determined. This line is at the center of the pillar elevation, through the 5900 drift. The normalized stresses (normalized by the UCS of both quartzite and siderite) are plotted (Figure 19) for positions along this line and given in the form of Figure 18. The range of breakout criteria derived from the laboratory for granite and limestone are shown on Figure 19. This plot indicates the following:

- The pillar stress state (N-S and vertical) perpendicular to the borehole is sufficient to result in spalling in quartzite in regions in the outer approximately 1/2 of the pillar.
- The pillar stress state is sufficient to result in spalling in virtually all of the pillar where siderite is present.

This simple correlation indicates that borehole breakouts can occur in highly silicic rocks, but only in the outer approximately 1/2 of the pillar, whereas breakouts are possible anywhere in the pillar in siderite. This generally agrees with observations where spalling occurs in the siderite-dominant rocks of the west borehole.
Figure 16 Relationship of the principal stresses for which core discing is likely to occur (solid symbols). The stress $\sigma_1$ is parallel to the borehole while the other components are perpendicular to the hole. The component $\sigma_m$ is the average of all three components. The black circles are derived from laboratory testing.

Figure 17 Stress conditions from base case model for a line from the west to east pillar boundaries plotted as given in Figure 16. Essentially all of the stress conditions in the pillar are conducive to potential discing.
Figure 18 Relationship between the maximum and minimum stresses perpendicular to a hole required for breakout. Three rock units: granite and two limestones are shown. The stress component on each axis is normalized by the compressive strength of the rock.

Figure 19 Limits of approximate breakout regions from Figure 18 plotted for stresses along an E-W line through 30 Vein, 5900 pillar. The line goes through the middle of the vein and the 5900 drift. The stress states indicate the potential for breakout in both quartzite and siderite, however, the potential for breakout in the weaker siderite zones is much increased.
Closure of Orebody Across 5900 Drift

The model was used to estimate the closure across the pillar at the 5900 drift. Figure 20 shows the displacement of the hangingwall side of the pillar (in cm). The total closure (hangingwall + footwall displacement) at the location of the 5900 drift is about 1.5". This can be compared to tape extensometer measurements made regularly and reported by T. Williams. The closure reported after completion of the Phase III mining is about 1.3", or roughly the same as predicted by the model. The deformation equates to a strain of about 1.5"/120" (10' vein width), or about 1%. The exact measurement and comparison is not particularly relevant – the important point is that the closures of the orebody are not large, and not sufficient to indicate complete crushing of the pillar.

4.3 Discussion

The comparison of the model results to observation and measurement are summarized below:

- **5900 Pillar Stresses** - the modeled stresses compare quite well with the IRAD stressmeter readings. The stress predictions for the base case (N40W s1 orientation) and ratio of s1/sy = 1.5, and for the alternative case of (N15W s1 orientation) bound
the West and East stressmeter response. This comparison is felt to be very good, considering the various inaccuracies inherent in the IRAD stressmeter gauge measurement. Since the N40W orientation compares well with past Coeur d'Alene district in situ stress measurements as well as numerous raise breakout observations, it is recommended that the N40W orientation be used as a basis for future modeling analyses.

- **Damage Estimates** - The base case orebody strength modeling predicts that a thin (roughly 10-15' thick) zone of failure develops around the outer periphery of the pillar as a result of the mining. A smaller (about 5' +/-) yield zone develops around the 5900 drift. This depth of failure correlates reasonably well with the rubbilized and unrecoverable core observed in the west observation borehole that was drilled in the 30 Vein. The East borehole passes outside the vein and thus correlation of failure is not certain. The modeling indicates that the interior of the pillar remains elastic and is not in a failed state.

- **Core Discing and Borehole Breakouts** - Extensive core discing and breakouts (particularly in the west borehole) were observed in the observation boreholes. Comparison of stress state to discing or breakouts is an inexact science. Here, we have used laboratory-based testing correlations of discing and breakouts to stresses to attempt to relate the modeled pillar stresses to observations. It was found that:
  - The pillar stresses indicate that the magnitudes are sufficient to create discing throughout most of the pillar, particularly in the siderite-rich rocks. In other words, the presence of discing at the outer regions of the pillar in any rock type, but particularly in the siderite, is not unusual or surprising. The fact that discing may occur is a natural result of the in situ stresses, but does not indicate that the central portions of the pillar have failed - it is simply highly-stressed.
  - The pillar stresses are also sufficient to cause borehole breakouts in the outer half of the pillar, particularly in the siderite-rich areas of the orebody. The extensive breakouts in the west half of the pillar may be indicative of the lower strength rocks encountered in the west side of the pillar.

- **Closure** - the closure of the 30 Vein at the 5900 drift correlates reasonably well with the model predictions.

5 Conclusions

The overall conclusion of the analysis is that the stress state predicted correlates reasonably well with the IRAD stressmeter readings, and that damage observed is as expected from the stress state. More importantly, the modeling indicates that the 5900 pillar is not currently in a failed state. Only the outer 10' to 15' of the pillar has yielded, while the interior is still in an elastic state. A question to be asked is whether or not this is unusual, given the potentially high induced stresses in the pillar. The answer is no - the 5900 pillar has a width:height ratio of approximately 10:1 (100 ft diameter by 10' +/- width). Many empirical studies have been performed in which the failure response of pillars in room and pillar mines have been observed (Figure 21). Virtually all of the pillars in which failure has been observed occur for pillar width to height ratios of less than 2. This makes sense since no pillars are observed to fail for such squat shapes. For example, strike or dip-stabilizing pillars in South African gold mines
with w:h ratios as high as 40 have been left in place. It is well known that these pillars remain elastic, although the foundations of these pillars may fail in shear. Kaiser and Kim (2008) have shown that pillars in relatively strong and brittle rocks with w:h ratios greater than about 2 have a confined inner core. The exterior rims of these pillars may fail by spalling, but the dilation and bulking of this exterior rim rapidly confines the inner core with the result that it remains elastic. Therefore, it is difficult to imagine the scenario that the 5900 pillar would actually fail throughout. Thus, the pillar will likely remain stressed at or near its current level, with the potential for relatively low level seismicity occurring in the highly stressed areas along the boundary of failed region along its periphery. This could result in shaking of the 5900 drift, but support with dwydag bolts and screen will likely be sufficient to maintain loosened material. It is more likely that the foundation of the pillar in argillite along its boundaries will shear and yield. If fault structures are present, these could produce larger events.

Based on the calibrations presented in this memo, it is felt that sufficient confidence in the model is available to move to the next level, which is simulation of future mining of Gold Hunter.
Figure 21 Empirical estimates of normalized pillar strength as a function of pillar width to height ratio. Empirical estimates underestimate the pillar strength at w:h ratios greater than about 2 due to a lack of data. Martin and Maybee (2000) show that pillars in brittle rocks harden and behave elastically for w:h ratios greater than about 2 (the shaded band). From Kaiser and Kim (2008).
References


Exhibit 6
MEMORANDUM TO: John Jordan, Doug Bayer, John Lund, Karl Hartman, Eric Carlson, Zach Thomas
FROM: Wilson Blake, Consultant
SUBJECT: Stability 5900 Drift Pillar

Introduction

Modeling of the 5900 drift pillar was conducted in 2004 prior to selecting the dimensions for final pillar implementation. These results indicated that a 50 ft pillar would be stable with a 1.5 factor of safety. The limitations of this modeling were recognized, and as a result, the stability of the 55 ft circular pillar surrounding the 5900 level access through the orebody has always been of some concern. Therefore, this pillar was instrumented in mid-2005 to determine stresses in the pillar back and ribs, as well as closure across and along this pillar. Instrumentation readings have continued, with the last readings taken 08/18/2011. The stress data basically shows that the stress increased in the pillar rapidly after the pillar was formed, but as mining continued the rate of increase decreased, and since 2010 the stress has dropped in the pillar except for a continuing slight increase on the east side. The stress gages also responded to bursting in the pillar, the last burst occurring in 12/09. While it was clear that nearby mining was no longer stressing the pillar, it was known that the pillar was still being loaded by stope closure as a result of continued mining in the Gold Hunter.

Drift closure across and along the 5900 pillar was gradual until the 12/09 burst, and since has slowly but steadily increased to the 1.3 inch range.

Both the stress and closure values agreed well with the computer model simulations of mining from the 5900 level in the Gold Hunter. Itasca concluded that the 5900 pillar was stable and too big to fail suddenly and violently, behaving more like a stabilizing pillar.

This conclusion appeared to be confirmed by the observations all along the 5900 pillar itself, as well as from inspection of the E and W observation boreholes drilled through the pillar. While there was apparent stress deterioration at the back edge along the west end of the pillar, as well as very minor stress effects around the 5900 drift, the 5900 pillar was basically intact, and its appearance had not basically changed since mining began.

Two of the three bursts that were located along the back edges of the pillar did not cause observable damage, but the last burst, 1.9 magnitude on 12/09/10, did minor damage to the 5900 level drift along the pillar, as well as to some sections of the back and left rib of the chevron drift, just south of the 5900 pillar. This damage consisted of minor spalling and shakedown which was all contained by the installed ground support. No rehabilitation was required.

The ground support consisted of a combination of Dywidag bolts and split sets with chain link mesh. This reinforcement was supplemented by cable bolts in the back of the 5900
drift, beginning before the intersection with the 30 vein and continuing through the pillar and past the intersection of the 40 vein.

This installed ground support has a dynamic support resistance of 9.3 kJ/m² (based on Table 7.2, “Rockburst Handbook for Ontario Hardrock Mines”, CANMET Special Report SP92-1E, 1992). This ground support is capable of containing the effects of a 2.5 magnitude burst at a distance of 10 m.

The occurrence of the 2.8 (USGS) magnitude burst in the 5900 pillar during blasting on 11/16/11, and its resulting extensive and widespread damage, was very much unexpected.

I made an initial visit to the 5900 pillar on 11/16, and a subsequent visit on 11/23. This brief report presents my observations and thoughts regarding the cause of the 5900 pillar burst, as well as the present stability of the 5900 pillar.

**Mechanism of 5900 Pillar 2.8 (USGS Magnitude) Rockburst**

At 01:07:26, a 2.8 magnitude rockburst occurred as the last hole of the round from the overlying 5500 level underhand stope was blasted. The burst magnitude was determined by the USGS national earthquake center, however, on the nearby Montana Tech seismic sensors, the burst appeared to be larger, in the 3.0 range. While the damage from this burst blocked off the 5900 access drift, there was also extensive damage to the footwall access ramp system all the way up to the 5550 level, but particularly to some of the 5750 and 5700 sublevel openings. Such widespread damage is not characteristic of a simple pillar burst.

The numerical model results did indicate that small bursts around the edges of the pillar could be expected with magnitudes up to 2.0. We did have such bursting, with the largest a magnitude 1.9. The model results also indicated that the only way the pillar could fail was if the height to width ratio changed and the pillar lost confinement, in which case a foundation failure might occur. The model assumed a 10:1 width to height ratio. The foundation failure would occur out in the walls, rather than in the core of the pillar. And further, the model results did not include any geologic structures intersecting the pillar.

With the observed stress deterioration along the inner and outer edges of the pillar, likely in the 10 ft range, the width:height ratio of the in place doughnut shaped pillar is actually 3.5, assuming a 10 ft. vein thickness.

The in situ stress in the 5900 pillar area before mining was some 1.2 psi/ft of depth for the vertical stress, and 1.5 times this value for the horizontal stress. The actual vertical distance to surface above the Gold Hunter is in the 7000 ft range, hence the vertical stress would be 8400 psi, and the maximum horizontal stress, N40°W direction, is 12,600 psi. From the stress gages we know that the stress increase in the pillar from mining off of the 5900 level, taking into account the ore and waste rock modulus values, was also some 12,600 psi. Hence, the stress in the pillar was very near the unconfined compressive strength of the pillar, and any further loss of confinement could lead to a pillar failure.

It was initially presumed that the 2.8 rockburst in the 5900 pillar would represent a classic pillar burst since calculations of the stored strain energy in the pillar, if released instantaneously, could generate a burst of this magnitude. However, with a classic pillar
from the back and walls of the pillar was very large slabs of rock, with no dust, indicated
that the 2.8 burst was not a classic pillar burst. In addition, the domed cavity formed
above the burst zone was not fractured and appeared to still be stressed. When this zone
was bolted, during rehabilitation, the ground began ‘working’ and some slabs appeared to
‘pop’ off during scaling. Hence, this confirmed that the rock in the remaining 5900 pillar
was still stressed, indicating that this pillar did not completely fail.

It is concluded that the most likely mechanism of failure of the 5900 pillar was a
foundation failure. These type failures occur when the pillar rock is much stronger than
the wall rocks, as is the case for Gold Hunter. Shear failures in the wall rocks take place
going out from the edges of the pillar. The Itasca modeling concluded that this failure
mechanism could occur in the 5900 pillar, as well as the diminishing 5500-5700 sill
pillar. Favorably oriented structure through the pillar would further reduce the strength
of either pillar.

A 3.8 magnitude sill pillar burst at the Macassa Mine in 1996 was determined to be a
foundation failure. There was major damage out in the footwall, and only minor
observable damage along the pillar or out in the hanging wall. In this case the pillar was
some 200 ft long by some 80 ft high. There was over 2 inches of closure measured
across the overcut immediately above the sill pillar.

Our 2.8 burst did major damage to the pillar, as well as major damage along some
openings up and to the east along the footwall. The majority of the energy released, as
well as the resulting damage, was due to instantaneous wall closure over the entire mined
out area around the pillar, not from the release of all the stored strain energy in the pillar.
For this reason the 5900 pillar is still somewhat intact and partially loaded. The closure
process is continuing to load this pillar, thus, there is the possibility of small strain bursts
still occurring in this pillar.

We need to measure the closure induced by this burst along the 5900 level drift. If none
of the existing closure points survived, then we can resurvey existing spads in the back
along the main drift to determine their displacements as a result of the burst. It is likely
that several inches of closure across the vein resulted from this burst.

**Stability of 5900 Pillar**

It is apparent that the 2.8 burst in the 5900 pillar did not completely destress this pillar.
Hence, it is possible that further small bursts could occur in this pillar as it continues to
be loaded by ongoing wall closure from continued mining off of the 5900 level. It is also
apparent that the remaining intact pillar has been significantly reduced in size, hence, the
amount of stored strain energy now in the pillar has also been significantly reduced. To
deal with any future bursts, ground support is being installed in and along the 5900 pillar
to contain the effects of any further bursting.

In addition to the combination of longer Dywidag bolts, split sets, chain link mesh and
cable bolts, the back and ribs will be sprayed with 2+ inches of shotcrete. The addition of
the shotcrete adds 2 more kJ/m$^2$ to the 9.3 kJ/m$^2$ to result in a total dynamic support
resistance of some 11.3 kJ/m$^2$, which is substantial (with the shotcrete and 11.3 kJ/m2,
would this support contain greater than 2.5 richter burst? Some mention of what range
this type of support could withstand would be good). Further, after the present

Ronnel E. Barrette, etal vs Helca Mining Co., etal  
Docket No. 43639
rehabilitation is completed, it is planned to construct some form of tunnel through the 5900 pillar, and backfill the open ground around this tunnel with a foam type concrete. This will prevent damage to the 5900 pillar drift from any magnitude burst that might occur in or along the edges of the 5900 pillar. (will you recommend or say this is approach would be the recommended long term option?)

**Summary**

The 5900 Pillar burst, of 2.8 USGS Richter magnitude, was most likely a foundation failure since this pillar was not completely destroyed. Deterioration and a few small bursts around the edges of this pillar resulted in reducing the pillar confinement, and hence, its strength. It is not known whether any geologic structure through the pillar contributed to the occurrence of this burst.

The large amount of energy released by this burst, as well as the resulting damage, was due to the instantaneous wall closure over the entire mined out area surrounding the 5900 pillar. Wall closure will continue to load the remaining 5900 pillar as mining continues in the underhand stopes currently being mined below.

The ground support installed during rehabilitation of the 5900 pillar will contain the damage from any further small bursts that might be induced by continuing closure. Installing some type of tunnel sets through this pillar, and isolating them from the pillar by something like TechFoam, will insure the long term stability of the access through this pillar. While I would conclude that the occurrence of another large burst in this pillar is unlikely, it cannot be totally eliminated. discounted.
Subj: Re: 11-16-2011 USGS 2.8 5900 Pillar
From: mpboard@yahoo.com
To: WBlake298@aol.com
Wilson:

I am sorry to hear about your medical issues, but it sounds like things will work out OK. This is exactly what Barry Brady had and it worked out well. Take care of yourself.

This looks pretty ugly - I hadn't heard about it - am in Italy at the moment, returning home on Saturday but going to China on Friday - gone for 3 weeks.

Well, I guess this shows the need for understanding structure in the orebody, although not certain that it will ever be known. I think this shows the need to evaluate the conservatism in that sill pillar. I haven't heard a word from Hecla since I sent that draft report to them that I also sent to you. I recommended 60', but if there is a structure in there, the thickness is sort of irrelevant to a point.

Makes me nervous. I'm sure MSHA is wondering if something more drastic needs to be done there.

Cheers,

Mark

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From: "WBlake298@aol.com" <WBlake298@aol.com>
To: mpboard@yahoo.com
Sent: Thursday, November 17, 2011 10:10 AM
Subject: Re:11-16-2011 USGS 2.8 5900 Pillar

Mark:

Don't know if you heard, but with night shift blasting, 1:07 am, the 5900 pillar was demolished with huge burst. Am attaching pictures I took yesterday pm, but they don't really show other that the beginning of event just before the pillar. Back domed up 15+ ft, looked like carved, the walls broke out 10-15 ft on both sides. The muck was huge pickup sized slabs, and no dust. Had floor heave on 5500 stope above, as well as lots of scattered shock damage 5900 level and sublevels going up. Looks like all instrumentation gone, but should have the 60 ft long wall closure measure points of Ted. Burst came with 5500 blast, and not good location on MP 250 data, but fair location with the new ESG sys with only 6 stations at some distance.

MSHA up yesterday, and they have started repairing, and will go in cautiously as the domed back looks almost perfect. I expected to see a pile of broken rock - like round, but the huge slabs and no dust, as well as the back looking intact, suggest fault initiation through the pillar.

When I calculated stored SE in 200 MPa doughnut pillar came up with 2.5 - 2.8 max event if SE released instantaneously - did this back in 08 and 09. Terry showed core from an old hole through there and the rock in the FW and up to 30 vein looked like really silicified quartzite. Needless to say this does not bode well for the sill along this stretch of rock.

I finally went to Dr after laryngitis never went away, and had polyp on vocal cords. When removed was

Thursday, November 17, 2011 America Online: WBlake298

Ronneil E. Barrette, et al vs Helca Mining Co., etal Docket No. 43639 306 of 1172
cancerous, so starting 5 weeks of radiation, which should be 100% successful.
I'll keep you posted and we need to get you involved.
Wilson
MEMORANDUM TO: John Jordan, Doug Bayer, John Lund, Karl Hartman, Eric Carlson, Zach Thomas

FROM: Wilson Blake, Consultant

SUBJECT: November 16, 2011 Mine Visit Report

Introduction

On Wednesday November 16, 2011, I visited the Gold Hunter to review the 2.8 magnitude rockburst that occurred in the 5900 Pillar during night shift blasting, and blocked off the main 5900 level drift, as well as causing damage to openings up to the 5500 level.

This summary report presents my observations and thoughts regarding this mine visit.

5900 Pillar 2.8 Rockburst

At 01:07:26, the 2.8 rockburst occurred as the last hole of the round from the overlying 5500 level underhand stope was blasted. Because of this, the MP 250 system was not able to get any location for this burst. From one of the ESG Paladin units the burst was located near the 5900 pillar. Based on damage the burst obviously occurred in the 5900 pillar, as can be seen in the photo below.

From the size of the muck and the lack of dust it does not appear that this was a classic pillar burst where the pillar basically implodes and is pulverized. It also appears that the cable bolts in the back along the brow likely limited the damage to the south along the
5900 drift. The walls along the instrumentation cut out appeared to have come in some 10 or more ft, and the back arched up to a dome some 15 ft above the original back. The back and upper ribs did not appear to be fractured or broken up as was expected. Hence, while the magnitude of the burst corresponds to the strain energy that was stored in the pillar, we cannot yet assume that the remaining pillar is completely destressed. Therefore during rehabilitation work we need to proceed with caution.

Cores from an old exploration hole through the central pillar area showed that the footwall rocks are very solid and silicified up to the 30 vein—looking more like LF quartzite than the usual argillaceous GH wall rocks. There did appear to be some low angle structures in the cores, but nothing that pointed to the presence of well defined faults running through the core. The observation hole through the east side of the pillar also indicated that this part of the pillar was much more solid and competent than is the west side.

**Model Results and 5900 Pillar Burst**

From the numerical modeling carried out by Itasca it was presumed that the 5900 pillar was too large and too confined for a pillar burst to occur. Because the actual burst appears to have been structurally controlled, we may want Itasca to rerun the model with structure running through the pillar in order to see if we can replicate the burst. We really need to better understand why this burst occurred, as it has significant implications with respect to mining the main sill—particularly along the more burst prone eastern portion of the sill.

**5900 Pillar Instrumentation**

We need to recover the instrumentation box since the gage readings up to the time of the burst can likely be recovered. The tape extensometer should also be undamaged and recovered. If any of the closure points along the walls are still intact, we need to preserve them in order to be able to determine the vein and wall closure induced by this burst.

**Rehabilitation**

While it appears that we may have to remove the brow to better be able to stabilize the back, this and all the rehabilitation work needs to be done cautiously. We should be able to determine the condition of the back and upper ribs by test drilling with the jumbo. We obviously need to be able to get at least 2+ inches of shotcrete on the back and walls before bolting. It did appear that one of the instrumented cable bolts was sticking out of the back. This would have been a 20 ft cable bolt.

**Summary**

The 2.8 burst in the 5900 pillar was not expected and did not appear to be a classic pillar burst. Because the upper ribs and back appeared to be solid, we can’t assume that the remaining pillar is destressed, hence the rehabilitation needs to proceed with caution. And, finally, we need to better understand the cause of this burst to be able to relate it to mining the main sill.
Exhibit 9
OF THE
COLORADO SCHOOL OF MINES

ROCK-BURST MECHANICS

by

WILSON BLAKE

VOLUME 67, NUMBER 1    JANUARY 1972
QUARTERLY OF THE COLORADO SCHOOL OF MINES

Volume 67 January 1972 Number 1

ROCK-BURST MECHANICS

by

WILSON BLAKE

Price $3.00

Guy T. McBride, Jr.
President
ABSTRACT

Results of an experimental and analytical study of a rock-burst-prone pillar at the Galena Mine, Wallace, Idaho, have been used to explain the mechanics of rock bursting. The author has shown that a rock burst will occur when the following two conditions are satisfied: (1) the average stress in a mine structure exceeds the strength of the structure, and (2) the stiffness of the mine structure exceeds the stiffness of the mine loading system. It follows that a rock burst can be prevented by (1) reducing stress in the mine structure to a value below the strength of the structure, or by (2) reducing stiffness of the mine structure to a value below the stiffness of the mine loading system.

As part of a field test to verify this hypothesis for the cause of rock bursting, a burst-prone stope pillar was successfully destressed by blasting a single line of long holes in the footwall of the vein. As a result, the pillar was fractured and softened, reducing stiffness and stress in the pillar.

The design of mine structures and mining methods to control rock bursting can be determined in the laboratory using the finite-element method of stress analysis. The stability of such structures in the field, with regard to rock bursting, can be evaluated using the broad-band microseismic technique.


## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgments</td>
<td>xi</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>General Concepts</td>
<td>1</td>
</tr>
<tr>
<td>State of the Art</td>
<td>2</td>
</tr>
<tr>
<td>Scope of Investigation</td>
<td>6</td>
</tr>
<tr>
<td>Field and Laboratory Observations</td>
<td>9</td>
</tr>
<tr>
<td>Geologic Setting</td>
<td>9</td>
</tr>
<tr>
<td>Rock Properties</td>
<td>9</td>
</tr>
<tr>
<td>In Situ Stress</td>
<td>15</td>
</tr>
<tr>
<td>Mining Method</td>
<td>16</td>
</tr>
<tr>
<td>Rock-Burst History</td>
<td>17</td>
</tr>
<tr>
<td>Microseismic Study of Rock Bursting</td>
<td>21</td>
</tr>
<tr>
<td>Microseismic Method</td>
<td>21</td>
</tr>
<tr>
<td>Microseismic Field Monitoring</td>
<td>23</td>
</tr>
<tr>
<td>Sequence of Events Leading up to Bursting</td>
<td>29</td>
</tr>
<tr>
<td>Stress Analysis of Mining Method</td>
<td>38</td>
</tr>
<tr>
<td>Finite-Element Method</td>
<td>33</td>
</tr>
<tr>
<td>Simulation of Mining in 40-135E Stope</td>
<td>34</td>
</tr>
<tr>
<td>Concept of Mine Stiffness</td>
<td>39</td>
</tr>
<tr>
<td>Experimental Results on Test Specimens</td>
<td>39</td>
</tr>
<tr>
<td>Pillar Stiffness Versus Loading System Stiffness</td>
<td>40</td>
</tr>
<tr>
<td>Effect of Geology on Mine Stiffness</td>
<td>40</td>
</tr>
<tr>
<td>Mechanics of Rock Bursts</td>
<td>47</td>
</tr>
<tr>
<td>Hypothesis for the Cause of Rock Bursting</td>
<td>47</td>
</tr>
<tr>
<td>Field Test of Burst Hypothesis</td>
<td>47</td>
</tr>
<tr>
<td>Suggestions for Mine Design</td>
<td>57</td>
</tr>
<tr>
<td>Conclusion</td>
<td>59</td>
</tr>
<tr>
<td>Recommendations for Further Work</td>
<td>61</td>
</tr>
<tr>
<td>References</td>
<td>63</td>
</tr>
</tbody>
</table>
ILLUSTRATIONS

1. Generalized structural geology of the Coeur d'Alene Mining district. 10
2. Surface geology at the Galena Mine. 11
3. Vertical cross section through silver vein at the Galena Mine. 12
4. Stress-strain curves for Galena Mine rocks. 14
5. Vertical longitudinal projection of the silver vein at Galena Mine. 16
6. Incidence of damaging rock bursts. 18
7. Broad-band microseismic system. 22
8. Cumulative plots of rock noise source locations. 24
9. Geophone and instrumentation station locations. 25
10. Typical microseismic record and location analysis. 26
12. Rock noise source locations, March 4, 1970. 29
13. Damage to sill drift and stope from pillar burst. 30
14. Typical stope cross section and finite element computer model idealization. 35
15. Variations of stress in the pillar with mining. 36
16. Maximum shear stress contour plots for 80-foot pillar. 37
17. Specimen and loading system stiffness relationships. 41
18. Compression of pillar and stope wall displacements. 42
19. Variation of pillar stiffness and loading system stiffness with mining. 44
20. Rock noise source locations, April 15-16, 1970. 49
21. Maximum shear stress contour plots for 30-foot pillar. 50
22. Stope pillar and destressing pattern. 52
23. Contour plots of seismic velocities, fps. 53
24. Compression of pillar and stope wall closure resulting from destressing. 54
TABLE

1. Physical properties of Galena Mine rock..........................................13
2. Physical properties of Galena Mine rock with confinement...............13
3. Seismic velocities, 40-135E stopes...................................................27
4. Material properties for models.........................................................34
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INTRODUCTION

The phenomenon of rock bursts has been associated with mined excavations throughout the world in all rock types and at all depths—on the surface in granite quarries in the northeastern United States to more than 2 miles below the surface in the gold fields of Witwatersrand in South Africa. In almost every burst-prone mine in the world, fatalities from bursts have been reported. In addition to hazardous working conditions, the loss of production and expense owing to repairs and cleanup following a burst makes the rock-burst problem a major factor in mining economically at depth.

GENERAL CONCEPTS

A rock burst is generally defined as a sudden rock failure characterized by the breaking up and expulsion of rock from its surroundings, accompanied by the violent release of energy. All rock bursts produce seismic waves that propagate outward from their source. Hence, while little was known about the basic mechanics of bursts prior to this study, a great deal of information about rock bursts has been inferred from studies of their associated seismic waves.

Seismic disturbances produced by rock bursts have been recorded at seismological stations hundreds and even thousands of miles away. The largest bursts have been given Richter earthquake magnitude ratings up to 5.5. Besides damage to surface structures from such large bursts, damage to underground workings is enormous. At the Wright-Hargreaves mine in Canada, a major rock burst in 1964 caused so much damage to the underground workings that the mine had to be closed (Buckle, 1965).

Rock bursts have been a severe operational hazard in certain deep mines since 1900. Numerous committees and organizations have been formed throughout the world to study the problem. The control or elimination of rock bursts has been the goal of research for over 50 years. But little has been determined about basic causes; hence, control measures have at best been only partially effective, as is attested to by the number and severity of bursts throughout the world each year.
Rock bursts first became a recognized operational problem in the Kolar Fold Field of India in 1898. By the end of 1903, some 75 rock bursts had occurred, resulting in six fatalities and scores of serious injuries. The depth of mining at this time was less than 1500 feet below the surface. Investigations of these bursts (Bosworth-Smith, 1903; Smeeth, 1904) led to the conclusion that rock bursts were caused by great pressure on pillars in a geologic setting characterized by strong rigid pillars and a rigid hanging wall which yielded slightly. The pillar yielded suddenly when this pressure reached the strength of the pillar, resulting in a burst. All the bursts observed at this time were associated with pillars; so it was concluded that where there was no pillar, there would be no burst.

The rock-burst problem in the gold mines of the Witwatersrand of South Africa began in the early 1900s at depths of less than 500 feet. By 1915 a committee was formed to investigate. Committee members suggested the concept of domes, zones of fractured rock forming around stopes, to account for the observation that the rock around the mined openings appeared fractured and broken. They also concluded that in addition to supporting load, the domes also transferred load to pillars. Hence, in addition to the concept of pillar bursting, they suggested that the removal and failure of pillars may cause a dome to fail. This concept was introduced to explain rock bursts which did no apparent damage to pillars or other mine workings.

During the late 1920s, the theory of elasticity was used to account for high pressures existing around mined openings. Jones (1926) used the solution for a circular hole in a plate under hydrostatic loading to show that the stress at the boundary of the hole is twice the applied stress. He inferred that stress is concentrated around mined openings and also around the domes formed around stopes. Crowle (1927) expanded this concept to show that fractures develop around excavations because of stress concentration, and, if the fracturing is sufficiently violent, it results in a rock burst. In addition, he suggested that the fracturing of rock around stopes forms the domes.

Prior to 1930, all conclusions and hypotheses concerning rock bursts were based primarily on observation. Simple theory was introduced only to confirm observations. Though the observations were certainly correct, little effort was made toward understanding the mechanism causing a burst. The major emphasis was in modifying mining methods to minimize the creation of dangerous burst-prone pillars. During all this time, the number and severity of bursting increased.
By the end of the 1930s, two main causes for rock bursts were generally accepted: (1) the pressure-dome theory supported by operators of mines where the veins dipped steeply, and (2) the cantilever theory supported by operators of mines where the veins were mostly flat-lying.

The pressure-dome theory (Crowie, 1931; Dinsdale, 1937; Spalding, 1937) used stress concentrations in the vicinity of mine openings to account for rock bursts. The rock fractures when stress in this concentrated zone exceeds the strength of the rock. If the rock is brittle, the fracturing process may be violent and result in a small rock burst. As these fractures progress outward from an excavation, a dome-like area of fractured rock develops. This zone is destressed by virtue of being fractured, but a high-stress zone exists around the dome in the unfractured rock. Large bursts occur when the load supported by the dome is concentrated in pillars or remnants, and when two or more domes meet, resulting in a further stress concentration. Stope closure results as a consequence of the fracturing of rock within a dome.

The cantilever theory (Sinclair, 1936; Joseph, 1938) was advanced to explain the cause of rock bursts in the rather flat-dipping beds of the Witwatersrand. As mining progressed and support was removed over a large area, the hanging wall sagged. The larger and deeper the mined-out area, the greater the sag. Bedded layers within the sagging area acted as beams or cantilevers. As sagging continued, layers separated and began to fracture in the hanging wall, and small rock bursts occurred. As further sag continued, beams were sheared at their support ends, and large bursts resulted. Manifestations of these bursts were seen in spalling of support pillars or remnants; hence, more than one burst could be observed in a single pillar.

Both theories were based primarily on observed and measured behavior of stope walls and suited to a particular geometry. It is apparent that the basic cause or mechanism of a rock burst must be the same, regardless of the particular mine geometry. It is interesting to note that the recommended control technique for both theories was identical—prevent sag or closure.

Despite all attempts to control and minimize stope closure—i.e., use of waste packs, granite blocks, hydraulic fill, etc.—bursting continued and became more severe as mines went deeper. This fact was interpreted by some as an indication that limiting closure was not an effective means of controlling bursting.

The first mathematical model to explain rock bursting was proposed by Weiss (1938), who used elastic theory, experimental results, and what he called “elastic hysteresis” to explain the phenomenon of bursts. Basically
a time-dependency factor was included in the description of bursts. He reasoned that the state of stress around openings depends on both past and present loading, which accounted for the large accumulations of strains and forces necessary to cause bursting. Because of time dependency, a single burst did not completely destress an area; it took several bursts (aftershocks) over a certain period of time. With this model he could account for the cyclical nature of bursting as related to the mining cycle. Though this model appeared to describe the observed patterns of bursting, it was never accepted by mine operators because in the late 1930s, it was felt that mathematics couldn't be used to predict mine behavior. All the energy released by a large burst could not be accounted for by the collapse of a specific part of a mine structure. Hence, Weiss concluded that the major source of the energy must be in the solid rock away from the excavation.

As a result of this early research, modifications of mining methods for particular mines tended to minimize the rock-burst hazard, the most common modification being longwall-type techniques which avoided the creation of pillars. As mining went deeper, bursting increased in both incidence and severity. By the late 1940s, the South Africans recognized that if the rock-burst problem was to be understood, an intensive research program involving both engineers and scientists was necessary. As a result, in 1949 the Council for Scientific and Industrial Research (CSIR) was formed.

During the 1950s this team re-examined the rock-burst problem from a mathematician's point of view (Hill, 1954; Roux and Denkhaus, 1954). The physical properties of rocks were examined in detail in the laboratory (Denkhaus, 1958a), the state of stress existing on the Witwatersrand was inferred (Leeman, 1958), and the theory of elasticity was used to a greater extent (Denkhaus, 1958b).

The seismic location of rock bursts showed that the bursts were occurring back from the face in solid rock, and calculations of the seismic energy released by this bursting indicated that large amounts of seismic energy were being released daily (Cook, 1963a). Stimulated by this observation, Cook (1963b) proposed that the mechanics of rock bursts could best be analyzed by an energy approach. He showed that as an excavation is made, a large amount of energy is released by wall displacements toward the opening. He postulated that to control bursting, this energy must be released in small enough amounts that it could be dissipated nonviolently.

Further work by Cook (1965), dealing with the behavior of rock specimens in conventional and stiff testing machines, implied that rock
bursts might be considered as a stability problem in the same way as a specimen behaves in laboratory tests. That is, depending on the relative stiffness of the specimen versus the loading system, the specimen will fail violently or nonviolently if energy can or cannot be extracted from the loading system at failure. A similar but more complicated mathematical model was proposed by Diest (1965). The concepts suggested by these studies appeared to be very promising, since, for the first time, a mechanism was used to account for the two types of failure—violent and nonviolent. However, there has been no further published work to advance these concepts and apparently there was no attempt to test them in the field.

Cook and others (1966) summarized some 15 years of rock-burst research in South Africa, concluding that rock bursts are controlled by the rate at which energy is released as an excavation is made. They postulated that if the energy released is greater than the amount which can be dissipated nonviolently, then this energy is released violently, and a rock burst results. This energy is derived from the displacement of a rock mass as it moves towards an opening that is created or enlarged.

Though the energy approach is certainly valid and energy is undoubtedly released as an excavation is slowly created or enlarged, it has never been shown that this energy is released violently. If these openings were created or enlarged instantaneously, then the resulting release of energy would be violent (Duvall, 1965). But since the mining of openings is a slow process, the energy released daily by instantaneous mining-induced displacements is far less than the amount of energy released by the blasting to create or expand these openings. If this were not so, every blast would be accompanied by a rock burst. Since closure is a slow process, the energy released by displacements resulting from closure will be nonviolent. There is no doubt that the largest amount of energy released by a rock burst is derived from the gravitational or stress field by instantaneous displacements towards an opening or broken volume or rock; but a question remains regarding the mechanism by which this process is started.

For a specimen in a testing machine, closure of the platens results in compression of the specimen, causing strain energy to be stored in both the specimen and loading system. By virtue of this closure, an equal amount of potential energy is dissipated in the loading system. When the strength of the specimen is reached and the specimen fails violently, it is apparent that this phenomenon has been started by the recoil or the release of the stored strain energy of the loading system. This suggests that in designing mine structures to control bursting, the accumulation of strain energy in and around such structures must also be considered.
In summary rock bursts have been adequately described and their effects known for some 70 years; rock-burst-prone mine structures—i.e., pillars, dikes, etc.—have been recognized; and the overall energy balance for a total mine system can be determined. Yet, the basic mechanics of rock bursts are unclear because little research has been directed towards how a burst actually begins. No study to date has examined the sequence of events leading up to bursting, analyzed the stresses induced by mining, and determined the relative stiffness of the mine structure and loading system for an actual field example.

Scope of Investigation

Study of the basic mechanics of rock bursts requires a knowledge of the sequence of events leading up to and contributing to a burst. To minimize the variables, we must study a rock-burst environment as close to ideal as possible: the rock is nearly elastic; the mining method does not change; rock bursts do occur; and there has been a burst history. The Galena Mine of the American Smelting and Refining Company at Wallace, Idaho, was selected for study because it met almost all these requisites.

Previous work in this mining district by the Bureau of Mines (Blake and Leighton, 1970) had established the fact that the broad-band microseismic method could be used to monitor rock-burst-prone mine structures. The source location of rock noise events could readily be obtained and used to map the location of stress buildup around a stope as a burst was approached (Leighton and Blake, 1970). Hence, detailed broad-band microseismic monitoring of a rock-burst-prone stope began at the Galena Mine in November 1969 and continued through 1970.

As a foundation for analytical studies on the mechanics of rock bursts, finite-element stress-analysis model studies of the mining method at the Galena Mine were simulated on a computer. Results were correlated with results of microseismic studies and observed field behavior to insure that the computer model agreed with actual field conditions. It was necessary to look at the geology, the physical properties of the mine rocks, and to determine the in situ state of stress so that input data and boundary conditions could be provided for the model.

The behavior of a rock specimen in both conventional and stiff-testing machines was examined and applied to the observed and calculated behavior of an actual mine pillar under load because the geometry and loading of a pillar at the Galena Mine are almost identical to the loading of a specimen in a testing machine. The relative stiffness of both the mine pillar and mine-loading system was determined.
Finally, to complete this study, we interpreted the information as a hypothesis for the cause of rock bursts consistent with observed and calculated data, and then tested this hypothesis in both the laboratory and field.
FIELD AND LABORATORY OBSERVATIONS

The rocks in the Coeur d'Alene mining district are late Precambrian and are primarily Belt series quartzites. They were originally shallow water sediments, metamorphosed to quartzites, argillites, and phyllites. At the Galena Mine, the host rock for the mineralized veins is the Revett formation, which consists mainly of thickly bedded to massive quartzites (Kesten, 1961).

GEOLGIC SETTING

As seen in figure 1, the dominant structural feature in the district is the Osburn fault zone. At the mine, the major structural feature is the Polaris fault zone. In addition to this major faulting, extensive minor bedding-plane faults are present in the silver vein area. (See surface geology in figure 2 and a cross section through the main silver vein in figure 3.)

The silver vein lies within a zone of parallel fractures some 300 feet in width. The vein material is predominantly siderite, the ore being argentiferous tetrahedrite and minor amounts of chalcopyrite. The vein is continuous over a horizontal distance of some 800 feet and a vertical extent of some 3000 feet, and is about 6 feet in width. This sheet-like body dips at an angle of some 70 degrees.

For this study the geologic factors of importance are the thickly bedded to massive character of the Revett quartzite and the fact that the silver vein is situated in a highly fractured zone on both local and regional scales—and that this fracturing is principally parallel to the silver vein.

ROCK PROPERTIES

Extensive laboratory testing of rocks at the Galena Mine was done by Chan (1970), who divided the Revett formation into five main groups, as follows:

- group 1 — homogeneous, fine-grained massive quartzite
- group 2 — argillaceous, fine-grained thin-beded quartzite
- group 3a — highly mineralized, medium-grained quartzite
- group 3b — low-mineralized, coarse-grained quartzite
- group 4 — homogeneous, medium-grained quartzite

HECLA 009251

Ronnei E. Barrette, et al v Hecla Mining Co., et al Docket No. 43639
Figure 1—Generalized structural geology of the Cœur d'Alene mining district (after Rael, 1961).
Figure 2.—Surface geology at the Calena Mine (after Keston, 1961).
Figure 3.—Vertical cross section through silver vein at the Galena Mine (after Kesten, 1961).
Results of uniaxial compressive tests are summarized in Table 1, and typical stress-strain curves are shown in Figure 4. All rocks failed violently when stress in the rock exceeded its strength; however, the rocks of groups 2 and 3b failed less violently than the rocks of groups 1, 3a, and 4. The compression machine used was a conventional hydraulic press—a "soft" testing machine.

**Table 1. Physical properties of Galena Mine rock (after Chan, 1970)**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of specimens</th>
<th>Mean Poisson's ratio ($v$)</th>
<th>Mean modulus of elasticity ($E$, $10^6$ psi)</th>
<th>Mean uniaxial compressive strength ($σ_e$, psi)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>0.29</td>
<td>7.63</td>
<td>33,100</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>0.27</td>
<td>1.67</td>
<td>12,000</td>
</tr>
<tr>
<td>3a</td>
<td>12</td>
<td>0.24</td>
<td>6.24</td>
<td>11,600</td>
</tr>
<tr>
<td>3b</td>
<td>12</td>
<td>0.28</td>
<td>1.78</td>
<td>15,800</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>0.25</td>
<td>6.17</td>
<td>21,800</td>
</tr>
</tbody>
</table>

Results of triaxial tests on the group 1 rocks are summarized in Table 2. As expected, the ultimate strength and modulus of elasticity increase markedly with increasing confinement.

**Table 2. Physical properties of Galena Mine rock with confinement (after Chan, 1970)**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of specimens</th>
<th>Confining stress, psi</th>
<th>Mean ultimate strength ($σ_e$, psi)</th>
<th>Mean modulus of elasticity ($E$, $10^6$ psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>0</td>
<td>33,100</td>
<td>7.83</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>1,500</td>
<td>38,400</td>
<td>10.20</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2,000</td>
<td>46,600</td>
<td>22.45</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>4,000</td>
<td>60,900</td>
<td>70.90</td>
</tr>
</tbody>
</table>

In situ seismic velocities were determined over travel distances up to 2000 feet. The average P-wave and S-wave velocities were found to be 19,400 fps and 12,200 fps, respectively. These values correspond to an in situ Young's modulus of $11.5 \times 10^6$ psi and a Poisson's ratio of 0.19. Elastic moduli based on the seismic velocities were considered to be good estimates of the wall rock moduli at the Galena Mine since they represent
Figure 4.—Stress-strain curves for Golman Mine rocks (after Chan, 1970).
the entire block of rock between measurement points and fell within the range of values determined from laboratory tests.

In summary, this quartzite wall rock is hard and brittle, and behaves primarily in a linear elastic manner. In addition, it is a competent and high-strength rock that fails violently in conventional, "soft," testing machines. Though the vein rocks are lower in strength, they also fail violently.

**IN SITU STRESS**

Agaton (1987) used the overcore stress-relief method to determine the state of stress at a depth of 4000 feet in the Galena Mine. He found that

\[
\begin{align*}
\sigma_x &= -11,200 \text{ psi}^* \\
\sigma_y &= -11,000 \text{ psi} \\
\sigma_z &= -8,900 \text{ psi} \\
\tau_{xy} &= +2,600 \text{ psi} \\
\tau_{xz} &= +1,200 \text{ psi} \\
\tau_{yz} &= +500 \text{ psi}
\end{align*}
\]

The virgin rock stress could not be inferred from these figures since this test was performed in a high-stress zone created by mining. However, these results do suggest the presence of a high horizontal stress. To determine the in situ stress, we measured overcore stress-relief away from the influence of the mined-out portions of the silver vein.

A site was selected on the 4600 level (some 6000 feet below surface) 3000 feet east of the silver vein. Measurements were to be made in three holes to determine the complete state of stress. However, owing to severe core discing, usable results were obtained for only one hole. These results gave a vertical stress of -7300 psi and a horizontal stress of -6500 psi. The vertical stress agrees well with the calculated overburden stress of -7100 psi, but the horizontal stress is greatly in excess (by approximately 400 psi) of that which can be accounted for by the Poisson's ratio effect.

Based on these data and field observations, the stress field at the Galena Mine was interpreted to be essentially hydrostatic, and it was inferred that the mine is in an active tectonic horizontal stress field.

*The minus sign will be used to denote compressive stress.*
The mining method at the Galena Mine is an overhand horizontal cut-and-fill system. A vertical longitudinal projection of the silver vein is shown in figure 5. Stoping progresses upward from one level to another by a series of horizontal cuts. Each cut is mined by a series of 8-foot rounds, some 12 feet high. Mining in most stopes is on a single shift basis and the mining cycle consists of slushing and roof bolting, drilling, and blasting. Few timber wall supports are used in a stope. A pillar is created.
as a stope and is mined upwards because this mining method results in mined out areas above each unmined stope. As the pillar size is reduced, the stress in the pillar is increased until the strength of the pillar is reached and the pillar bursts.

A staggered or staggered mining method at present is used to reduce the size of bursts and minimize the resulting hazard and damage. This stoping sequence minimizes the mining-induced stress concentrations by spreading out small pillars along a diagonally advancing front which avoids the higher stresses created by a long horizontal flat-back pillar. This technique has allowed mining to continue and production to be maintained, but bursting still occurs as each pillar reaches a critical burst geometry.

Though stopes closures have not been measured, good estimates of closure can be made by observing the squeeze on sill drift timbering in mined-out areas. In an area on the 3000 level, which has been mined out for at least 7 years with a mined-out area of some 1000 feet by 500 feet, the sill drift is still open and passable, and the squeeze on drift timbering is less than 1 foot, indicating the highly elastic nature of the Galena Mine wall rock.

**ROCK-BURST HISTORY**

Rock bursting was first reported at the Galena Mine in 1956 when the top part of the silver vein was being mined upward from the 2400 level to the 2200 level, and the first flat-backed pillar was created. Bursting has continued to date with 128 large damaging bursts. To be reported as a large burst, enough damage must be done so that the burst area can be located and the damage mapped. A loss of production usually accompanies large bursts. Small bursts and bumps, which may occur almost daily with the blasting, and large bursts, which produce no visible damage to mine workings, are not reported because they cannot be located.

Rock bursts also occur when geometric or geologic features concentrate stress in mine structures and this stress exceeds the strength of the structure. Of the 128 damaging bursts reported, some 90 have been classed as pillar bursts because the damage was concentrated in or associated with a pillar. Figure 6 is a plot of the number of pillar bursts with respect to pillar size. It is apparent that when pillar size is reduced below 60 feet, an initial burst geometry is reached; and a critical burst geometry is reached when the pillar size is reduced below 40 feet.

No bursts have been reported or detected from old workings because the mining method results in essentially 100 percent extraction.
Figure 6.—Incidence of damaging rock bursts.
Any bursting has been reported for a working area after more than 48 hours since blasting in that area. During all mine shutdowns of greater than a weekend, no bursting has ever been reported.

Most bursting occurs along with the mine blasting. A burst occurs when the change in geometry brought about by blasting produces a critical burst geometry. With electric blasting, bursts usually occur within a second or two after start of the round and almost always before the last delays of the round are fired. This feature further emphasizes the highly elastic response of the rock at Galena Mine.

Strain energy is stored in the rock, owing to the gravitational and tectonic stress field acting on the rock at depth at the Galena Mine. When an underground excavation is made, both the stress and the strain energy per unit volume are concentrated in rock surrounding the opening. For the geometry of a pillar, where two or more openings are approaching each other, the stress and strain energy are further concentrated. The pillar fails when the average stress in the pillar exceeds the strength of the pillar. For the hard, brittle quartzites at the Galena Mine, this failure is usually sudden and violent, and results in a rock burst accompanied by release of large amounts of energy.
MICROSEISMIC STUDY OF ROCK BURSTING

The microseismic method of detecting instability in underground mines, developed by the U. S. Bureau of Mines in the early 1940s (Obert and Duvall, 1945), relies on the fact that as rock is stressed, strain energy is stored in the rock. The buildup of strain energy is accompanied by small-scale displacement adjustments that release small amounts of seismic and, sometimes, acoustic energy. These small-scale disturbances, microcracking, shearing, sliding and crushing of crystal grains, which can be detected with the aid of special geophysical equipment, are called microseisms or rock noises.

MICROSEISMIC METHOD

Early applications of this technique were based on counting rock noises generated within an entire rock structure, rather than studying specific sections of that structure. A recent study by the U. S. Bureau of Mines (Blake and Duvall, 1969) has resulted in a new, broad-band microseismic system (fig. 7). This system consists of accelerometers as geophones, low-noise preamplifiers, high-gain amplifiers, and a FM magnetic tape recorder. The associated test and analysis equipment consists of an oscilloscope, direct-write oscillograph, and a programmable electronic desk calculator. The frequency response of the system is flat from 2 to 20,000 Hz; the noise level is less than 2.0 µv, and the dynamic range, including manual set attenuation, is greater than 100 db. Signals with acceleration levels as low as 2 µg can be detected.

Rock noise source locations in the field have been more qualitative than quantitative, primarily because of an insufficient number of geophones and low recording speeds. Rock noise source locations can be calculated by a number of methods (Leighton and Blake, 1970) provided that the seismic velocities, geophone coordinates, and arrival times of P- and S-waves are known.

Basically, three methods may be used to locate the source of a rock noise event. Two of the methods give unique mathematical solutions, and the third results in an approximate or best-fit solution. The mathematical solutions are based on (1) differences in first arrival of P-waves at five geophones, and (2) the travel time differences of S-P-wave arrivals at four geophones. By using the standard distance equation
Figure 7.—Broad-band microseismic system.

\[ d_i = \sqrt{(x-a_i)^2 + (y-b_i)^2 + (z-c_i)^2} \]  \hspace{1cm} (1)

where

- \(a_i, b_i, c_i\) = \(i^{th}\) geophone coordinates,
- \(d_i\) = distance from source to \(i^{th}\) geophone,
- \(x, y, z\) = unknown source coordinates,

and the velocity-arrival time relationships

\[ d_i = \frac{V_{\text{P}} x_i}{t_i} \]  \hspace{1cm} (P-wave method) \hspace{1cm} (2)
Rock-Burst Mechanics

\[ d_i = \Delta t_{sp} \left( \frac{1}{V_i^p} - \frac{1}{V_i^s} \right) \] (S-P-wave method) \hspace{2cm} (3)

where

\[ V_i^p \text{ and } V_i^s = \text{P- and S-wave velocities in the direction from source to each geophone,} \]

\[ t_{sp} = \text{relative times of the first arrival of the P-wave at each geophone,} \]

\[ \Delta t_{sp} = \text{differences in times of arrival of the S-wave and P-wave at each geophone,} \]

three linear independent equations can be obtained and solved for the unknown \( x, y, z \) source coordinates. The approximate solutions are based on trial and error, iterative type procedures when less than the required number of geophones for an exact solution is used, and a least squares procedure when more than the required number of geophones is used.

A field study in the Coeur d'Alene district (Blake and Leighton, 1970), using this new microseismic system and source location techniques, showed that rock raise source locations could be accurately calculated in three-dimensional space, and that cumulative plots of source location densities delineated and mapped areas of increasing stress. At the Galena Mine, it was found that these areas of inferred high stress were potential rock-burst zones (fig. 8). The numbers in figure 8 refer to the number of rock noises located at a particular point. These numbers have been contoured to show rock noise source location densities, indicating zones of inferred high stress. Besides locating potential rock-burst zones, analysis of data suggested that the microseismic method might be used to study the sequence of events leading up to bursting in burst-prone mine structures.

Microseismic Field Monitoring

A stope, which was approaching an initial pillar-burst geometry, was selected for study. Figure 9 is an isometric projection of the Galena Mine, indicating the stope, 40-185 E, and the location of geophones. Microseismic monitoring of this stope began in November of 1969, when the stope pillar was 60 feet thick. One small burst had occurred with the blasting in September of 1969, when the pillar was some 80 feet thick. From the reported damage, and from spalled rock on the west wall of the raise and along the 3700-level drift west of the raise, the burst source location was inferred to be west of the stope in the solid rock. No damage was re-
Figure 8.—Cumulative plots of rock noise source locations, 76R, 3400 to 3200 levels (after Blake and Leddington, 1970).
ported in the stope or along the sill drift.

Field monitoring procedures consisted of recording daily during the working week from 2:00 to 2:45 p.m. Day shift mine blasting was at 2:20 p.m. Seismic velocities were computed from the daily blasting, using shot-time contactors. Analysis procedures consisted of scanning the recorded tapes to determine where the data were located, making expanded time-scale seismologic records of recorded events, calculating rock noise source locations using the desk computer, and plotting coordinates of located events. An event, to be located, had to be detected and recognized on at least five channels. A typical record of a rock-noise event and its location analysis is shown in figure 10. All the data analysis was performed underground and kept current. In addition, the stope and sill drift were inspected daily for any signs of stress buildup.

Figure 10.—Typical microseismic record and location analysis.
Rock noise source locations resulting from three 8-foot backstop cuts during the time period of November 14, 1969, to February 4, 1970, are noted in figure 11. Two views of the stope are shown on figure 11—a longitudinal vertical projection and a cross section through the center of the stope—so that the rock noise source locations can be seen in three dimensions. The pillar size was reduced from 60 to 36 feet, indicated on figure 11 by dashed lines. These data indicate that the pillar had not yet reached a critical burst geometry. The zones of inferred high stress are around the bottom of the stope and away from the stope walls. No indications of a stress buildup in the pillar were detected or observed.

During the latter part of February 1970, while the stope was being slushed out and backfilled with sand, no locatable rock noises were detected during recording times. This is usual at the Galena Mine and indicates the high degree of elasticity of the rock. That is, rock noises are generated during and immediately after blasting because of the change in geometry, but equilibrium is quickly reached; hence, few rock noises are generated during slushing and sandfilling.

A comparison of data from seismic velocity surveys on February 2 and March 4, 1970, given in table 3, did suggest that stress in the pillar had increased because of its reduced size. As expected, those geophone locations in the immediate pillar area showed the largest velocity increases.

Table 3. — Seismic velocities, #0-135 E stope

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1</td>
<td>19,699</td>
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<td>2</td>
<td>18,408</td>
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<td>3</td>
<td>19,397</td>
<td>20,519</td>
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<tr>
<td>4</td>
<td>19,397</td>
<td>20,519</td>
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<tr>
<td>5</td>
<td>20,413</td>
<td>21,335</td>
</tr>
<tr>
<td>6</td>
<td>20,424</td>
<td>20,535</td>
</tr>
<tr>
<td>7</td>
<td>contactor*</td>
<td>contactor</td>
</tr>
</tbody>
</table>

*A shot-time contactor was used to put a spike on the tape when the velocity survey charge was detonated.

An 8-foot backstop round was pulled in the back 30 feet of the pillar on March 4, 1970. The geometry of the stope and the rock noise source
Figure 11. Rock mass source locations, November 14, 1969: February 4, 1970, 40-155E, with relative intensity contours.
locations resulting from this round are shown in figure 12. These data indicated that the back part of the pillar was now highly stressed and that a critical pillar burst geometry had been reached. There were still no visual indications of high stress in the stope or along the sill drift.

The back part of the pillar started popping audibly on the afternoon of March 5, 1970. Output from the geophones close to the stope indicated that the stope was becoming unstable; hence, the miners were removed from the stope and held out. At 6:45 a.m. on the next day, March 6th, a burst occurred in the back part of the pillar in this stope. The effects of this burst in the stope and along the sill drift over the pillar—typical of the damage resulting from a small pillar burst—are shown in figure 13.

![Figure 12.—Rock noise source locations, March 4, 1970, 40-135E, with relative intensity contours.](image)

**Figure 12.—Rock noise source locations, March 4, 1970, 40-135E, with relative intensity contours.**

**SEQUENCE OF EVENTS LEADING UP TO BURSTING**

The behavior of the pillar in 40-135E stope, as it was mined to a critical burst geometry, was almost identical to the behavior of the four other stope pillars that have been monitored at the Galena Mine since 1968—all of which burst. Hence, based on microseismic monitoring, a definite sequence of events has been observed to take place prior to a pillar burst at the Galena Mine.
Figure 18—Damage to drift and stope from pillar burn, 10/1/55.
ROCK-BURST MECHANICS

When a stope pillar is greater than 75 feet in thickness, little rock noise is generated by blasting. The locatable events are scattered around the stope area. As the pillar is reduced below 60 feet, reaching an initial burst geometry, the rock noises generated by blasting tend to concentrate around the bottom of the stope and out around the stope walls at about stope height, obvious zones of high stress concentration. As the pillar size is reduced to a critical burst geometry, below 40 feet, the number and magnitude of rock noises generated by blasting increases. Minor bursting may occur around the bottom and unmined end of a stope. Up until this time, few rock noises have had their origin in the pillar area. Once the pillar reaches a critical burst geometry, some 35 feet, most of the rock noises are now generated from the immediate pillar area. The pillar almost always bursts during this cut.

These data suggest that the average stress in the pillar increases only gradually until the pillar size is reduced below 40 feet, when average stress in the pillar increases greatly. The fact that rock noises do occur prior to this inferred large stress increase in the pillar suggests that small localized areas around the stope are under a high stress because of geologic or geometric effects. This pattern is consistent with the observations on damaging bursts with respect to pillar size, as shown in figure 6.
STRESS ANALYSIS OF MINING METHOD

Finite-element stress-analysis computer model studies were made of the mining method to gain insight into the stress distribution around a stope pillar.

FINITE-ELEMENT METHOD

The finite-element technique is based on the displacement or stiffness method of analysis developed by structural engineers for the aircraft industry (Clough, 1960). A continuous solid is modeled by a mesh of a finite number of elements interconnected at corner or nodal points. This physical idealization of a solid as an assemblage of finite elements involves no mathematical approximation. The only approximation is in assuming a displacement function for each element. The usual procedure is to use a linear displacement function which results in plane sections remaining plane after deformation. The finite-element solution does converge to the exact solution as element size is reduced to a point.

Derivation of the finite element matrix equilibrium equation

\[
\vec{f} \quad = \quad [k] \quad \vec{u}
\]  

has been shown to be a linearization of the Navier displacement equilibrium equations of classical elasticity (Blake, 1966). In this equation, nodal point forces \( \vec{f} \) are related to nodal point displacements \( \vec{u} \) by the stiffness matrix of the system \([k]\). Equation (4) is simply a generalization of the one-dimensional force-spring-displacement relationship

\[
f \quad = \quad k \times .
\]

Once geometry and material properties are defined for each element, this equation is solved, taking into account initial and boundary conditions for a particular problem. Solutions are in the form of nodal point stresses and displacements and element stresses.

The method achieves its great versatility from the fact that each element can have completely different material properties, and, in addition, any stress-strain relationship may be used. Thus, nonhomogeneities and anisotropies are easily taken into account. Finally, since the stiffness matrix is completely general, any geometry or shape can be modeled.
A large-scale, high-speed digital computer is required, owing to the large number of elements normally required to adequately model most practical problems. A CDC 6600 with 65K word storage was used in this study.

**Simulation of Mining in 40-135E Stope**

The mining of 40-135E stope was simulated on the computer because data from microseismic monitoring had shown a characteristic sequence of events leading up to rock bursting. The stope cross section and the finite element idealization are shown in figure 14. Material properties for the vein and wall rock were based on the work of Chan (1970) and on field measurements. Properties of the sand backfill were based on a study by Nicholson and Busch (1968). Material properties for the model are given in table 4.

**Table 4. Material properties for models**

<table>
<thead>
<tr>
<th>Rock type</th>
<th>Young's modulus (E), x 10^6 psi</th>
<th>Poisson's ratio (ν)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartzite wallrock</td>
<td>11.7</td>
<td>0.19</td>
</tr>
<tr>
<td>Mineralized quartzite</td>
<td>5.75</td>
<td>0.26</td>
</tr>
<tr>
<td>Fractured quartzite</td>
<td>1.0</td>
<td>0.25</td>
</tr>
<tr>
<td>Compacted sand backfill</td>
<td>0.075</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Based on the in situ stress determination and the influence of the mined-out portion of the silver vein in the vicinity of 40-135E stope, a hydrostatic stress of -7500 psi was used as the stress boundary conditions for the model. Uniform displacements were applied to the boundaries of the model which produced this stress state. A plane strain section across the vein was considered to be representative of the way in which a stope is subjected to load because of the geometry of the silver vein.

The model stope was mined in a series of fifteen 10-foot cuts. Each cut was backfilled with compacted sand, and blasting fractures were simulated in the stope walls and back prior to beginning the next cut. (Material properties used and the extent of the fractured zone surrounding this stope were based on seismic velocity surveys through fractured rock around other stopes and mined openings at the mine.) The material properties of the model stope were changed before each computer run.
Figure 14—Typical stope cross section and finite element computer model idealization.
Results from this simulated mining of 40-135E stope are shown in figure 15. The maximum principal stress $\sigma_{\text{max}}$ and the average stress $\bar{\sigma}$ in the pillar are plotted against pillar thickness. Both the maximum stress and the average stress in the pillar do not significantly begin to in-
crease until the pillar size is less than 50 feet, and the highest stresses occur when the pillar thickness is some 35 feet. As the pillar size is reduced to less than 20 feet, both stresses decrease rapidly, owing to the blast-fractured zones joining. Comparison of these results with figure 6 indicates that the model results agree with the observed field behavior of a pillar.

Maximum shear stress contours for the critical 35-foot pillar are shown in figure 16. In addition to the obvious high stress concentration in the pillar area, note that the stress is also concentrated around the

Figure 16.—Maximum shear stress contour plots for 30-foot pillar, 1000 psi contour interval.
bottom of the stope and out around the stope walls. The agreement of these data with the rock noise source locations for this stope is also readily apparent (figs. 11 and 12).

Small failures occur when the maximum principal stress in and around the pillar exceeds the strength of the rock locally. These failures generate rock noises and small rock bursts. A large failure occurs and results in a rock burst when the average stress in the pillar exceeds the strength of the pillar or of a large portion of the pillar. Based on the unconfined compressive strength of the rock, pillar bursting will begin when the pillar size is reduced below 50 feet. It is apparent from results shown in table 3 that confinement will increase the strength of the rock in the pillar, but little field data regarding detailed material properties of the pillar were available; hence, no attempt was made to model the effects of confinement on the pillar.

It is interesting to note that the maximum stress computed for the sandfill is only ~850 psi. Thus the sandfilling, while helping to minimize the damage from a rock burst, does not carry enough load to reduce the critical high stresses created in the pillar, and, therefore, has little effect on reducing the incidence of bursting.

The data from both microseismic monitoring and finite element modeling agree well with the observed behavior of stope pillars at Galena Mine, and explain the sequence of events leading up to bursting. However, these results only confirm what was already obvious—when the average stress in the pillar exceeds its strength, the pillar bursts.

Something else must be considered—the relative stiffness of the pillar and the loading system at failure—to determine why a pillar fails violently instead of nonviolently.
CONCEPT OF MINE STIFFNESS

In recent years it has been recognized that to interpret results correctly for rock specimens loaded in a testing machine, the properties of the testing machine itself must be considered. Many of the modes of failure observed in failed test specimens are a result of the characteristics of the testing machine and are not inherent rock properties. These additional effects must be eliminated to determine the true rock response.

EXPERIMENTAL RESULTS ON TEST SPECIMENS

A normal testing machine consists typically of many elements (platen, cross-heads, screws, frame, hydraulic system, etc.); each contributes to the overall properties of the machine, and, in turn, affects the specimen being tested. The most important characteristic of a testing machine is its stiffness, that is, the rigidity of the loading system, taking into account all its components. Recent studies by Cook and Hojem (1966) and Wawersik (1968) have shown that the behavior of rocks tested in conventional testing machines was surprisingly different from the behavior of the same rocks tested in a rigid or stiff testing machine. Rocks that failed violently in conventional or soft testing machines were found to fail nonviolently in a stiff testing machine. This result has led to an examination of the effects of relative stiffness of the specimen and loading system on specimen behavior.

Since a rock specimen and a testing machine are made up of basically elastic members, elastic strain energy is stored in each as a specimen is loaded by a testing machine. The amount of strain energy stored in each is inversely proportional to its stiffness, i.e., the softer of the two stores, the greater amount. The strain energy per unit volume in the specimen is given by

\[ w = \frac{\sigma^2 a}{2k l} \]  

where

- \( w \) = strain energy stored
- \( \sigma \) = stress
- \( k \) = stiffness
- \( a \) and \( l \) = cross-sectional area and length of the specimen, respectively
When the applied stress reaches the specimen strength, it is the relative stiffness of each that determines the mode of failure—violent or nonviolent. (See fig. 17.)

For case a, where the stiffness of the specimen is greater than the stiffness of the loading system, \( |k_s| > |k_l| \), violent failure occurs when stress in the specimen reaches its strength because there is sufficient strain energy available in the loading system to continue to load the specimen; hence, this recoil of the machine destroys the specimen. Such is the case when Galena Mine rocks are tested to failure in a conventional or soft testing machine.

For case b, where, \( |k_s| > |k_l| \), a nonviolent failure occurs because the stored strain energy available is not sufficient to deform the specimen further until additional load is applied by the testing machine.

The stiffness of a mine pillar and the loading system at the mine were studied since the geometry and loading of a stope pillar at Galena Mine are essentially identical to the geometry of a specimen loaded in a testing machine. The results of the finite element computer model studies, stresses and displacements were determined for every element and nodal point in the model; these results were used to compute the stiffness of the pillar and loading system as the pillar was mined. Remember that the only boundary conditions used in the model were the constant displacements applied to the model boundaries.

**PILLAR STIFFNESS VERSUS LOADING SYSTEM STIFFNESS**

By using the stresses and displacements from the simulated computer mining of 40-135E stope, the stiffness of the stope pillar for a unit length was calculated by

\[
    k_p = \frac{f_i}{u_i} \tag{7}
\]

where

- \( f_i \) = total force on the pillar
- \( u_i \) = resulting average pillar displacement

The force on the pillar was obtained by summing the stress in all elements acting on the pillar, determining the average stress acting on the pillar, and multiplying this average stress by pillar length to obtain the total force.

* Lack of data on the complete stress-strain curve for Galena Mine rocks resulted in assuming that their complete stress-strain curve is symmetric.
Figure 17.—Specimen and loading system stiffness relationships.
f₁ acting on the pillar. Nodal point displacements along the pillar length were summed, and the average pillar displacement u₁ was determined. The pillar stiffness k₁ was computed in this manner for every 20-foot increment of pillar size. One pillar configuration and the resulting pillar compression and stope wall closure are shown in figure 18. The computed pillar stiffness is given in units of lb/in per inch of stope length because the com-

Figure 18.—Compression of pillar and stope wall displacements.
The stiffness of the mine loading system was also obtained from the computer model results. The total load on the model \( W \) was constant, \( \Delta W = 0 \), because of the constant displacement boundary conditions on the model. Thus the stiffness of the loading system can be calculated from the relationship

\[
k = \frac{\Delta f}{\Delta u} = \frac{f_1 - f_2}{u_1 - u_2}
\]

where

- \( f_1 \) and \( u_1 \) = force and displacement previously determined for the rock pillar
- \( f_2 \) and \( u_2 \) = force and displacement, determined in the same manner, for the sand-filled pillar

See figure 18 for the resulting displacements for the sand-filled pillar. The loading system stiffness was also computed for every 20-foot increment of pillar thickness and is given in units of lb/in. per inch of stope length. This manner of computation results in the loading system stiffness having a negative slope that corresponds to the unloading system stiffness.

The relationship of the pillar stiffness \( k_p \) to the loading system stiffness \( k_l \) as the pillar was mined is shown in figure 19. The stiffness of the pillar is greater than the stiffness of the loading system until the pillar size is reduced to less than 20 feet—where the effect of the simulated blast fractures serves to soften the pillar.

These data indicate that the pillar-loading system stiffness relationship is unstable until the pillar size is reduced below 20 feet. In other words, a burst will occur in the pillar area any time the average stress in the pillar exceeds the strength of the pillar, until the pillar size is reduced below 20 feet. The aforementioned relationship can occur more than once—depending on the geometry of the pillar—because the pillars are roughly 100 feet long, which explains the occurrence of more than one burst in a pillar. That this is the case at the Galena Mine is apparent from observations on bursts.

**Effect of Geology on Mine Stiffness**

The calculated stiffness of the pillar and mine loading system represent upper limits of stiffness since the finite element results are based on an elastic analysis. The effects of folding, faulting, jointing, fracturing, inhomogeneity, and inelasticity will all tend to reduce the stiffness of
Figure 19.—Variation of pillar stiffness and loading system stiffness with mining, 49-195E stope.
both the pillar and mine-loading system. The effect of confinement has not been considered in this study. The mine-loading system involves a much larger volume of rock; as a result, its stiffness will be affected to a greater extent because the system will probably contain a larger number of stiffness-reducing features. This will also be true for any mine structure and mine-loading system stiffness relationship.
MECHANICS OF ROCK BURSTS

Sufficient information has now been obtained to deduce the mechanics of rock bursts and to present a hypothesis for the cause of rock bursting consistent with field observations of these phenomena.

HYPOTHESIS FOR THE CAUSE OF ROCK BURSTING

As mine structures are created by the excavation of underground openings, they disturb the gravitational and tectonic stress fields, resulting in stress and the strain energy per unit volume being concentrated in the mine or rock structure surrounding the opening. When stress in the rock structure reaches the strength of the rock, the rock fails, owing to geometric and geologic effects or because of depth, etc. If the rock structure is stiffer than that of the applied loading system, available stored strain energy in the loading system instantaneously loads the rock structure further, causing it to fail violently in the form of a rock burst. Since a rock burst fractures a volume of rock, which is instantaneously destressed, and so thought of as an opening being created, a large volume of rock is instantaneously displaced towards this opening, resulting in energy being released suddenly and violently.

The fact that stress in the rock exceeds the strength of the rock is necessary, but is not in itself sufficient to cause a rock burst. In addition, the stiffness of the rock or rock structure must exceed the stiffness of the loading system so that the available stored strain energy of the latter is released to destroy the structure.

This hypothesis applies not only to hard, brittle rocks under high stress, but also to soft, brittle rocks under moderate stress which suggests an explanation for such things as coal bumps. Though pillars have always been associated with rock bursts, they are just the most prominent geometry of any number of rock-burst-prone geometries, such as the headings of shafts, raises and drifts, remnants, longwall faces, drift intersections, etc. A field test to confirm this hypothesis for the cause of rock bursting was carried out at Galena Mine.

FIELD TEST OF BURST HYPOTHESIS

After burst damage to the stope, sill drift and raise was repaired and...
the mining of the remaining pillar in 40-135E stope resumed, data from microseismic monitoring indicated that another potential burst zone had developed in the central part of the pillar. The geometry of the pillar, now some 30 feet in thickness, and rock noise source location densities are shown in figure 20. These data and past experience in monitoring 15 bursts at Calena Mine indicated that further mining, that is, reducing pillar size to increase stress in the pillar, would result in another rock burst.

If the hypothesis developed for the cause of bursting is correct, then this potential burst could be prevented by reducing the average stress in the pillar to a value well below the strength of the rock in the pillar, or by reducing pillar stiffness to a value less than the stiffness of the loading system. It would appear that destressing the pillar by fracturing would affect both desired results.

Work in South Africa by Hill and Plewman (1957) had indicated that destressing was effective in controlling rock bursting. More recent work in South Africa by Cook and others (1966), however, implied that destressing is not an effective means of controlling rock bursting. This observation was based on seismic monitoring of destressing rounds which indicated that all of the seismic energy detected was due to explosives. They postulated that for destressing to be effective, a larger amount of seismic energy would be released, indicating that strain energy from the stress field was involved which reduces the stress and the energy available for bursting.

Strain energy from the stress field is released any time a blast occurs because instantaneous creation or enlargement of an opening causes displacements towards that opening, although the volume of rock is usually small. Thus, the strain energy released is less than the energy released by the explosive itself; hence the strain energy is not usually recognized. If we use the results of Duvall and Stephenson (1965), the seismic energy released by detonating a cubic foot of explosive is 1.4 x 10⁷ ft-lb, whereas the amount of seismic energy released from the stress field (for an assumed modulus of rigidity of 4.0 x 10⁸ psi, a volume of rock of 5.0 x 10⁷ ft³ and a hydrostatic compressive stress of 7500 psi) is 1.0 x 10⁷ ft-lb, an order of magnitude less than the energy from the explosive.

Destressing of the pillar in 40-135E stope was simulated in the computer model by reducing the elastic modulus of the vein rock from 5.75 x 10⁶ psi to 1.0 x 10⁶ psi (determined by seismic velocities in fractured rock). The resulting maximum shear stress contours, which indicate a large reduction in the pillar stress concentration, are shown in figure 21. (See fig. 16 for comparison.) The value of the maximum principal stress in the pillar has been reduced to −9900 psi, and the average stress in the
Figure 39—Rock burst source locations, April 15-10, 1970, 40-1322, with relative intensity contours.

Ronne E. Barrette et al. vs Heica Mining Co., et al
Docket No. 43639
pillar has been reduced to $-6200$ psi. These data indicate that fracturing the pillar is certainly effective in reducing stress in the pillar.

The stiffness of the pillar prior to destressing was $7.8 \times 10^6$ lb/in. per inch of stope length, and the absolute value of the stiffness of the loading system was $3.4 \times 10^6$ lb/in. per inch of stope length which indicated the pillar was burst prone. After destressing, the stiffness of the pillar was
reduced to $2.8 \times 10^5$ lb/in. per inch of stope length, which indicates that the pillar-loading system stiffness relationship is now stable, and, as a result of destressing, the pillar is no longer burst prone.

Based on these results, the pillar in 40-135E stope was destressed by blasting a series of 20-foot long holes, 1.5-inch-diameter, drilled in the footwall of the vein on 5-foot centers. These holes were loaded within 5 feet of the sill and 3 feet from the collar with AN prill and fired with millisecond delays. See figure 22 for the pillar and destress hole pattern.

Seismic velocity surveys through the pillar were carried out to determine the effectiveness of the destress round in fracturing the pillar. Since seismic velocity is proportional to the effective elastic modulus of and to the stress level in the rock, any decrease in seismic velocity would indicate a decrease in elastic modulus, hence a softening of the pillar and a corresponding reduction in stress level. Though seismic velocity is also inversely proportional to the density of the rock, the effect of density changes is small compared to changes in effective elastic modulus and stress level.

The seismic velocity survey shot holes (fig. 22) were loaded with a half stick of 45-percent dynamite and a shot-time contactor, and were detonated. These blasts were recorded, the seismic velocities from each shot location to each geophone were computed, and, based on these data, a seismic velocity contour map of the pillar was compiled. This survey was repeated after the destress round was fired. The results of these seismic velocity surveys are shown in figure 23. The reduction in seismic velocity produced by destressing indicates that the pillar has been fractured and its effective modulus and stiffness have been reduced; therefore, it is inferred that stress in the pillar has also been reduced. The high stress acting on the pillar area has been transferred to a low stress acting over a large area—spread out around the stope and in the sandfill.

Though no closure pins were installed in the stope or sill drift over the pillar, an order-of-magnitude approximation of sill drift closure from the destress round could be obtained by inspecting the squeeze on timbersing along the sill drift. Subsequent to the March 6, 1970 burst, the drift had been retimbered, and the new posts, caps, and wedges showed no signs of taking any load prior to the destress round. As a result of destressing, posts were punched up into caps and the blocks and wedges on the caps showed up to 0.5 inch of closure. This amount of closure agrees with the predicted closure for this location from the computer model, 0.25 inch. The pillar compression and stope closure from the computer modeling of the destressing are shown in figure 24. A large amount of stored strain energy from the pillar area has been released nonviolently because
HECLA 009291
Figure 53 - Contour plot of seismic velocities, for 40-100Hz.

HECLA 009292
Figure 24.—Compression of pillar and stope wall closures resulting from destressing.

of this closure. Insufficient data on the actual closure and the two-dimensional character of the model precluded calculating the amount of energy released by destressing.

The success of destressing is attested to since the pillar was mined to completion without incident. No bumps or bursts occurred, and the few
In addition to confirming the hypothesis developed for the cause of rock bursting, the results also show that to be effective in controlling or eliminating bursting, the factors contributing to bursts must be controlled or substantially modified. Those techniques that have been successful in minimizing bursting, namely long-wall techniques and destressing, have resulted in modifying stress in the structure and the relative stiffness relationship of the structure and the loading system.
SUGGESTIONS FOR MINE DESIGN

The procedures developed in this study can be used to design mines or mine structures so that rock bursting can be controlled. Plane stress/strain finite element stress analyses can be used to model mine structures and mining methods adequately and economically because rock bursts are almost exclusively associated with tabular-like ore bodies. Since stresses and displacements are obtained for every point in the structure, these data can be used to find the average stress in the structure and the stiffness relationship of the structure and the loading system to determine if the structure will be burst prone.

The data needed to develop a finite-element model for a new mine can be obtained from diamond drilling. The geometry and extent of the orebody can be delineated by drilling. The physical properties of the ore and wall rocks can be determined from laboratory tests on core specimens in both conventional and stiff testing machines, including whether or not specimens fail violently in conventional testing machines. The in situ state of stress can be inferred from a structural analysis of the drill cores and estimated from hydrofracturing tests in the bore holes. These data can then be used for the model properties, boundary and initial conditions. Different mining methods and mine structures can be simulated by this computer model, using a trial-and-error approach to determine mine structures and mining methods which, in theory, are not burst prone. In addition, the effectiveness of different support systems for various mining methods can be evaluated in the same manner.

For the steeply dipping, sheet-like veins of the Coeur d'Alene mining district, bursting could be readily controlled by mining these veins from their bottom up, using a stair-stepped longwall-type heading. If and when stress ahead of the face exceeds the average strength of the rocks, the face could then be destressed by blasting to control bursting. For existing mines, where present mining methods may not be changed or modified economically, bursting in burst-prone mine structures can be controlled by destressing these structures. However, to destress successfully, the destress hole must be in the right place (where the stress is concentrated) and the rock sufficiently fractured. These zones of high stress can be located by the broad-band microseismic technique.

In addition to pillar destressing, destress blasting ahead of the face in development headings, shafts, raises, and drifts is now being successfully and routinely performed in the mines of the Coeur d'Alene mining district.
CONCLUSIONS

When the average stress in any mine structure is exceeded, the structure fails. Whether this failure is violent or not depends on the relative stiffness of the mine structure and mine-loading system. For the case of structure stiffness greater than loading system stiffness, the failure is violent and results in a rock burst. In other words, the stored strain energy in the loading system is released instantaneously at failure and thus drives the structure to violent destruction. A rock burst fractures and destresses a large volume of rock which can be thought of as the instantaneous creation of an opening. The instantaneous displacements of the rock mass toward this opening cause additional energy from the gravitational and tectonic stress field to be released violently.

Rocks will burst in any rock structure when the following two conditions are satisfied: (1) stress in the rock structure exceeds the strength of the structure, and (2) stiffness of the rock structure exceeds stiffness of the loading system. A rock burst can be prevented in any rock structure—the inverse of our hypothesis—by the following: (1) reduce stress in the rock structure to a value below its strength, or (2) reduce stiffness of the rock structure to a value below the stiffness of the loading system. The two most effective means of rock-burst control to date—longwall-type mining systems and destressing by blasting—have been successful because they minimize the creation of high-stress zones, and they reduce the stress and stiffness of rock-burst-prone mine structures, respectively.

Broad-band microseismic monitoring provides quantitative information about the behavior of a rock structure under load. It is an invaluable tool in detecting, delineating, and estimating the stability of potential failure zones in rock structures. In deep mines, zones of inferred high stress can be pinpointed in three-dimensional space. Though the rock bursts during this study had their foci in these inferred high-stress zones, not all of these zones experienced bursts.

The finite-element method of stress analysis can be used to model the behavior of mine structures under load, and to simulate mining methods. The resulting stresses and displacements computed by this technique can be used to determine and to design mine structures and methods which can control rock bursting.

While the results of this study have been based on an analysis of rock bursting in an ideal geometry and particular environment, we suggest
that the hypothesis developed and presented for the cause of rock bursting applies to both hard and soft rock environments, and thus explains both rock bursts and coal bumps.
RECOMMENDATIONS FOR FURTHER WORK

Now that a general model for the mechanics of rock bursting has been developed, additional studies dealing with specialized aspects of the rockburst phenomenon should be carried out to develop further this model.

More extensive field and laboratory testing of mine rocks is necessary so that the material properties used in finite element models are more realistic. In situ deformation moduli should be determined at critical points in mine structures so that the effects of confinement can be included.

To confirm the computer results for the behavior of particular mine structures, both stresses and displacements should be monitored in and around burst-prone mine structures as mining progresses. These data should be used as boundary conditions for the models where discrepancies exist between calculated and measured behavior.

If we use a more detailed finite element model of a rock-burst-prone structure, it should be possible to model the effects of a burst and compute the energy released. This number can be compared to calculations—obtained from seismic data—of the actual energy released. From these data, we can determine the volume of rock in a burst.

Modes of failure initiation in mine structures have never been examined completely. Insight into the modes of failure of mine structures under multiaxial loading can be gained by using stiff testing machines and the complete stress-strain curves for model mine structures. Results of such studies could also be used to refine further the computer models.

Finally, while this work has been concerned only with rock bursts in hard rocks, these results should be extended to include coal bumps.
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HECLA 009299
Q U A R T E R L Y O F T H E C O L O R A D O S C H O O L O F M I N E S

Exhibit 10
The pillar surrounding the 5900 main drift at the 30 vein location sustained major damage after a large rockburst that occurred at 1:07 a.m. on November 16th. The burst caused approximately 12 feet of the back to fail and damaged both ribs.

Repair of the area is planned in 2 stages. The primary or initial stage is to bolt and shotcrete the area. The long-term or secondary stage is to install a steel tunnel liner through the vein area of the drift and fill the void above and around the forms with Techfoam.

The initial stage of repair has been completed. 12 ft dywidags have been installed in the back on a 4ft x 4ft pattern and 20 foot cable bolts were installed on a 6 ft x 6ft pattern. Wire fencing was installed with 4ft and 6ft with splits sets. The ribs have been wired and bolted with 8 ft dywidags on a 4ft x 4ft pattern, and 6 ft and 4ft split sets. The entire area was then shotcreted to a depth of 2 to 3 inches. The amount of ground support that has been installed is far more substantial than the original support installed when the drift was driven in 2005.

The secondary long term repairs are still being engineered, but in general, a steel tunnel liner will be installed through the area (approximately 35 ft in length). The tunnel liner that is being considered is typically used for highway construction. Once the liner is installed and the ends sealed, Techfoam will be blown in from the ends or through ports in the liner to fill the void. This Techfoam is a foamed concrete type product that has an approximately 25 psi compressive strength. The Techfoam will be able to absorb any wall squeeze and cushion any potential damage from rockbursting without compromising the steel tunnel liner.

The rockburst in the pillar is classified as a foundation failure, and not a classic pillar burst (See Wilson Blake’s 5900 Drift Pillar memo). The burst likely caused closure across the 30 vein in the mined out areas above and below the 5900 level. The constant stress from closure is the contributing factor that is believed to have caused the pillar to burst. Although the pillar is still intact and is still carrying some load and stress, it is believe the majority of the stress was dissipated with the large rockburst and it will take months or years for the pillar to gain more stress that could cause any major rockbursts. In addition, the pillar is now smaller in size so it cannot carry the same load that caused this rockburst.
As per Wilson Blake's report, the initial ground support installed can withstand a Richter 2.5 rockburst, which he reports as very unlikely to occur. To insure the long-term stability of the drift through the pillar a permanent steel tunnel liner and Techfoam will be installed.

The drift was also re-bolted for 40 feet on either side of the ground fall to assure the areas near the rockburst zone are stable. 12 ft dywidags were installed on a 4 ft x 4 ft pattern in the back and 8ft dywidags were installed on a 4ft x 4ft pattern in the ribs.

The area of the rockburst is now stable and the mine would like to resume production. Final engineering of the tunnel liner should be complete by December 2nd. Fabrication and delivery is expected to take 2 weeks from the order date. Installation is expected to take 2 to 3 weeks, depending on Techfoam availability. The stage 2 long-term support should be complete by January 7th.

The stress meters that were originally installed in the pillar are no longer working since the rockburst. 6 new stress gauges will be installed, 2 in the back and 2 in each wall. The gauges will be installed inside 3 in diameter drill holes. The gauges in the back will be placed at 10 ft above the drift and the gauges in the ribs will be at a depth of 20 ft. The gauges are NX4300 stress meters. We have 3 gauges on site and will be installed by Friday, December 2nd. The other 3 gauges are on order and will be shipped December 7th. As soon as the other gauges arrive they will be installed. In addition to the stress gauges, closure points will also be re-established. Closure will be measured east-west across the drift and north-south across the vein until the tunnel liner is installed.

A data collector will be used to gather the data from the stress meters. The original data collectors were destroyed in the rock burst and it is unknown at this time when a new data collector will be ready. The gauges will be read with a hand held meter once a month until the data collector is functional. Data from the data collector will be downloaded and analyzed approximately every 60 days.
Exhibit 11
Lucky Friday Mine

Request for modification

5900 Main level Rockburst Repair

By: Doug Bayer

December 1, 2011

3 NX 4300 stress meters are being installed in the 30-vein pillar around the 5900 main drift. An initial reading will be taken on dayshift, December 1st. Since the stress meters monitor increases in stress, it is expected that the initial reading will be zero, or close to zero. Another reading will be taken on night shift December 1st and again on dayshift December 2nd to establish a baseline. The frequency of taking readings can be determined based on the results of the stress meters. It is expected the stress will build slowly over time, and may take weeks or months to show any measureable increase in stress.

We request the K order be modified to allow travel through the drift starting Friday, December 2nd to allow the services to the mine to be re-established. Power cables, water lines and compressed air lines need to be re-installed to provide services to the mine. Once the services are reconnected, the mine plans to resume production.

The tunnel liner will be installed as soon as possible after it arrives on site.

In addition to gathering stress data, the area will be visually inspected every shift by the underground supervisors.
Lucky Friday Mine

Request for modification

5900 Main level Rockburst Repair

By: Doug Bayer

December 2, 2011

The 3 stress gauges have been installed into the 5900 main drift pillar. Readings were taken and the gauges show a small increase in stress, which is expected. We will continue to take readings every shift for 1 week. If the gauges indicate no appreciable build up of stress, then the gauges will be read once a week. The readings will be reviewed daily by mine personnel and our rock mechanics consultant.

The rockburst area is now secure. Mine services such as chilled water, power and compressed air need to be restored through the area so the mine can be properly ventilated and cooled. Once the utilities are in place and operational, MSHA will evaluate the readings again prior to using the 5900 main drift for normal travel.

Because this rockburst was triggered during the designated blasting time, travel through the rockburst area will not be allowed until all the rounds have been shot. This is a precautionary measure, as we do not expect another rockburst. The mining crews will wait at the 5900 refuge chamber, which is on the north side of the rockburst area until 10 minutes after the rounds are blasted. There will be no travel through the rockburst area from light up time until 10 minutes following the last round going off. We are also investigating going to a centralized blasting system, which would take some time to implement.

The Con Tech tunnel liner was ordered on December 2 and is expected to arrive in 12 to 14 days. The process of installing the liner will begin as soon as the materials arrive onsite. The Techfoam pumps and product are standing by, and will be ordered 1 week prior to use.
Exhibit 12
Lucky Friday Mine

5900 drift pillar rockburst repair

Doug Bayer

December 2, 2011 Update

The pillar surrounding the 5900 main drift at the 30 vein location sustained major damage after a large rockburst that occurred at 1:07 a.m. on November 16th. The burst caused approximately 12 feet of the back to fail and damaged both ribs.

Repair of the area is planned in 2 stages. The primary or initial stage is to bolt and shotcrete the area. The long-term or secondary stage is to install a steel tunnel liner through the vein area of the drift and fill the void above and around the forms with Techfoam.

The initial stage of repair has been completed. 12 ft dywidags have been installed in the back on a 4ft x 4ft pattern and 20 foot cable bolts were installed on a 6 ft x 6ft pattern. Wire fencing was installed with 4ft and 6ft with splits sets. The ribs have been wired and bolted with 8 ft dywidags on a 4ft x 4ft pattern, and 6 ft and 4ft split sets. The entire area was then shotcreted to a depth of 2 to 3 inches. The amount of ground support that has been installed is far more substantial than the original support installed when the drift was driven in 2005.

The secondary long term plan will involve installing a steel tunnel liner through the area (approximately 28 ft in length). The tunnel liner is a 2 flange system that bolts together. The corrugated panels are 0.253 inches think and the liner will be 15' wide by 14'-02" high. Once the liner is installed and the ends sealed, Techfoam will be blown in from the ends or through ports in the liner to fill the void. This Techfoam is a foamed concrete type product that has an approximately 25 psi compressive strength. The Techfoam will be able to absorb any wall squeeze and cushion any potential damage from rockbursting without compromising the steel tunnel liner. The liner will be installed as soon as it arrives on site. Approximately delivery date is December 14th. Completed installation with the foam is estimated to take 5 to 8 days.

The rockburst in the pillar is classified as a foundation failure, and not a classic pillar burst (See Wilson Blake’s 5900 Drift Pillar memo). The burst likely caused closure across the 30 vein in the mined out areas above and below the 5900 level. The constant stress from closure is the contributing factor that is believed to have caused the pillar to burst. Although the pillar is still intact and is still carrying some load and stress, it is believe the majority of the stress was dissipated with the large rockburst and it will take months or years for the pillar to gain more
stress that could cause any major rockbursts. In addition, the pillar is now smaller in size so it cannot carry the same load that caused this rockburst.

As per Wilson Blake’s report, the stage 1 ground support installed can withstand a Richter 2.5 rockburst, which he reports as very unlikely to occur. To insure the long-term stability of the drift through the pillar a permanent steel tunnel liner and Techfoam will be installed.

The drift was also re-bolted for 40 feet on either side of the ground fall to assure the areas near the rockburst zone are stable. 12 ft dywidags were installed on a 4 ft x 4 ft pattern in the back and 8ft dywidags were installed on a 4ft x 4ft pattern in the ribs.

The stress meters that were originally installed in the pillar are no longer working since the rockburst. 6 new stress gauges will be installed, 2 in the back and 2 in each wall. The gauges will be installed inside 3 in diameter drill holes. The gauges in the back will be placed at 10 ft above the drift and the gauges in the ribs will be at a depth of 20 ft. The gauges are NX4300 stress meters. We have 3 gauges on site and were installed on December 1st. The readings taken on December 2nd indicate a small increase in stress, which is expected. We will continue to take readings every shift for 1 week. If the gauges indicate no appreciable build up of stress, then the gauges will be read once a week. The readings will be reviewed daily by mine personnel and our rock mechanics consultant. The other 3 gauges are on order and will be shipped December 7th. As soon as the other gauges arrive they will be installed. In addition to the stress gauges, closure points have been re-established. Closure will be measured east-west across the drift and north-south across the vein until the tunnel liner is installed.

A data collector will be used to gather the data from the stress meters. The original data collectors were destroyed in the rock burst and it is unknown at this time when a new data collector will be ready. The gauges will be read with a hand held meter until the data collector is functional. Data from the data collector will be downloaded and analyzed approximately every 60 days.

The rockburst area is now secure. Mine services such as chilled water, power and compressed air need to be restored through the area so the mine can be properly ventilated and cooled. Once the utilities are in place and operational, MSHA will evaluate the readings again prior to using the 5900 main drift for normal travel.

There are 6 power cables that need to be spliced and re-energized. Electricians will work from each side of the rockburst area, splice new cable to one end, pull the cable through the rockburst area, then splice the other end. Workers will limit their time in the rockburst area. Other utilities such as water and air lines will be reconnected using 6 inch HDPE pipe. These pipes are temporary and will be pulled through the area and connected on both ends and hung on the rib. Once the tunnel liner is in place, the permanent steel pipe lines will be re-installed.
When the mine is returned to production, other precautions will be instituted. Because this rockburst was triggered during the designated blasting time, travel through the rockburst area will not be allowed until all the rounds have been shot. This is a precautionary measure, as we do not expect another rockburst of that magnitude. The mining crews will wait at the 5900 refuge chamber, which is on the north side of the rockburst area until 10 minutes after the rounds are blasted. There will be no travel through the rockburst area from light up time until 10 minutes following the last round going off. We are also investigating going to a centralized blasting system, which would take some time to implement.
Exhibit 13
Lucky Friday Mine

5900 Main drift pillar and 5700-54 Ramp

Rockburst repair

By: Doug Bayer

December 6, 2011 Update

The 5700 level of 54 ramp that was damaged from the rockburst on November 16th has been repaired with 12 ft dywidag bolts on a 4 ft x 4 ft pattern and 20 ft grouted cable bolts on a 6 ft x 6 ft pattern.

Because the span of the sublevel is wider than the original drift size when the level was developed, 10" x 10" timber posts will be installed near the original rib line. The timbers will be placed on 5 ft centers and secured to the rib and or back. Girts will also be installed between the posts. The inside corner of the ramp will have posts installed as well as the old substation cutout along the opposite drift. The old muckbay that angles off the sublevel will be filled with waste rock as tight to the back as possible. This waste muck will be installed to eliminate exposure to persons in that area.

Travel through this area of 54 ramp will be limited to the crews working on the electrical lines and the required timber repair crews. The ramp also needs designated as a secondary escapeway, so emergency travel will be allowed.

The burst area on the 5900 main drift has been monitored for movement with closure points since December 2nd. Readings taken on
December 6 show no movement or closure and the shotcrete shows no signs of cracks or movement. The stress gauge readings show that the small expected increase in stress over time has slowed down. All of these factors indicate that the pillar is stable and not ‘loading’ up.

The pillar will continue to be monitored. Closure measurements will be taken with the survey instrument twice a day. The stress gauge readings will also be downloaded twice a day at the same time.

Persons traveling through the area will be required to visually inspect the drift before proceeding through. If the visual inspection shows the shotcrete is cracking or taking weight, miners will be removed from the area and no travel will be allowed until the tunnel liner is installed. Likewise, any closure measurements that indicate closure above the normal error factor will result in the drift being shut down to travel. Any significant changes in closure or the visual inspection will be reported to MSHA.

Limited travel through the area is required in order to resume some mining activities in the Gold Hunter area of the mine. Travel through the area will be via vehicle traffic, no foot traffic will allowed until the tunnel liner is complete. Travel will include: crews traveling to and from their work site at the start and end of shift, a level nipper delivering required supplies to the work areas, and truck haulage which would be approximately 3 trucks making 10 trips per shift. Mechanics/electricians would also travel through the area if required to repair equipment.
Exhibit 14
IN THE DISTRICT COURT OF THE FIRST JUDICIAL DISTRICT OF
THE STATE OF IDAHO, IN AND FOR THE COUNTY OF KOOTENAI

RONNEL E. BARRETT, an individual; }
GREGG HAMMERBERG, an individual; }
ERIC J. TESTER, an individual; } and MATTHEW WILLIAMS, an } individual, } Case No. CV 13-8793

Plaintiffs, }

vs. }

HECLA MINING COMPANY, a Delaware Corporation; JOHN JORDAN, an } individual; DOUG BAYER an individual; SCOTT HOGAMIER, an } individual; and DOES I-X, unknown parties, }

Defendants.

DEPOSITION OF JOHN JORDAN
TAKEN ON BEHALF OF THE PLAINTIFFS
AT COEUR D'ALENE, IDAHO
APRIL 6, 2015, AT 9:08 A.M.

REPORTED BY:

PATRICIA L. PULLO, CSR
Notary Public
INDEX

TESTIMONY OF JOHN JORDAN

Examination by Mr. Rossman

INDEX

DEPOSITION EXHIBITS:

No. 1 Amended Notice of Taking
    Deposition
    of John Jordan

No. 2 Rockhurst Plan

No. 3 E-mail dated 4/4/2011

No. 4 Map of 3900 Gold

No. 5 Itasca Denver, Inc.

No. 6 Itasca Denver, Inc.

No. 7 Calibration of 5900 Pillar Numerical Model, March 2010

No. 8 Geomechanical Analysis of Mining of the 5300-5900 Pillar, October 2010

No. 9 E-mail dated November 30, 2011

No. 10 November 8, 2013 letter from Jackson Kelly, PLLC

No. 11 Edited Transcript dated January 11, 2012

No. 12 Confidential Memo dated January 10, 2012 and attachments

No. 13 November 25, 2011 Memorandum from Wilson Blake, Consultant

No. 14 November 18, 2011 Memorandum from Wilson Blake, Consultant

No. 15 December 27, 2011 Memorandum from Wilson Blake and Mark Board, Consultants

No. 16 One-page document DOL 781-M-A (Evt#1159243A)-0031

No. 17 February 14, 2012 e-mail

No. 18 Lucky Friday Mine, Incident Report Form

No. 19 Lucky Friday Safety Department Memos

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Also Present:

MICHAEL L. CLARY
THE DEPOSITION OF JOHN JORDAN, was taken on behalf of the plaintiffs on this 6th day of April, 2015, at the law offices of Ramsden & Lyons, LLP, Coeur d'Alene, Idaho, before M & M Court Reporting, LLC, by Patricia L. Pullo, Court Reporter and Notary Public within and for the State of Idaho, to be used in an action pending in the District Court of the First Judicial District of the State of Idaho, in and for the County of Kootenai, said cause being Case No. CV13-8793 in said Court.

(Whereupon, Deposition Exhibit No. 1 was marked for identification.)

MR. ROSSMAN: Let the record reflect this is the time and place for the deposition of John Jordan in the case of Barrett, et al., versus Hecla Mining Company, et al., Case No. CV 13-8793, case filed in the District Court for the First Judicial District, State of Idaho, County of Kootenai.

AND THEREUPON, the following testimony was adduced, to wit:

JOHN JORDAN, having been first duly sworn to tell the truth, the whole truth, and nothing but the truth, relating to said cause, deposes and says:

EXAMINATION

QUESTIONS BY MR. ROSSMAN:

Q. Mr. Jordan, I know you've been deposed at least in the last year a few times, huh?

A. Yes.

Q. How many times have you been deposed in your life?

A. I think the three that --

THE WITNESS: Has it been three?

MR. CLARY: I don't remember.

THE WITNESS: Yeah.

BY MR. ROSSMAN:

Q. Well, we know you were deposed by MSHA in the Marek --

A. Yes.

Q. -- MSHA litigation.

A. That's correct.

Q. You were deposed by Marek's counsel in the civil litigation?

A. That's correct.

Q. Is there any other deposition?

A. No. I believe this is the third.

Q. So prior to 2014 you have not been deposed before?

A. No.
Q. Was there a reason why you focused on the November 25th report in preparing for your deposition?
A. It had been several years since events had occurred, and I wanted to understand -- refresh my memory.

Q. But you didn't review the November 18th report by Wilson Blake?
A. Perhaps that was the date. I...
Q. Well, I'll represent there was one on the 8th and there was one on the 25th. Do you recall which one it was that you read?
A. I believe it was the 25th.

Q. Okay. Did you read his December 27th report?
A. I did not read that in preparation for this.

Q. Okay. Outside of your meeting with Mike and Mike, did you do anything to prepare for your deposition?
A. No.

Q. Did you speak with anyone else?
A. No.

Q. Did you go back to Hecla and review any records or documents?
A. No.

Q. Okay. What's your educational background?
A. I have a degree from the University of Idaho in 1979, a bachelor of science in mining engineering, and master science, 1986, from Montana College of Mineral Science and Technology.

Q. And then give me a general description of your work history between '86 and going to work for Hecla.
A. Just generally I have worked as both an engineer and supervisor, and supervisor of engineers, over that period of time.

Q. Do you have any specialized training in rock mechanics?
A. A little. Not much.

Q. Describe for me the extent of your training in rock mechanics?
A. I took a graduate level course in numerical modeling when I was in my graduate program.

Q. What is numerical modeling?
A. Numerical modeling is a computerized technique where you utilize computer models to simulate conditions.

Q. When a model is developed can the data be manipulated to modify the output of the model?
A. If the input to the model is not correct, the output of the model will not be correct.
Q. If the input of the model changes, can the modified data be utilized in the model?
A. It's possible. I'm sorry. I don't...

Q. What kind of data does the model utilize?
A. It would utilize the properties of the rocks.

Q. What would it utilize what's known as boundary conditions, which would be the stress situation that the rocks are placed in. And then it would utilize the physical geometry of the openings that you're trying to model.

Q. Physical geometry being the size --
A. The dimensions of the room, yes.

Q. -- dimensions, which would include a width-height ratio?
A. Width-height ratios.

Q. I notice the Itasca modeling that was done in the spring of 2010 utilized some data from stress monitoring --
A. Yes.

Q. -- was that your understanding? How was that data utilized, to your understanding?
A. To my understanding, that data was utilized to compare to the prediction of the model and use that as a means of validating its correctness.

Q. And once a model is developed, is the -- some of these input factors, such as physical geometrics of the particular room that's involved -- if those change, can the model still be utilized?
A. The model can be modified to reflect the new conditions, yes.

Q. So where did you work before Hecla?
A. Immediately before Hecla I worked at the Galena Mine. I was mine superintendent for one year and general manager for a year.

Q. When was that? When did you work for Galena?
A. 2004 to 2006. At that time it was owned by Coeur d'Alene Mines.

Q. And when did you go to work for Hecla?
A. In June of 2006.

Q. To what position were you hired at Hecla?
A. Chief mining engineer.

Q. How long did you work in that position?
A. 2006 until 2009. So three years.

Q. And where did you go from there?
A. Approximately a year.

Q. So through about 2010?
A. Until 2011.

Q. It was late in 2009, probably September or...

Q. So through about 2010?
A. Until 2011.

Q. It was late in 2009, probably September of 2009, when I became the mine superintendent. So it was...
Q. During that time period, approximately '04 to '06 -- excuse me -- '06 to '09, did you have any engineers employed with Hecla that specialized or focused in rock mechanics?

A. I don't believe so.

Q. So any modeling that was done on the 5900 pillar during your employment with Hecla would have been done by an outside consultant?

A. Yes.

Q. Was there ever any investigation or assessment, internally at Hecla during your employment, regarding any rock mechanics issues relating to the 5900 pillar?

A. We monitored the instrumentation. We would download the data from the instruments and then send that off to the personnel for interpretation.

Q. When you say download the data from the instruments, I assume you mean stress monitoring gauges?

A. Stress monitoring gauges and -- and our rockburst monitoring system.

Q. And with the rockburst monitoring system, are you referring to the seismic assessment?

A. Yes.

Q. -- (unintelligible) monitoring?

A. Yes.

MR. RAMSDEN: Let him finish his question before you start your answer. That way it will go more smoothly.

MR. ROSSMAN: I appreciate that it's difficult. I understand.

BY MR. ROSSMAN:

Q. What were your -- how did your responsibilities change when you became mine superintendent?

A. I was supervising a larger group, and it would include hourly people as well as salaried staff.

Q. So outside of engineering, who did you supervise? What types of employees did you supervise?

A. At what time?

Q. As you're a mine superintendent for that year in '09-'10.

A. Okay. The -- I had the shift bosses -- the shift supervisors.
Q. They reported directly to you?
A. They reported to the general mine foreman, Doug Bayer, and myself.
I also supervised the maintenance group.
That would include both mechanics and electricians.
Q. And did they report directly to you or also to Doug Bayer?
A. No. They would report to -- Harvey Kine (phonetic) was the maintenance supervisor -- maintenance superintendent. I believe was his title at the time. And Mike Akker (phonetic) was the electrical superintendent.
Q. How would you describe your overall responsibilities as mine superintendent?
A. Primarily responsible for scheduling and execution of mining activities.
Q. And what did you say Doug Bayer's job title was at that time?
A. He was general mine foreman.
Q. How would you describe his overall responsibilities?
A. Execution of mining activities. He would assist in developing the schedules. And then once the schedules were published then it was Doug's responsibility to see that they were carried out.
Q. Did Doug report directly to you?
A. Yes.
Q. Did you have overall responsibility for safety of miners?
A. Certainly.
Q. How would you describe your responsibilities in the area of safety?
A. I'm not -- I'm not sure I -- certainly the mine safety is the responsibility of every individual in the mine. And mine would be to see to it that the -- our operating rules and regulations were followed.
Q. Were you responsible for developing a safety manual?
A. I was part of the process of developing the safety manual, yes.
Q. What part of that process did you -- were you involved?
A. Essentially review and approval.
Q. So during the period of time that you've worked with Hecla from '06 to the present, you've understood that there was a safety manual in place at the facility?
A. Yes.
Q. Were you responsible for ground control?
A. Yes.
Q. What's the purpose of that?
A. To protect the miners. That's all part of the process.
Q. Did Hecla have any ground control policies or procedures manual?
A. Yes. We had a ground control plan. I'm not sure if it's -- ground control plan.
A. Plan. And was it your responsibility to ensure that that plan was implemented?
A. Yes.
MR. ROSSMAN: Mike, due to logistics, I didn't bring extra copies of everything. It was just too much stuff. So I can hand it to you for review, or if you have access to your production, we can take a break. Whatever you need to do. And I can give you the Bates number.
MR. RAMSDEN: Well, let's just go as we're going and make copies as we need.
MR. ROSSMAN: Okay.
(Whereupon, Deposition Exhibit No. 2 was marked for identification.)
BY MR. ROSSMAN:
Q. I'll show you Exhibit 2, which is entitled Rockburst Plan. And it's DOL 781-M-A, 0578 Bates number through 0580. Do you recognize that document?
A. Yes. I know what this document is.
Q. What is that document?
A. That's our rockburst plan.
Q. What's the purpose of that rockburst plan?
A. It is a requirement for mines which have seismic activity. The MSHA regulation requires that you will develop and maintain a rockburst plan, the purpose of which is to describe the methods that will be used to mitigate rockburst hazards in the mine.
Q. This is something that you understood to be required by MSHA?
A. Yes.
Q. And you had responsibility as the mining superintendent ...
A. At the time this one was issued, I was...
1. Did you know when this particular rockburst plan was implemented? The last page at the bottom says 040111.docx. Does that look like --
2. A. Yes.
3. Q. -- about the date that that would --
4. A. So April 1st of 2011.
5. Q. At that point in time, you were vice president or general manager of the mine?
6. A. Yes.
7. Q. And did you have responsibility for implementation of this particular plan?
8. A. Yes.
9. Q. Did you have responsibility to ensure that it was carried out --
10. A. Yes.
11. Q. -- properly and effectively?
12. A. Yes.
13. Q. And safely?
14. A. Yes.
15. Q. So if we look at page 0580 of this particular document, it references the 5900 level or pillar where main access from the Silver Shaft intersects the Gold Hunter 30 vein. That's the first full paragraph. Is there a reason why that particular pillar was specifically addressed in this document, to your knowledge?
16. A. Yes. It helps to explain the seismic monitoring system.
17. Q. Okay. It says a monitoring program is being conducted at that level. Do you know what monitoring program that was referencing in April of 2011?
18. A. The stress -- stress gauge instrumentation.
19. Q. As well as the seismic?
20. A. Yes.
21. Q. So there was stress monitoring ongoing as of April 1st, 2011; is that correct?
22. A. Yes.
23. Q. And there had been stress monitoring ongoing at the 5900 level since about 2006; is that correct?
24. A. It pre-dated me. It...
25. Q. Do you know what the purpose of stress monitoring was at that particular level?
26. A. As stated, the object of the monitoring is to identify the change in load.
27. Q. Were you monitoring all levels of the mine where activity was being performed?
28. A. No.
29. Q. Why were you monitoring this specific pillar as opposed to other levels?
1 carrying out its mining activities?
2 A. Yes. That was our primary access into the
3 Gold Hunter vein.
4 Q. What do you mean by that?
5 A. That was the route that we would travel to
6 get to our production areas.
7 Q. In December of 2011 was there any other way
8 to access the Gold Hunter vein --
9 A. Yes.
10 Q. How was that?
11 A. From 2900 -- or 4900 -- pardon me -- you
could travel up and we had ramps that would connect
between the 4900 main level and the 5900 main level.
12 Q. So through 4900 there were ramps to connect
to the 5900 level?
13 A. Yes.
14 Q. Was there any way to carry out mining
activity at the Gold Hunter vein without at least some
access to the 5900 pillar?
15 A. No.
16 Q. So it was very important to Hecla?
17 A. Yes.
18 Q. In order for Hecla to perform its business --
mining business in the Gold Hunter vein, there had to
be some access to the 5900 --
1 A. Yes.
2 Q. – pillar?
3 Every day that pillar was not operating
4 affected the mining revenue of the company, correct?
5 A. And the paychecks of the mine employees.
6 Yes.
7 Q. In Exhibit No. 2, the Rockburst Plan, there's
8 a section titled Corrective Measures. Do you know what
9 that means?
10 A. Yes.
11 Q. What is that?
12 A. Those are the means that we would use to
mitigate rockburst hazards.
13 Q. So if a rockburst hazard developed, one of
14 these four options could be utilized to address that
15 concern?
16 A. Yes.
17 Q. And one of these four options could be
18 utilized to protect the safety of the miners and
19 employees working in that area?
20 A. Yes.
21 Q. How did the company determine when a
22 rockburst hazard existed?
23 A. Well, that's a very complicated situation.
24 We would rely on our monitoring system to monitor the
1 frequency of rockbursts. We would try to assess the
2 magnitude of the energy and the rate at which energy
3 was being released. We rely heavily on observations by
4 supervisors and miners.
5 Q. Is there a particular document that defines
6 when -- strike that.
7 There's always some -- at least at the Hecla
8 Lucky Friday Mine, there's always some risk or concern
9 about rockburst, correct?
10 A. At every mine in the Silver Valley there is
11 some seismic level of activity.
12 Q. So how did Hecla determine when a general
13 rockburst risk became a hazard warranting corrective
14 measures?
15 A. As I said, we would review the seismic data
16 from the rockburst monitoring system, the seismic
17 network, and we looked at it on a daily basis.
18 Q. You say we looked at it on a daily basis,
19 who?
20 A. Hecla.
21 Q. Who at Hecla would be responsible for
22 reviewing the seismic and stress data on a daily basis?
23 A. Zac Thomas was doing that. And Jeff Parker
24 also would review it. They would have to -- at the
25 start of every day shift, they would provide a report
1 before the crews went underground.
2 Q. What kind of a report?
3 A. It was just a listing of what the seismic
4 activity had occurred in the past 24 hours.
5 Q. Just seismic activity?
6 A. Mm-hmm.
7 Q. Would they issue a report on stress
8 activity -- stress monitoring?
9 A. No.
10 Q. So each shift Zac Thomas or Jeff Parker would
11 prepare a report regarding seismic activity?
12 A. Yes.
13 MR. RAMSDEN: Each shift or each day?
14 THE WITNESS: Each day.
15 MR. ROSSMAN: Okay.
16 BY MR. ROSSMAN:
17 Q. When was that policy initiated?
18 A. When I got there in 2006 that was our
19 practice.
20 Q. So one of the things that Hecla would look to
21 in determining whether or not a rockburst hazard
22 existed warranting corrective measures was to look at
23 seismic data on a daily basis?
24 A. Yes.
25 Q. Who would read the report that Mr. Thomas and
Q. What was Zac Thomas's job title?
A. I think he was a planning engineer at the time.

Q. What was Jeff Parker's job title?
A. Also mine planner.

Q. So what would you look to in this seismic data component of your evaluation, of whether there's a rockburst hazard, to determine whether or not a hazard existed?
A. Primarily what we were looking for would be rockbursts to occur with our blasting that would indicate that there's been an adjustment to the new state of -- the new geometry after a blast.

Q. Blasting certainly can affect the propensity for a rockburst at a particular level, correct?
A. Certainly.

Q. And that's because, as you said, changing the geometry of that particular --
A. Right.

Q. -- shelf?
A. You take -- taking something that was in equilibrium and disturb the equilibrium.

Q. And that equilibrium disturbance can affect not just the shelf at which the blasting is occurring but also other areas of the mine, correct?
A. Typically what you're going to see is the burst is going to occur adjacent to the blasting. That release of energy will trigger -- is -- is what's causing the new geometry, and it's also sending transient levels of energy through the rock.

Q. To other levels?
A. No. To the area adjacent to where the mining is going on.

Q. And as that geometry at a particular shelf is modified, that can affect the stress transfer at a level below that particular shelf where the blasting occurred; is that correct?
MR. RAMSDEN: Object to the form.
MR. ROSSMAN: or a would you like me to refer to it?

Q. Let me clarify. 2011 there were two rockbursts at the 5900 pillar, correct?
A. Yes.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q. One on November 16, 2011, correct?</td>
<td>A. Yes.</td>
<td>34</td>
</tr>
<tr>
<td>Q. And one on December 14, 2011, correct?</td>
<td>A. Correct.</td>
<td>34</td>
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<tr>
<td>Q. The one on November 16, 2011, there was no rehabilitation measures being taken at that level at the time of the blast, correct?</td>
<td>A. That's correct.</td>
<td>34</td>
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<td>Q. And did you read Wilson Blake’s memos regarding his -- after the November 16, 2011, burst?</td>
<td>A. Yes.</td>
<td>34</td>
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<tr>
<td>Q. Was it your understanding or belief, based upon the consultant's input, that the blasting had some effect on that burst?</td>
<td>A. That wasn't the interpretation that I went on.</td>
<td>34</td>
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<tr>
<td>Q. What was your understanding as to the cause of that burst?</td>
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<td>Q. What was your understanding as to the cause of that burst?</td>
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<tr>
<td>Q. Yes.</td>
<td>MR. RAMSDEN: November 16th, right?</td>
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<tr>
<td>Q. So as of December 14, 2011, your understanding as a general manager of the mine -- your belief was that the November 16th burst had been caused -- was a strain burst or a foundation failure?</td>
<td>A. Yes.</td>
<td>35</td>
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<tr>
<td>Q. Strain burst?</td>
<td>A. Yes.</td>
<td>35</td>
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<tr>
<td>Q. And that strain burst had been caused or contributed to by blasting at -- at one or more different levels?</td>
<td>A. The mining excavation process.</td>
<td>35</td>
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<td>Q. Including blasting?</td>
<td>A. Including blasting.</td>
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<tr>
<td>Q. You said there was mid-shift blasting going on in 2011. What does that mean?</td>
<td>A. Halfway through the shift, miners, if they had a round -- if miners had a round that was ready to be blasted, they could blast it.</td>
<td>35</td>
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<td>Q. And were there any -- well, strike that.</td>
<td>A. Yes.</td>
<td>35</td>
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<tr>
<td>Q. Originally when you answered a prior question you said there was blasting at the end of each shift --</td>
<td>A. Yes.</td>
<td>35</td>
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<td>Q. -- historically at Hecla?</td>
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A. Yes.

Q. When did the mid-shift blasting start?

A. I don't know. That was a Hecla practice when I got there.

Q. So Hecla had been mid-shift blasting as long as you had been there?

A. Mm-hmm.

Q. Yes?

A. Yes.

Q. When blasting was occurring, knowing that it may cause or contribute to stress phenomena or potential rockbursts in the mine, were there any safety precautions or steps taken to protect miners during blasting?

MR. RAMSDEN: Object to the form of the question. Go ahead and answer.

THE WITNESS: Well, it's unclear to me if you're referring to the blasting or to the seismic.

BY MR. ROSSMAN:

Q. I'm speaking more to the risk of rockbursting or seismic activity. Would there be any steps taken to protect miners during blasting?

A. We would initiate the blast at a specific time such that the process of igniting, lighting the fuses, would allow enough time for people to travel before the blast went off, to the 5900 or 4900 main level from the workplaces.

Q. As to protect them from the blasting itself, correct?

A. From the blasting itself and also the consequences as -- as I said, the consequences of the seismic activity that results from excavation is typically very adjacent to the blast area. So we would travel out of the area where the blasting was going to occur, the areas where there would be a high probability of a seismic event.

Q. So if there was blasting above or below or around the 5900 pillar, would there be any steps taken at the 5900 pillar to ensure the safety of miners?

A. At that time, no.

Q. You say at that time, no. Has there been at some point?

A. We have initiated a remote blasting system.

Q. What is that?

A. It's one that allows us to travel to the -- it was initiated after I left there. So I'm not exactly sure where it's located. But you electronically initiate the blast now.

Q. And what do you do with the employees during that blasting?

A. They have retreated back to the shaft at the time that happens.

Q. So they're not on the 5900 level during blasting at -- at other levels?

A. They're on the 5900 level, but they're a half mile away.

Q. You said that in determining whether or not there's a rockburst hazard warranting corrective measures you would also evaluate the management of energy or the rate of energy release?

A. We would review the rate that the energy was being released, yeah.

Q. What kind of data would you get in that area?

A. Simply the number of events.

Q. Number of what events?

A. Seismic events.

Q. So that relates back to the seismic monitoring?

A. Yes.

Q. Is there a particular number of seismic events that would constitute a level of concern for corrective measures?

A. No. It would be more the frequency with which they were occurring. But there was no specific number that ...

Q. And then you also said you take into account observations by supervisors?

A. Supervisors and miners, yes.

Q. How would -- what kind of miner or supervisor observation program was in place?

A. When an event was detected, we would inform the supervisors that there had been an event between shifts, or with the previous blast, and give them an approximate location where that was. And we would ask them to go in and review the area, just take a look and see if there are any hazards that exist there.

Q. What would they be looking for?

A. They'd be looking for broken bolts, places where rock had bagged the wire, if -- if that's something you could understand. If we saw that the cyclone fence we put in had dropped and was full of loose rock, then we would attribute that to rockburst or the seismic activity.

Q. Look for cracks in shotcrete?

A. Yes. If there was shotcrete in the areas, yeah.

Q. Would you look for loose rock?
There's a standing rule that if miners feel uncomfortable from the -- the noise or the activity, they get out of there. On occasion, if we were on the surface and a lot of information -- a lot of seismic activity was detected on the monitoring network, we would call down and find a supervisor and have him go into the area and pull the miners out.

Q. So you said there was a standing rule that if a miner's uncomfortable based upon what they're observing that they're to leave the mine?
A. That they're to leave the area, yes.

Q. Leave the area.
A. That goes back to the days when I was mining.

Every miner has the right to withdraw from an area if he believes it to be hazardous.

The data was downloaded periodically, and until it was downloaded, we had no means of reviewing it. So it would have to be downloaded every six months; I'm not sure what the frequency was. And then that would be sent to Spokane to NIOSH and they would translate the instrumentation results for us.

Q. Okay. On November 16, 2011, the burst at the 5900 level damaged or destroyed most of the stress monitoring equipment, correct?
A. That's correct.

Q. And new stress monitoring was installed on December 1st, 2011, correct?
A. Sometime around that period.

Q. NIOSH was not interpreting that data; is that correct?
A. That's correct.

Q. Who was interpreting that at --
A. Zac Thomas was doing the instrumentation.

Q. Zac Thomas would actually take the reader down and read the data or retrieve the raw data from each of the leads?
A. Zac typically did not do that. But when he...
Q. And then he would issue a summary or a report of those stress changes at various times?
A. He maintained a database of the conditions.
Q. Okay. Did you or anyone else have access to that database?
A. Anyone could have access to that if they requested it.
Q. Where was the database located?
A. On a computer.
Q. So someone with access to the computer, if they knew particularly where to look, they could locate that information?
A. I suppose, yeah.
Q. Did Hecla ever distribute or disseminate to miners any instructions or directions on how to access that data?
A. No, not that I'm aware of.
Q. Did they ever tell the miners during December of 2011 that they had access to that data?
A. Not that I'm aware of.
Q. Were you reviewing that data?
A. I would look at the data.

Q. How often?
A. Daily.
Q. What was the purpose of looking at that data?
A. To see if there were any changes that deviated from what our expectations for the rock behavior were.
Q. Was there some documentation somewhere that identified what your expectations were for stress changes at that level during that period of time?
A. I don't believe so.
Q. Did you have an understanding as to what the normal stress changes were, or acceptable stress changes were, during that time period at that level?
A. Yes. We would expect to see a steady increase in stress. We would expect to see some change as time progressed, because that's how the rocks behave, but we would not expect to see sudden changes of an irregular magnitude in either direction.
Q. What would sudden changes of an irregular magnitude indicate?
A. It would depend on -- if it was a negative change, it would indicate that something had slipped; if it was a positive change, it would indicate that stress was building up.
Q. That would be a concern?
A. Yes.
Q. That is to identify sudden or unexpected changes in stress at a particular area?
A. Yes.
Q. And the best way to assess, given the geological deviations or variations at a particular area, would be to have multiple areas of stress monitoring, correct?
A. We had multiple stress gauges installed, yes.
Q. The more stress gauges, the better or more accurate understanding you would have of the stress changes at a particular location, correct?
A. That's correct.
Q. So is it important, for safe monitoring in a particular area, to obtain reliable data by having multiple monitors?
A. The most reliable data that we have at any time is the seismic data. That gives us the best understanding of what's going on.
Q. But you also have stress data for a reason, correct?
A. Yes.
Q. That is to identify sudden or unexpected changes in stress at a particular area?
A. Yes.
Q. And the best way to assess, given the geological deviations or variations at a particular area, would be to have multiple areas of stress monitoring, correct?
A. We had multiple stress gauges installed, yes.
Q. The more stress gauges, the better or more accurate understanding you would have of the stress changes at a particular location, correct?
MR. RAMSDEN: Object to the form, foundation, speculation. Go ahead.
THE WITNESS: Me or him?
MR. ROSSMAN: You. Go ahead and answer.
THE WITNESS: Would you state that again.
MR. ROSSMAN: Let's have her read it.
(Record read as requested.)
THE WITNESS: At a particular location or -- each gauge is going to tell you the conditions that that gauge sees. More gauges are going to give you different answers. I would say if you have too many, then, no, it wouldn't be a good idea, because you're going to get conflicting information due to the
BY MR. ROSSMAN:

Q. You were aware of that in December 2011, correct?

A. Yes.

Q. You were aware that at least one of those prior bursts -- well, including the November 16th burst, two of those bursts had caused damage at that level?

A. One had caused damage.

Q. One other than the November 16th burst?

A. The November 16th burst was the one that caused the damage.

Q. And you understood or -- you understood while working at Hecla in December of 2011 that there had been a long history of rockbursts at the Lucky Friday silver mine?

A. Certainly.

Q. And as compared to other mines in other areas of the world that was an area where there was an increased level of rockburst activity or seismic activity?

BY MR. RAMSDEN: Object to the form, foundation. Go ahead.

THE WITNESS: The Lucky Friday vein, which we were not mining -- we were mining in the Gold Hunter area. The Lucky Friday vein located in a different host rock, the revett formation, had a very long history of large and frequent seismic events, much more frequent than what we saw in the Gold Hunter. So certainly I was aware of that.

BY MR. ROSSMAN:

Q. And the 5900 pillar was located -- or provided access to the Gold Hunter --

A. Yes.

Q. -- shaft or the Gold Hunter mine through the Lucky Friday Mine, correct?

A. Yes.

Q. You understood that as of April of 2011 the company was aware that large seismic events had been picking up in the previous couple years; is that correct?

A. What's a large seismic event?

MR. ROSSMAN: Let me pull out a document and talk about it.

(Whereupon, Deposition Exhibit No. 3 was marked for identification.)

BY MR. ROSSMAN:

Q. I show you Exhibit No. 3. And that is -- looks like a document obtained Wilson Blake. It's Bates page WBLAKE298. It's an e-mail from Wilson Blake
1. Increased frequency of seismic events at the mine; is that correct?
2. A. Yes.
3. Q. You were recognizing that the events -- seismic events were getting larger, correct?
4. A. Yes, they were getting somewhat larger.
5. Q. And so what did the company do as a result of Mr. Blake's -- or as a result of its recognition that seismic events were increasing in frequency and size?
6. A. I really can't tell you. I don't recall exactly what we did.
7. Q. Did the company do anything --
8. A. We continued --
9. Q. -- in response to recognition that seismic events were increasing in frequency and size?
10. A. We continued to monitor our seismic release rates. Whether Zac Thomas -- at that point I was general manager, and I wasn't dealing with the specifics of who was doing what. I'm surprised that Ron Krusemark isn't on here but -- on this distribution list -- because he would have been the chief engineer at that time.
11. Q. So your testimony is that the company continued to monitor seismic events after receiving this e-mail?
12. A. Yes.
13. Q. Is that something that you're testifying it was not being done prior to April of 2011?
14. A. No. I would say that it was my understanding that we recognized that there was an increased frequency of events and that they were getting larger.
15. Q. Okay. So as of April 4, 2011, you'll agree that you were recognizing, based upon the input of Mr. Blake, that there was an increased frequency of seismic events at the --
16. A. Mm-hmm.
17. Q. -- mine; is that correct?
18. A. Yes. And it appears that he is recommending that we start calculating seismic energy release rates.
19. Q. So you were recognizing that there was an
activity goes hand in hand with mining in the Coeur d'Alene district. Okay. What do you mean by that?
A. When you mine in the Coeur d'Alene district, you will have some seismic activity.
Q. You understood that in 2011, correct?
A. Yes.
(Whereupon, Deposition Exhibit No. 4 was marked for identification.)

BY MR. ROSSMAN:
Q. I show you Exhibit No. 4. I don't see a Bates page on this. But can you tell me what your understanding, if anything, is as to what this is?
A. This would be a long section of the 11, 14, 12, 15 and 16 stopes.
Q. Okay. Can you tell me -- well, strike that.

Up at the top under the word "mined out" there's a 5200-10 stope. I assume that's the -- what we refer to as the 10 stope?
A. Yes.
Q. Above that it says "mined out." What does that mean?
A. That is the area that had been excavated from 4900 in the Gold Hunter 30 vein.
Q. So it had already been excavated or thoroughly mined; is that correct?
A. Yes.
Q. And there was -- in 2011 was there mining activity at the 10 stope?
Q. And then there's a big section titled -- that says "mined out" in the middle of the page. What is that referring to?
A. That is the area that had been mined by those stopes that I previously mentioned, 11, 14, 12, 15 and 16. So that is the area that had been completed.
Q. So the area all around this 5900 pillar had been mined out?
A. Yes.
Q. And then there's a little section in the middle that says "5900 Gold Hunter Drift." What is that?
Q. Do you recall reviewing the modeling that was done in spring of 2010?
A. I don't recall it. But I'm sure I would have if it was done.
Q. Do you know why Mr. Board was doing modeling of the 5900 pillar in spring of 2010?
A. No.

Whereupon, Deposition Exhibits Nos. 5, 6, 7 and 8 were marked for identification.

(A short break was taken.)

(Witness examining document.)

MR. ROSSMAN: Let's go back on the record.

BY MR. ROSSMAN:
Q. Let's start with Exhibit No. 5 in front of you.
A. Okay.
Q. Appears to be a technical memorandum from Mark Board at Itasca, dated March 22nd, 2010; is that correct?
A. Yes.
Q. Now, do you now recall this particular modeling being done?
A. No, I do not. This was 2010 when I would have been我的 superintendent. So I wouldn't have had my fingers on it. I was probably aware of it at the time, but it wasn't something I was focused on.
Q. Well, in early 2011 you became general manager at the mine, correct?
A. Yes.
Q. And at that point in time did you make an effort to review modeling that had been done for the 5900 pillar approximately a year earlier?
A. No, I did not.
Q. So is it your testimony that you don't recall ever reviewing this modeling documentation?
A. I don't recall it. It wouldn't surprise me if I had looked over it probably at about the same level that I just did. I would have glanced through it.
Q. Would it surprise you if you never reviewed it at all?
A. It wouldn't surprise me.
Q. So you don't recall as you sit here today reviewing this documentation?
A. I do not.
Q. Okay. He references in the second paragraph, first sentence, "A previous study of the stressmeter data and pillar failure observations was conducted by Pikalns (sic) & Associates (2009)."
A. Yes.
Q. Mr. Board references throughout these
documents -- and these are all documents related to his
modeling -- he references the risk of pillar failure or
failure throughout the pillar. Was that really what he
was, to your understanding, evaluating?
A. No. As I said, I don't know that I really
have an understanding of what he was evaluating here.

But the subject is calibration of the 5900 pillar
numerical model. So my assumption would be that's
what he was looking at.

Q. Did you know what the risks were that were
identified by Mr. Board in his modeling of pillar
failure at the 5900 level in December of 2011?
A. December of 2011. He identifies in -- I
believe it was in this one, three failure modes. And
those are the failure modes that would be associated
with any excavation in rock. So...

Q. What did you understand those failure modes
be?
A. Strain bursting, fault-slip and pillar
punching was the third one.

Q. And in December of 2011 did you understand
what his conclusions were regarding the stability of
the 5900 pillar from his modeling?
A. Did I understand his conclusions in here?

(Indicating.)

Q. Yes.
A. No.

Q. Did you know what his conclusions were?
MR. RAMSDEN: Objection --
THE WITNESS: I don't even recall reading it.
MR. RAMSDEN: I'll object. He didn't even
say he read it, so ...

MR. ROSSMAN: Right.

Q. Okay. And if you hadn't read it, had anyone
told you what Mr. Board's conclusions were regarding
the risk of pillar failure at the 5900 pillar?
A. Not that I recall.

Q. In December of 2011 you're a general manager
of the mine, correct?
A. Yes.

Q. One of your responsibilities was for the
safety of personnel within the mine, correct?
A. Yes.

Q. And there had actually been a study regarding
the safety from pillar failure at the 5900 level
conducted in 2010; would you agree?
A. I would agree that it was conducted. I was
not aware that it was conducted.

THE WITNESS: I wasn't aware of it.

BY MR. ROSSMAN:
Q. Was somebody responsible for telling you that
modeling had been done at that --
A. I'm sure that it -- it had been done. And
I'm sure I was aware of it. But, no, I had a lot of
things that I had to be aware of. And I had people
that I could utilize to review material like this and
tell me this is an issue that needs your attention.

Q. Whose responsibility was it to be aware of
and incorporate, act upon, the modeling data and
conclusions developed by Mr. Board?
A. 2010 would have been Cindy Moore was the
chief mining engineer at that time. And she would have
told me, John, here's something we need to talk about.

Q. Was there someone at Hecla that was
responsible for knowing and understanding the modeling
that had been done in 2010 for the 5900 pillar?
A. In 2010 Lisa Carney was still working.

Q. I guess -- let me rephrase the question.

Was there someone at Hecla that was
responsible for knowing and understanding the modeling
that had been done in 2010 for the 5900 pillar?

A. There was no one specifically charged with
that.
Q. And as general manager of the mine, do you know as you sit here today whether anyone at Hecla knew and understood the modeling that had been done a year before for that pillar?
A. No. I -- I can't tell you who specifically would have been charged with that review.
Q. Mr. Board states in the middle of the third paragraph on the first page of Exhibit 5, "The conclusion from the analyses" -- and this is in the middle of the paragraph. "The conclusion from the analyses indicate that the pillar is yielded around its periphery, but that the interior of the pillar remains at an unyielded, elastic state."
A. Yes.
Q. Did you have that understanding at any point in time?
A. Yeah.
Q. How did you develop that understanding?
A. Looking at the coring -- he shows some pictures in here -- in one of these of core. And that is exactly the conclusion that you would reach from looking at those pictures.
Q. Show me what you're referring to, if you would, please.
A. It's in Exhibit 7.

Q. Okay. What page are you referring to?
A. 25.
Q. And what about that coring on page 25 would indicate to you the conclusion of Mr. Board that I identified from Mr. Board's report?
A. The discing in the 10 to 30 and the discing in the 30 to 55.
Q. What does that indicate to you?
A. That the conditions in the 30 to 55 are similar to what he refers to down here in your -- the conclusion from the analyses in the middle of that ...

MR. RAMSDEN: And when you say "down here," you're referring to Exhibit 5.
THE WITNESS: I'm sorry. To -- yes, to the sentence that you called out.
BY MR. ROSSMAN:
Q. Okay. Had you ever seen those pictures of the coring that was done in 2010?
A. I've seen -- I saw the core as it was coming out. 2010, that -- I would have been mine superintendent. And I recall looking at that core as the hole was being drilled.
Q. Do you recall developing any opinions or understanding at that point in time?
A. Not a full understanding of it, no.
A. Okay.
Q. The first said technical memorandum. And I think this is more of a general report with a table of contents.
A. Okay. I apologize. What page?
Q. Page vi.
A. Vi.
Q. Okay. If you go to the middle of the first paragraph under Summary of Overall Conclusions. Do you see the sentence that starts with "It is" and then italicized "expected"?
A. Yes.
Q. Okay. It says, "It is expected that a pillar of this dimension should have an elastic core. As discussed in the document, the pillar has a width:height ratio of around 8 to 10:1." Do you see that?
A. Yes.
Q. So he was concluding a width-height ratio of 8- to 10-to-1; is that correct?
A. Yes.
Q. And that's what the width-height ratio was as of March of 2010, correct?
A. Evidently. And evidently I calculated in my head wrong.

Q. Okay. I want you to look -- let's go back to 5 real quickly. Well, before we go there, stay at that same page. I apologize.
A. Okay.
Q. I want to ask you if you agree with this statement. He says right after identifying the width-height ratio of 8- to 10-to-1, is that correct?
A. Yes.
Q. And that's what the width-height ratio was as of March of 2010, correct?
A. Evidently. And evidently I calculated in my head wrong.

A. (Complying.)
Q. That's the first report by Mr. Board.
A. Okay.
Q. Can you turn to page 18, please.
A. (Complying.) Okay.
Q. You'll agree that this assessment within Exhibit No. 5 is focused on the 5900 pillar, correct?
A. It appears that that's the case, yes.
Q. Okay. There's three bullets in the middle of that page. And he's talking about stressmeter calibration results.
A. In the first bullet he says, "stressmeter calibration and results to factors such as: Gauge contact area with the borehole wall - the calibration and response of the gauges is highly sensitive to match of gauge seating platens to the hole wall and the resulting contact area."
Q. Do you know what he's saying by that?
A. Yes. And it's what I referred to 45 minutes ago that there's only a very small portion of each gauge that is actually in contact with the rock. Okay. And you're inferring the behavior of that small area to the behavior of everything around it. So that -- that match will be very -- very much impact the output of your gauge.

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Docket No. 43639
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Q. So if you have a monitor -- a stress monitor at a location on the east wall of the 5900 pillar, what that's telling you is the stress levels at that isolated location on that wall?
A. Yes.
Q. At that particular point in time?
A. Yes.
Q. And he's also telling you that the "calibration and response of the gauges is highly sensitive to the match of the gauge seating platen." On that?
A. Yes.
Q. The gauge seating platen are the insert that goes into the borehole in the wall to house the monitoring gauge; is that --
A. That's what I would interpret it to.
Q. I don't -- I'm not real familiar with all the jargon for instrumentation.

Q. The company had been monitoring at the 5900 level since as long as you had been there, correct?
A. Yes.
Q. Stress monitoring?
A. Yes.
Q. And they'd had a lot of problems with the -- with the monitoring gauges that had been installed, correct?
A. Well, you know, it seemed that way to me. Although, those who had worked with stress monitoring gauges seemed to feel that, you know, that's just the way they are. They're -- they don't live for a long time, and they're -- they're kind of difficult to work with. So I was led to believe that it wasn't unusual.
Q. And from those individuals did you understand that there are a lot of factors that can affect the accuracy of a monitoring gauge?
A. Yes.
Q. And a lot of those factors depend upon, not just the equipment, the effectiveness of the equipment itself, correct?
A. Which equipment?
Q. The monitoring gauge itself.
A. That those are big factors, yes.
Q. The monitoring gauges can be -- can be variable in their effectiveness --
A. Yes.
Q. -- is that your understanding?
A. Yes.
Q. And you understood that in '11, correct?
A. Yes.
Q. And it also can be affected by the manner in which the platen was installed in the boreholes of the wall. Did you understand that?
A. The boreholes were drilled. They were diamond drilled.
Q. Do you know that?
A. No. I don't know that. They may have been drilled with a jumbo.
(Whereupon, Deposition Exhibit No. 9 was marked for identification.)

BY MR. ROSSMAN:
Q. Show you Exhibit No. 9. This appears to be an e-mail from Wilson Blake, dated November 30, 2011, to Doug Bauer regarding instrumentation. You're not identified on this e-mail. But I want to ask you if you understand what he's saying here.

He says in the third -- fourth sentence down, "Don't know if could schedule DD with the likely press for production, but maybe room on side of drift if it broke out similar to back. All other holes could be drilled with Jumbo."

So do you know what he's referring to when he says "could schedule DD with the likely press for production"?
A. Diamond drilling is what the DD is.
Q. Okay.
A. I'm not sure when he's talking about the likely press for production.

Q. Then he said, "All other holes could be drilled with Jumbo." What's jumbo?
A. Jumbo is a percussive drill.
Q. And a percussive -- the jumbo drill is not a diamond drill?
A. That's correct.
Q. Do you know what Mr. Thomas's training and experience is in stress monitoring?
A. Very little. What he learned he learned on the job working with Ted Williams from NIOSH.
Q. Did he work at NIOSH?
A. Did who work at NIOSH?
Q. Mr. Thomas.
A. No.
Q. He worked as Hecla's representative when Mr. Williams would deal with the monitoring?
A. Correct.
Q. Do you know if anybody assisted Mr. Thomas in installing the monitoring gauges?
A. I think it's possible that Jeff Parker may have.
Q. And so from prior experience with utilizing stress monitoring at different levels, you understood that there was a pretty high failure rate with a lot of these gauges, correct?

22 (Pages 82 to 85)
Q. Do you ever recall being provided with that memo?
A. I don’t recall it, no.
Q. Do you ever recall anyone telling you that Wilson Blake had concerns about the long-term stability of the 5900 pillar?
A. No.
And from reading this, it appears that that’s a statement out of context and misinterpreted by MSHA.
Q. Well, the attorney for Jackson-Kelly is emphasizing that what Mr. Blake was referencing in that report was the long-term stability of the pillar as opposed to the short-term stability. Would you agree?
A. That’s what he says, yes.
MR. RAMSDEN: He who, Jackson-Kelly or Blake?
THE WITNESS: Jackson.
MR. ROSSMAN: The attorney on behalf of Jackson-Kelly. Karen Johnston. It’s a she.
BY MR. ROSSMAN:
Q. I want to ask you some questions about who’s Phil Baker?
A. Phil Baker is the chief executive officer of Hecla.
Q. Do you report to Mr. Baker?
A. No.
BY MR. ROSSMAN:
A. Okay.
Q. You ever read this transcript?
A. No.
Q. If you could look at page 0464. In the middle of the page, under Phil Baker, second paragraph, he says, “We would not suggest to you that the rock burst is any way related to this specifically.” He’s referencing the rockburst on December 14, 2011.
A. In other words, it doesn’t have anything to
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9
MR. RAMSDEN: Object, foundation, calls for speculation.
BY MR. ROSSMAN:
Q. Do you know?
A. I do not.
Q. Did you believe in January of 2012 that the 5900 shaft or pillar was very stable?
A. Yes. The 5900 shaft and the 5900 -- or the silver shaft and the 5900 drift are not in any way connected.
Q. Okay. So what do you understand that he's referring to when he references "the shaft"?
A. The shaft would be the silver shaft.
Q. Gold Hunter?
A. No. The Lucky Friday silver shaft.
Q. And that does not include the 5900 pillar?
A. No. The 5900 pillar is some 4 to 5,000 feet away.
Q. Do you know what he's referring to when he references a rockburst?
A. Yes.
Q. What?
A. The rockburst that occurred in either November or December.
Q. At the 5900 pillar?
A. Yes.
Q. He says, "And when you say you're concerned with the rock burst, the rock burst incident only happened because we had a haulage way that was going through the 30 vein, which we had mined around, and had created a pillar, and it was known that that pillar would have the potential to burst."
Q. Did you know that the pillar in December or -- or in November of 2011 had the potential to burst?
A. All pillars have a potential to burst in a seismically active mine.
Q. And you understood that at the time?
A. Yes.
Q. You understood that in December as well?
A. Yes.
Q. And the company had known that since the creation of the pillar, correct?
A. Yes.
Q. And then he says, "And the thing that ended up happening was we ended up not being able to predict when that burst might happen."
consequences occurring, and the steps that could be used to mitigate those consequences. Q. So it identifies potential hazards themselves, correct? A. Yes. Q. It identifies mitigation measures that can be taken, correct? A. Yes. Q. It also identifies a risk ranking with control measures, correct? A. Yes.

Q. How is that risk ranking utilized? A. To assess what the risk after the control measures are implemented will be. Q. There's an initial risk ranking and then measures are implemented will be. Q. There's an initial risk ranking and then there's a post control risk ranking; is that correct? A. Yes.

Q. So if you look at page 2 of 3, this appears to relate to some of the work that was being done in -- or at least after the December 14th burst. But No. 8 says, "Concrete shaft liner breaking up below the 5900 station has been identified." Do you know what that means?

A. Yes.

Q. And it's talking about operational impacts. Do you know what that means?

A. Yeah.

Q. What is that refers to is an operational impact would be something that reduces or impacts your ability to operate the shaft. In this particular case, the impact would be that you'd have to stop hoisting and repair those cracks. Q. And by stopping hoisting how does that affect the operation?

A. It shuts the operation down.

Q. And that has a revenue impact?

A. Certainly.

Q. And that was a consideration or -- or one of the factors that was addressed in this particular assessment; is --

A. One of many, yeah.

Q. One of many was the impact -- operational impact that mitigating that particular hazard might cause?

A. Yes.

Q. Is that an important consideration at Hecla? A. It wouldn't be one of the more important considerations on there, but it's certainly a consideration.

Q. When would, to your understanding, identification of a particular hazard warrant recognizing it on this document? So, in other words, once Hecla started using this document, what types of hazards would warrant inclusion or this type of assessment?

A. This was the first assessment that Hecla had done.

Q. So it's your -- A. The first formal risk assessment that Hecla had done.

Q. Your testimony is there was never a formal risk assessment done before January 12, 2012?

A. Whatever the date was when this was performed.

Q. How did Hecla perform risk assessment prior to this date?

A. The Lucky Friday was not performing risk assessments prior to that date. Not formal risk assessments.

Q. Clarify formal risk assessments. What do you mean?

A. A formal risk assessment is through this process. An informal risk assessment would be a miner walking into an area and saying, oh, there's a broken hose. If I turn the valve on, it would whip around and hit me. So I need to repair the hose. He's assessed the risk, and he has identified a mitigation measure and then he performs that mitigation. Once that's been performed, the risk is lowered.

Q. Did you as general manager in 2011 perform informal risk assessments similar to what we have on this document?

A. We would. But we would never have documented it to the same extent. That's one of the values that having a formal risk assessment process does is it documents; it assigns responsibilities for who will execute what and when.

Q. So prior to January 12, 2012, the company performed these types of risk assessments; it just was more of an informal process?

A. That's correct.

Q. And the informal process included the same types of considerations that we've talked about.
Q. One of those considerations would have been operational concerns --
A. It would --
Q. -- operational impacts?
A. Operational impacts, certainly.
Q. Do you recall there being any risk assessment being performed following the November 16, 2011, rockburst at the 5900 pillar?
A. Yes, in an informal process.
Q. Who was involved in that?
A. Myself, Doug Bayer, John Lund, Wilson Blake.
Q. Anyone else?
A. I'm sure there were many others, but we didn't document it, so I can't go back and identify all the players.
Q. Was Phil Baker involved?
A. I don't believe so, no. Not -- he would have been involved by being briefed as to what we were ...
Q. Was Larry Radford involved?
A. Larry would have been involved, yes.
Q. Was this a particular meeting or was this a -- how was this handled?
A. Probably a collection of meetings.
Q. Are there e-mails related to these meetings?
A. Possibly. I don't recall every e-mail that might have been floating around.
Q. Would there have been calendaring documentation to identify this meeting?
A. What?
Q. Did you keep a calendar?
A. Not a formal calendar, no.
Q. Would there be any way to identify when this meeting occurred -- or this series of meetings?
A. It would have been after the -- after the event and before we started implementing the repair plan.
Q. Okay. What was discussed, to your recollection, in this risk assessment?
A. What we would need to do to repair the damage. What we wanted to install as a -- you know, a long-term mitigation process. That was the process where we came up with the idea of installing the tunnel liner and the Tekfoam surrounding it.
Q. Were there discussions regarding operational impacts of the 5900 pillar being shut down?
A. There were some considerations given to the operational impacts. But there was a clear recognition that we wouldn't be able to operate while the tunnel was -- liner was being installed.
Q. While the liner was being installed --
A. Correct.
Q. -- you wouldn't be able to operate?
A. Correct.
Q. There was prep work that was performed prior to installation of the liner, correct?
A. Yes.
Q. There was installation of bolts and other types of ground control measures taken?
A. Yes. Bolts, shotcrete, cable bolts, the instrumentation. There was a lot of work that needed to be done then.
Q. At some point the decision was made to restart mining of the 10, 11 and at least 14 stopes during that rehabilitation process, correct?
A. Correct.
Q. Who made that decision?
A. That was -- we submitted -- we were operating under an order -- I think that's correct, Mike -- from MSHA that controlled what we could and what we couldn't do.
So once we had completed phase 1 of the installation of the ground support, the shotcrete, et cetera, then MSHA said, okay, now at this point you can go back mining until the tunnel liner arrives. And then once the tunnel liner arrives we will stop all operations and proceed.
Q. Who was responsible for communicating with MSHA during that 103(k) process?
A. Primarily it was Doug Bayer.
Q. Anyone else?
A. The safety manager at the time, Scott Hogamier was also communicating with them.
Q. Were you communicating directly with MSHA?
A. Not -- yeah, we were communicating directly. They had a presence on site, and we did a lot of talking back and forth.
Q. You say they had a presence on site, what does that mean?
A. They had an inspector that was pretty much on site every day.
Q. Do you know who that was?
A. For a while it was Scott Amos. And at times I remember that Rod Gust was there.
Q. Do you know what Mr. Amos or Mr. Gust were doing at the site?
A. They were inspecting, looking at the various activities, ensuring that we were complying with our work plan.
Q. Were you personally observing them in what they were doing?
A. Yes.
Q. Do you know how often they were inspecting?
A. It seemed like they were there constantly.
Q. And do you know were you aware 1 0 were one of the recipients of it?
A. Yes.
Q. Did you read it entirely?
A. Yes.
Q. Did you understand it?
A. To the extent of my ability to do so.
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A. Yes.
Q. Did you understand it?
He said these --

Oh, I'm sorry. Were you finished?

Q. Can you finish?

A. I don't know if the factor of safety was a specific output of the subsequent studies.

Q. Then it says, "The limitations of this modeling were recognized, and as a result, the stability of the 55 ft circular pillar surrounding the 5900 level access through the orebody has always been some concern." Do you agree with that statement?

A. Not -- not entirely, no.

So with Mr. Blake's statement that the stability of that pillar was always of some concern?

A. Yes. I don't think that it was always a concern. It got to be a matter of concern when we started having these major rockbursts that were occurring adjacent to the opening rather than in the interior of the pillar where we had anticipated there would be some yielding.

Q. He seems to indicate there were concerns as far back as 2004 given the limitations of the modeling that was done. You disagree with that?

A. I do.

Q. Okay. He says, in the middle, it says, "Both the stress and closure values."

A. And where are we at?

Q. The third paragraph down.

A. Third paragraph. Okay.

Q. He said, "Itasca concluded that the 5900 pillar was stable and too big to fail suddenly and violently, behaving more like stabilizing pillar."

A. Yes.

Q. Do you agree with that statement?

A. Yes.

Q. If you look at page 2.

A. (Complying.)

2011?

A. Yes.

Q. And did you understand that the model assumed a 10:1 width-to-height ratio in reading this memo?

A. Yes.

Q. And did you understand that Mr. Blake is telling you from the modeling that if the height-to-width ratio changed and the pillar lost confinement, in which case a foundation failure might occur? Did you understand that in December of 2011?

A. No, I did not. And to this point I still do not understand foundation failures very clearly.

Q. Okay. He says, "The model assumed a 10:1 width to height ratio." You said you read this memo, correct?

A. Yes.

Q. Let's look at the next paragraph. "With the observed stress deterioration along the inner and outer edges of the pillar, likely in the 10 ft range, the height-to-width ratio of the in place doughnut shaped pillar is actually 3.5, assuming a 10 ft vein thickness."

Do you agree that he's telling you that it's now 3.5 width-to-height ratio?

A. Yes, that's what he's saying.

Q. So now he's telling you that as a result of
the November 16th burst -- or subsequent to the
November 16th burst, the pillar is now approximately
one-third the size it was at the time of the modeling.
Would you agree?
A. Yes.
Q. Did you understand that in November of 2011?
A. I'm not understanding now what it is you're
driving at.
Q. Did you understand that the width-height
ratio of the pillar had substantially changed after
November 16th of 2011?
A. No. I didn't realize that at that time.
Q. Did you understand that the modeling that had
been done was based upon a width-to-height ratio of
10-to-1?
A. I didn't understand that, no.
Q. Was there any discussion in these risk
assessment conferences about there being a substantial
change in the width-to-height ratio of the pillar?
A. This risk assessment doesn't have anything to
do with this. (Pointing.)
Q. Were you involved then in the decision to
send employees into the 5900 pillar to execute the
rehabilitation plan?
A. Yes.
Q. And in doing so did you understand that the
dimensions of that pillar had substantially changed?
A. I did not, no.
Q. Did you understand that the modeling that had
been done in 2010 was based upon entirely different
dimensions than existed at that time?
MR. RAMSDEN: Object to the
THE WITNESS: No. And, in fact, I'm not sure
what the import of this ratio is. That they're talking
about is if it gets below whatever number he said,
you'll have a foundation failure. That has never
occurred.
BY MR. ROSSMAN:
Q. Okay. You're trying -- by having modeling
you're trying -- one of the things you're trying to do
is predict when a foundation failure -- when or if a
foundation failure may occur, correct?
A. Or other mechanisms, yes.
Q. Or other mechanisms. And one of the factors
that the modeling assumes in determining when or if a
foundation failure will occur is the width-to-height
ratio of the pillar?
A. So they say.
Q. Okay. And did you understand when sending
crews down into the 5900 level that the dimensions --
said, "Hence, the stress in the pillar" -- and he's
1 talking about prior to the November 16th burst -- "was
2 very near the unconfined compressive strength of the
3 pillar, and any further loss of confinement could lead
4 to a pillar failure." Do you recall reading that?
5 A. I don't recall reading that. I see it now.
6 Q. Do you recall being told that a consultant
7 had opined that shortly prior to November 16th the
8 stress in the pillar was near its compressive strength?
9 A. I recalled that the summary on the back end
10 said that the occurrence of another large 2.8 magnitude
11 burst is very unlikely. Can't be totally
12 eliminated, but it's quite unlikely. That's the big thing that I
13 recall from this document.
14 Q. Okay. So let's focus on the question I'm
15 asking. My question is did you understand that prior
16 to the November 16, 2011 burst, Mr. Blake believed that
17 the stress in the pillar was very near the unconfined
18 compressive strength of the pillar?
19 A. No, I didn't. This is written November 25th, which is after the burst.
20 Q. Did you understand that he opined after
21 November 16th --
22 A. Okay.
23 Q. -- that the strength -- stress in the pillar
24 was very near its compressive strength?
25
26 MR. RAMSDEN: Object to the form, mischaracterizes what the report says. Go ahead and answer the question.
27 THE WITNESS: I don't recall being concerned about that issue.
28 BY MR. ROSSMAN:
29 Q. Do you believe that the November 16th burst
30 to some extent may have de-stressed the pillar?
31 A. Yes.
32 Q. Did you take any steps to determine how much
33 the pillar had been de-stressed?
34 A. There's no means to do that.
35 Q. Mr. Blake was calling for additional modeling
36 of the pillar; do you recall that?
37 A. No. I don't recall that.
38 MR. ROSSMAN: Okay. Let's look at ...
39 (Whereupon, Deposition Exhibit No. 14 was marked for identification.)
40 BY MR. ROSSMAN:
41 Q. Show you Exhibit 14, which is the
42 November 18, 2011, report from Mr. Blake. If you look
43 under Model Results and 5900 Pillar Burst, page 2 of
44 his report, second sentence, "Because the actual burst
45 appears to have been structurally controlled, we may
46 want Itasca to rerun the model with structure running
47 through the pillar in order to see if we can replicate
48 the burst. We really need to better understand why
49 this burst occurred, as it has significant implications
50 with respect to mining the main sill - particularly
51 along the more burst prone eastern portion of the
52 sill."
53 A. Okay.
54 Q. Did you develop an understanding in November
55 of 2011 that Mr. Blake was calling for additional
56 modeling based upon the November 16th burst?
57 A. Yes. That's -- that's clear.
58 Q. Did you ask for any additional modeling?
59 A. I don't know if we commissioned Itasca to do
60 that or not.
61 Q. I'll represent I haven't seen any
documentation representing additional modeling after
November 16, 2011. Do you recall there being such?
62 A. I do not.
63 Q. Do you recall discussing whether or not to
64 have Itasca do further modeling?
65 A. I do not recall.
66 Q. Do you recall making a decision not to do
67 further modeling?
68 A. No. I don't recall that either.
8 occurred in 13 it 14 But he was believing at that time, if I'm 15 interpreting him correctly, that this was likely a 16 foundation failure. And it turns out that the current 17 thinking is that it's a fault-slip mechanism.

BY MR. ROSSMAN:
19 Q. And he was believing it was a foundation 20 failure right up to December 14, 2011, correct?
21 MR. RAMSDEN: Object to the form, calls for 22 speculation.
23 BY MR. ROSSMAN:
24 Q. Did anyone tell you prior to December 14, 25 November 16, 2011, burst was anything other than a 26 foundation failure?
A. My belief at that time was that it 27 was a pillar burst.
28 Q. Okay. Did anyone tell you prior to 29 December 14th that they felt it was a fault-slip?
A. No.
30 Q. In fact, Mr. -- will you agree that by saying 31 "we may want Itasca to rerun the model with structure 32 running through the pillar in order to see if we can 33 replicate the burst" and that "we really need to better 34 understand why this burst occurred" that he didn't 35 fully understand why the November 16th burst occurred?
A. Yes.
36 MR. RAMSDEN: Object, calls for speculation.
37 BY MR. ROSSMAN:
38 Q. Did you fully understand why that burst 39 occurred?
A. I did not.
40 Q. And what he was saying is he would really 41 like to see additional modeling to better understand 42 why that occurred, correct?
A. MR. RAMSDEN: Object, speculation.
44 THE WITNESS: Correct. His concern was in 45 the next three to four years that we would be mining 46 that pillar. It wasn't -- there's nothing in here that 47 says that should be done before we undertake to 48 initiate repairs.
49 BY MR. ROSSMAN:
50 Q. So he's telling you in two reports that the 51 dimensions of the pillar have substantially changed. 52 And he's telling you that he doesn't fully understand 53 the cause of the November 16th burst. And you didn't 54 feel it was important to do further modeling to 55 understand the cause of that burst or the safety of 56 that pillar before sending employees in?
A. That's not what --
57 MR. RAMSDEN: Object, compound.
58 THE WITNESS: -- he was referring to.
62 Q. Okay. Did anyone tell you prior to December 14, 63 November 16, 2011, that they believed that the mechanism for the 64 pillar before sending employees in?
A. That's not what --
65 MR. RAMSDEN: Object, compound.
66 THE WITNESS: -- he was referring to.
70 Q. In fact, Mr. -- will you agree that by saying 71 "we may want Itasca to rerun the model with structure 72 running through the pillar in order to see if we can 73 replicate the burst" and that "we really need to better 74 understand why this burst occurred" that he didn't 75 fully understand why the November 16th burst occurred?
A. Yes.
76 MR. RAMSDEN: Object, calls for speculation.
77 BY MR. ROSSMAN:
78 Q. Did you fully understand why that burst 79 occurred?
A. I did not.
80 Q. And what he was saying is he would really 81 like to see additional modeling to better understand 82 why that occurred, correct?
A. MR. RAMSDEN: Object, speculation.
84 THE WITNESS: Correct. His concern was in 85 the next three to four years that we would be mining 86 that pillar. It wasn't -- there's nothing in here that 87 says that should be done before we undertake to 88 initiate repairs.
89 BY MR. ROSSMAN:
90 Q. So he's telling you in two reports that the 91 dimensions of the pillar have substantially changed. 92 And he's telling you that he doesn't fully understand 93 the cause of the November 16th burst. And you didn't 94 feel it was important to do further modeling to 95 understand the cause of that burst or the safety of 96 that pillar before sending employees in?
A. That's not what --
97 MR. RAMSDEN: Object, compound.
98 THE WITNESS: -- he was referring to.
1. We had a higher frequency of seismic events on the eastern portion of the 30 vein than we did on the western portion.

Q. If you look at Exhibit 4, can you tell me what you're referring to by the eastern portion of the sill? (Indicating.)

A. That wasn't -- I couldn't tell you exactly what zones he -- he refers to. But I do know that the eastern portion did have a tendency to demonstrate more seismic frequency.

Q. He says under Summary, "Because the upper ribs and back appeared to be solid, we can't assume that the remaining pillar is destressed, hence the rehabilitation needs to proceed with caution." Do you recall reading that?

A. Yes.

Q. What did you understand he meant by that?

A. Proceed with caution.

Q. Okay. What steps did Hecla take to proceed during the rehabilitation process with caution?

A. The process -- the plan that we put together utilized a process that was as conservative as we could possibly make it and still complete the activity. We actually started repairs 50 to 75 feet before the area where we had the damage. So we were certain that all the area up there was as secure as possible so that our people would be working in secured ground.

Q. Did you afford consideration to the need for further modeling before sending employees into that sill -- into the pillar?

A. I did not.

Q. The company could have -- well, strike that. The company initiated rehabilitation procedures very shortly after the November 16th burst, correct?

A. Yes.

Q. The purpose for that was because without the pillar you couldn't continue to mine, correct?

A. No.

Q. Okay. Why did you initiate rehabilitation steps so quickly after the burst?

A. As I said before, that's the best time to get in and initiate your rehabilitation because the stress has been relieved to some extent by the release of stress that accompanies the rockburst or that the rockburst is evidence of.

Q. We saw reference in a prior exhibit to reference that at least in November -- or at least in 2010 the pillar was wide enough to withstand the stress at that particular level --

A. Mm-hmm.

Q. -- correct?

A. Yes.

Q. What did you understand that to mean?

A. That the load on the pillar was not excessive compared to what the pillar could tolerate. That we were still above unity with the factor of safety.

Q. And that by referring to the pillar being wide enough to handle that load, is it fair to say that a wider or larger pillar is more -- generally more stable than a smaller pillar?

A. I think that's a fair statement.

Q. Mr. Blake said "Because the upper ribs and back appeared to be solid, we can't assume that the remaining pillar is destressed." Did you read that portion of his memo?

A. Yes.

Q. Did you have that understanding?

A. I didn't agree with that. It's pretty common knowledge that after a rockburst the stress -- state of stress is lower.

Q. Does that assume that the dimensions of the pillar haven't changed as a result of the burst?

A. Yes.

Q. So Mr. Blake is telling you that because the upper ribs and back appeared to be solid, we can't assume that the remaining pillar de-stressed, but you didn't believe him?

MR. RAMSDEN: Object to the form. It's argumentative. Go ahead and answer.

THE WITNESS: I disagreed with him. I had a different opinion.

BY MR. ROSSMAN:
Q. You had that opinion based upon your general assumption that after a rockburst the pillar is somewhat de-stressed?
A. Yes. It's somewhat de-stressed and that is the time to initiate repairs.
Q. Do you know what he meant when he said the upper ribs and back appeared to be solid?
A. Yeah. He said that there was -- yes. That there was no evidence of damage in that portion of the opening.
Q. Do you know how he related that to the statement that we can't assume the pillar is de-stressed?
MR. RAMSDEN: Objection --
THE WITNESS: No. I don't know how he related that.
BY MR. ROSSMAN:
Q. Okay. Were you involved in the decision to restart mining during the rehabilitation process?
A. Which part of the rehabilitation process?
Q. Well, prior to December 14, 2011, the company started mining --
A. Yes.
Q. -- 10, 11 and 14 stopes?

A. Yes. When we had the modification to the (k) order that allowed us to resume operation, we brought our employees back.
Q. And you --
A. And that was part of the process that said that once the liner arrives, we will cease mining operations.
Q. You believe that MSHA approved the company's continuing to restart mining?
A. They did.
Q. Did you speak to anybody at MSHA that represented that they were agreeable to you continuing mining?
A. Yes.
Q. Who did you speak with?
A. Scott Amos.
Q. Who was present?
A. Scott Amos was present. I think Doug Bayer was present at that time.
Q. When was this?
A. This was sometime between the two rockbursts.
Q. What was discussed?
A. The plan to move forward and install the liner.
Q. Okay.
1. Q. To your knowledge at the time that MSHA approved mining activity had they seen any monitoring data from the stress monitoring?  
A. I do not know.
2. Q. Had they seen any closure data?  
A. I do not know.
3. Q. Was there anything that would have prevented Hecla from waiting until the tunnel liner was installed to restart mining?  
A. No.
4. Q. The purpose for the tunnel liner at the 5900 level was to provide further stability?  
A. Yes.
5. Q. And with the tunnel liner and the additional rehabilitation measures, it was expected that the pillar could withstand seismic activity up to 2.2 on a Richter scale, correct?  
A. I'm not sure what number on a Richter scale it was assessed at. But it was assessed that that would be adequate to allow us to continue operations through that stretch.
6. Q. Was it ever discussed by you or in your presence -- anyone else in your presence whether or not to suspend mining until the liner was installed?  
A. Not that I recall.

Q. Was that a consideration for you?  
A. Not that I recall.

WHEREUPON, Deposition Exhibit No. 15 was marked for identification.

BY MR. ROSSMAN:

Q. Show you Exhibit 15. That's the December 27, 2011, Wilson Blake and Mark Board memorandum. Do you recall reviewing this?
A. Yes.

Q. And this was after the December 14, 2011, burst; is that correct?
A. Yes.

Q. Do you recall asking Mr. Blake and Mr. Board to prepare a memo relating to that rockburst?
A. The question is do I recall initiating that request?

Q. Yes.

Q. Do you recall what the purpose of their evaluation of that rockburst was?
A. Essentially I think this was to follow up on Wilson's -- Wilson Blake's concerns. And we brought Mark in to discuss it, talk about things like additional modeling that could or should be done, et cetera.

Q. Okay. If you look at page 5, there's a section entitled December 14 Event where they're describing that particular event, is that correct? Do you see that section?
A. I see it. I'm trying to review it and understand what's being said here.

(Brief pause.)

BY MR. ROSSMAN:

Q. I'm just talking about that section entitled December 14 Event.
A. Oh, okay. Down at the bottom?


A. (Witness examining document.) Okay.

Q. You agree in that section they are providing their opinion regarding the cause of the December 14th rockburst?
A. Yes.

Q. If you look at page 6, the top of the page they say, "This" -- and they're referring to the December 14th burst -- "appears to be a typical strain burst mechanism resulting from the solid pillar in the wall of the 5900 drift reaching its peak strength."

Q. Do you recall developing that understanding?
A. Yes.

Q. It appears that the causing mechanism of
this event was the November 16 event." And they have
two bullets, correct?
A. That's the conclusion that they reached, yes.
Q. They say, "The November 16 event ejected rock
from the 5900 drift, expanding the drift size, reducing
the width:height ratio of the pillar (to around 3:1),
and increasing the mining-induced stress in the
pillar." Did you see that conclusion?
A. I see that conclusion.
Q. And did you agree with that?
A. I don't understand the differences because we
didn't reduce the pillar by a factor of 3, from
10-to-1 to 3-to-1. So if it's 3-to-1 now, I don't
understand why it would ever have been considered a
10-to-1. That part confuses me. Other than that, I
can certainly read it. And they're saying that, yes,
that this was a reduced pillar and that was the cause.
This is after the fact, but ...
Q. Well, you agree that Mr. Blake was telling
you on November 25th that the pillar had reduced its
width-height ratio as a result of the November 16th
burst?
A. I still am confused as to how it reduced from
10-to-1 to 3-to-1.
Q. Will you agree that Mr. Blake was telling you
at least as of November 18, 2011, that he believed the
pillar walls had reached near their peak strength at
the time of the November 16th burst?
MR. RAMSDEN: Object to the form.
THE WITNESS: I can't -- I've got to go back
and sort through this.
BY MR. ROSSMAN:
Q. And from what we've read, will you agree that
Mr. Blake had told you on November 25th that we
can't assume that the pillar has de-stressed based upon
the solid ribs and walls of the pillar?
A. I'm sorry you an as to where
this burst occurred on December 14, 2011?
Q. That was the -- the
instrumentation.
A. Yes.
Q. How is seismic monitoring system monitoring
the east wall of the pillar?
<table>
<thead>
<tr>
<th>Page 138</th>
<th>Page 140</th>
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<tbody>
<tr>
<td>Q. Did you have an understanding as to the extent to which you were stress monitoring the east wall?</td>
<td>Q. So the first negative readings you believe you spoke to Mr. Thomas?</td>
</tr>
<tr>
<td>A. I'm sorry.</td>
<td>A. Yes, I believe so.</td>
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<tr>
<td>Q. How were you monitoring -- stress monitoring the east wall?</td>
<td>Q. What do you recall being discussed?</td>
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<tr>
<td>A. We had stress gauges installed.</td>
<td>A. Why would the -- we be getting a negative reading on that.</td>
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<td>Q. Do you know how many?</td>
<td>Q. And do you recall what Mr. Thomas said?</td>
</tr>
<tr>
<td>A. No. I don't know how many we had.</td>
<td>A. Mr. Thomas said that it simply showed a tensile condition relative to the point of its installation.</td>
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<td>Q. Do you know the location?</td>
<td>Q. Could you ask him how it was installed?</td>
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<td>A. Generally I know the locations.</td>
<td>A. Yes.</td>
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<tr>
<td>Q. What is your understanding of the location of the stress monitoring on the east wall prior to December 14th?</td>
<td>Q. What did he say?</td>
</tr>
<tr>
<td>A. I'm not following you.</td>
<td>A. He told me that it was installed using the procedure that we have for installation of the phones that we got from -- or the gauge that we got from NIOSH.</td>
</tr>
<tr>
<td>Q. Is it fair to say there was a single gauge installed on the east wall after the November 16th burst?</td>
<td>Q. Did he use a jumbo or did he use a diamond driller for the borehole?</td>
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<tr>
<td>A. I believe so. There was also one vertically.</td>
<td>A. I'm not sure.</td>
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<td>Q. On the top?</td>
<td>Q. Did you ask him?</td>
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<tr>
<td>A. Yes.</td>
<td>A. No.</td>
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<tr>
<td>Q. And there was one on the west wall?</td>
<td>Q. Did you ask him what the geology was of the rock in which the platen was installed?</td>
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<tr>
<td>A. Yes.</td>
<td>A. No.</td>
</tr>
<tr>
<td>Q. And did you understand that prior to December 14th the stress monitoring on the east wall was registering nothing but negative readings?</td>
<td>Q. Did you ask him to inspect that when you were seeing negative readings?</td>
</tr>
<tr>
<td>A. It was showing a tensile condition, yes.</td>
<td>A. Yes. And I believe he went down and checked the installation.</td>
</tr>
<tr>
<td>Q. Did you ever ask or direct anyone to evaluate why it was showing a continuous negative reading?</td>
<td>Q. Did you ever see any pictures of the monitoring gauge?</td>
</tr>
<tr>
<td>A. Yes. We talked to Zac Thomas about it.</td>
<td>A. No. I didn't see.</td>
</tr>
<tr>
<td>Q. Who is &quot;we&quot;?</td>
<td>Q. Did you ask anyone else to inspect it?</td>
</tr>
<tr>
<td>A. Well, I talked to Zac Thomas about it. I'm sure there were others involved in the conversation --</td>
<td>A. No, I did not.</td>
</tr>
<tr>
<td>Q. When did you talk to Zac?</td>
<td>Q. Mr. Thompson worked with NIOSH, correct?</td>
</tr>
<tr>
<td>A. -- likely Doug Bayer.</td>
<td>A. Thomas.</td>
</tr>
<tr>
<td>Q. When did you talk to Zac about the negative readings?</td>
<td>Q. Thomas?</td>
</tr>
<tr>
<td>A. Probably as soon as we found out that the gauge had gone in a different direction.</td>
<td>A. Yes.</td>
</tr>
<tr>
<td>Q. Did you ask Mr. Thomas to inspect the monitoring gauge?</td>
<td>Q. Did you ask Mr. Thomas to inspect the monitoring gauge?</td>
</tr>
<tr>
<td>A. Zac, yes.</td>
<td>A. Yes.</td>
</tr>
<tr>
<td>Q. Excuse me. The individual with NIOSH. Wasn't it Mr. Thompson?</td>
<td>Q. Did you ask Ted Williams to inspect the gauges?</td>
</tr>
<tr>
<td>A. No. Mr. Williams.</td>
<td>A. I don't think so. Ted was retired at that point.</td>
</tr>
<tr>
<td>Q. Williams. I apologize. Did you ask Ted Williams to inspect the gauges?</td>
<td>Q. Did you ask anyone at NIOSH to inspect the gauges?</td>
</tr>
</tbody>
</table>

36 (Pages 138 to 141)
A. Not that I recall.
Q. Did you contact the manufacturer?
A. Yes. We had Zac contact the manufacturer.
Q. When did you have Zac contact the manufacturer?
A. When there was some questions about that.
Q. That was after the burst, correct?
A. Could have been.
Q. Did you ask anyone to contact the manufacturer before the burst as to why there were negative readings on the east wall?
A. I did not.
Q. Do you know if anyone did?
A. I do not.
Q. Did you have any discussions with anyone else about the negative readings other than Mr. Thomas when you started seeing them?
A. I don't recall.
Q. Did it cause you any concern?
A. Not a huge one, no.
Q. Why?
A. I didn't feel that the data was all that pertinent, that it was all that reliable and that it was my feeling that the seismic monitoring system was our best method of monitoring the conditions in that pillar.
Q. It's fair to say your primary focus was with the seismic monitor?
A. Yes.
Q. You weren't concerned with the stress monitoring?
A. Not nearly to the extent that I was with the seismic monitoring.
Q. Were you concerned with the stress monitoring?
A. Pardon me?
Q. Were you concerned with the stress monitoring?
A. Yes. I felt that we needed to do it.
Q. But when you were receiving negative readings, you didn't afford it any --
A. Negative readings are possible.
Q. Negative readings are possible for many reasons, correct?
A. Yes.
Q. And did you initiate any investigation to determine why the negative readings were occurring at any time?
A. No, I didn't.
Q. Did you ask anyone to?
A. If it had been felt that we would have an impact from the mining then we would not have done it.
Q. So if a consultant had told you at that point in time that the consultant believed that the November 16th burst was triggered by mining activity at the 5700 level that would have been something that you would have considered?
A. Certainly. If the consultant would have said we don't want to restart the overhand stopes, we wouldn't have started the overhand stopes or the upper stopes.
Q. Did you ask Wilson Blake to provide an opinion regarding whether you could mine those stopes during the rehabilitation process?
A. I don't recall.
Q. Did you ask Mark Board, to your understanding?
A. I don't recall.
MR. ROSSMAN: Take a short break.
THE WITNESS: Sure.
(Exit Mr. Clary.)
(Whereupon, Deposition Exhibits Nos. 16 through 19 were marked for identification.)
MR. ROSSMAN: Let's go back on the record.
BY MR. ROSSMAN:
Q. Mr. Jordan, between November 16th and December 14th were you reviewing stress monitoring data?
A. Was I personally reviewing it?
Q. Yes.
A. I looked on it on occasion. I did not perform a formal review.
Q. Do you have an estimate as to how often you would have reviewed it?
A. Probably two to three times a week.
Q. And in doing so, when you would review it, what would you do?
A. Look for the highlights to -- were there any -- is there anything going on that's unusual. I'd always talk with the people that were gathering the data and see if there's anything that they saw that I might be overlooking.
Q. Do any evaluation of the data in comparison to any previous monitoring?
A. The stress monitoring you're referring to?
Q. Yes.
A. No.
Q. Show you Exhibit No. 16. Do you recognize that document?
A. Yes.
Q. What is that?
A. That is similar to this. (Pointing.)
It's --
MR. RAMSDEN: Similar to 4?
THE WITNESS: Similar to Exhibit 4. And it's basically a tighter view showing the area that was being mined.
BY MR. ROSSMAN:
Q. Did you ask Wilson Blake to provide an estimate regarding whether you could mine those stopes during the rehabilitation process?
A. I don't recall.
Q. Did you ask Mark Board, to your understanding?
A. I don't recall.
Q. Show you Exhibit 17. Who's Mike Clary?
A. (Nonresponsive.)
Q. I believe that's the individual that was sitting here?
A. Yes, yes.
Q. In-house counsel for Hecla?
A. Yes.
Q. He sent an e-mail on February 14, 2012, to Brad Breland, is that correct?
A. Yes.
Q. And that's identifying mining activity in 10, 11 and 14 stopes between November 17, 2011, and December 13, 2011; correct?
A. Correct.
Q. And that's identifying mining activity in 10, 11 and 14 stopes between November 17, 2011, and December 13, 2011; correct?
A. Correct.
Q. And that's identifying mining activity in 10, 11 and 14 stopes between November 17, 2011, and December 13, 2011; correct?
A. Correct.
Q. And that's identifying mining activity in 10, 11 and 14 stopes between November 17, 2011, and December 13, 2011; correct?
A. Correct.
Q. And that's identifying mining activity in 10, 11 and 14 stopes between November 17, 2011, and December 13, 2011; correct?
A. Correct.
1. A. Correct.
2. Q. So from this e-mail it does indicate that there was active mining between November 17 and December 13 of both east and west sides of stope 14, correct?
3. A. Correct.
4. Q. Show you Exhibit No. 18. Do you recognize that document?
5. A. I know what it is, yes.
6. Q. What is that?
7. A. This is a 5,000 something or other form. This is our incident reporting form.
8. Q. And do you know whose handwriting that is on the form?
9. A. I see that it's signed by Howard Pettit who was a mine supervisor.
10. MR. ROSSMAN: Okay. Can I see that?
11. (Document tendered.)
12. BY MR. ROSSMAN:
13. Q. The purpose of this particular document is to report -- this particular document was to report the November 16, 2011 burst; is that correct?
15. Q. If you'll look at the first page, incident timing, November 16, 2011.
16. A Yes.
17. Q. Okay. And whomever's handwriting this is -- go to third page.
18. A Okay.
19. Q. "Direct Causes: Blasting" -- and I don't know what the next word is -- "end (sic) will trigger rockbursts." Do you know what that says?
20. A. It says, "Blasting can and will trigger rockbursts." Is that a representation on behalf of Hecla?
21. A. That's the conclusion that Howard Pettit reached.
22. Q. And that was your understanding as well at the time, correct?
23. A. Excavation can trigger rockbursts, yes.
24. Q. And did you understand that to be a direct cause of the November 16, 2011, burst at that point?
25. A. No. I would understand that to be Howard Pettit's opinion as to what caused it. I didn't feel that that was a definitive conclusion, and that's why we brought Mr. Blake in, subsequently Mr. Board, in to review it.
26. Q. Okay. And did anyone -- Mr. Blake or Mr. Board prior to December 14th ever tell you that the blasting of 5700 did not have any contribution to the burst on November 16th?
27. A. Not that I recall, no.
28. Q. Did you have any involvement in safety meetings?
29. A. Yes.
30. Q. What involvement did you have?
31. A. As general manager I didn't attend all of the crew meetings -- or the tailgate sessions. But there would be a monthly crew meeting that I would participate in.
32. Q. Show you Exhibit 19. Do you recognize that document?
33. A. Yes. This is a safety committee meeting document.
34. Q. First page appears to be a -- is this an agenda for a safety committee meeting?
35. A. Yes.
36. Q. Appears to be an agenda for a safety committee meeting on August 8th, 2011, is that correct?
37. A. December 8th.
38. Q. First page?
40. Q. The second page relates to a meeting on October 13, 2011?
41. A. Yes.
Q. Okay. Do you recall what was discussed about centralized blasting?

A. Yes.

Q. Have you seen such a document relating to this December 8th, 2011 meeting?

A. Boy. If I did, I saw it three years ago.

Q. Do you recall what was discussed during that meeting?

A. No, other than what's on the agenda here. I see that there's a discussion on centralized blasting.

Q. Okay. Do you recall what was discussed about centralized blasting?

A. I believe I raised that topic and asked to have it put on there. We talked about developing a remote blasting ability so that we could ensure that everyone was out at the mine -- or out at the station before shooting any blasts rather than relying on timing to get people collected.

Q. What was decided?

A. That we would go ahead and install a centralized blasting system that would get the specifics of how it was being accomplished at the Galena Mine, which was utilizing a centralized blasting system, and that we would see if it was possible for us to implement that or -- and at the same time investigate to see if there were other systems that would be better implemented.

Q. What kind of systems? You mean for remote blasting?

A. Yes.

Q. It says "1st Quarter Safety" -- or it talks about safety goals being discussed as well; is that correct?

A. Mm-hmm.

Q. What was discussed about those to your recollection?

A. I couldn't recall any specifics on that.

Q. Do you recall members of the safety committee asking questions about the monitoring of the 5900 stope --

A. I don't.

Q. -- or pillar?

A. I don't recall that, no.

Q. Do recall people asking what the monitoring results were --

A. I don't recall --

Q. -- during that rehab period?

A. -- that, no.
CERTIFICATE OF WITNESS

I, JOHN JORDAN, being first duly sworn,

depose and say:

That I am the witness named in the foregoing

deposition; that I have read said deposition and know

the contents thereof; that the questions contained
 therin were propounded to me; and that the answers
 therein contained are true and correct except for any
 changes that I may have listed on the Change Sheet
 attached hereto.

DATED this _____ day of ____________,


JOHN JORDAN

SUBSCRIBED AND SWORN to before me this _____

day of ____________, 20___.

NAME OF NOTARY PUBLIC

NOTARY PUBLIC FOR ____________

RESIDING AT ____________

MY COMMISSION EXPIRES ________

REPORTER'S CERTIFICATE

I, Patricia L. Pullo, Certified Shorthand

Reporter, do hereby certify:

That the foregoing proceedings were taken

before me at the time and place therein set forth, at

which time any witnesses were placed under oath;

That the testimony and all objections made

were recorded stenographically by me and were

thereafter transcribed by me or under my direction;

That the foregoing is a true and correct

record of all testimony given, to the best of my

ability;

That I am not a relative or employee of any

attorney or of any of the parties, nor am I financially

interested in the action.

IN WITNESS WHEREOF, I have hereunto set my

hand and seal this 17th day of April, 2015.

PATRICIA L. PULLO, C.S.R. #697

Notary Public

816 Sherman Avenue, Suite 7

Coeur d'Alene, ID 83814

Exhibit 15
IN THE DISTRICT COURT OF THE FIRST JUDICIAL DISTRICT OF
THE STATE OF IDAHO, IN AND FOR THE COUNTY OF KOTENAI

RONNEL E. BARRETT, an individual; )
GREGG HAMMERBERG, an individual; )
ERIC J. TESTER, an individual; )
and MATTHEW WILLIAMS, an )
individual, )
       Plaintiffs, )

vs. )

HECLA MINING COMPANY, a Delaware )
Corporation; JOHN JORDAN, an )
individual; DOUG BAYER an )
individual; SCOTT HOGAMIER, an )
individual; and DOES I-X, unknown )
parties, )
       Defendants. )
       )

Case No. CV 13-8793

DEPOSITION OF SCOTT HOGAMIER
TAKEN ON BEHALF OF THE PLAINTIFFS
AT COEUR D'ALENE, IDAHO
APRIL 7, 2015, AT 8:54 A.M.

REPORTED BY:

PATRICIA L. PULLO, CSR
Notary Public
THE DEPOSITION OF SCOTT HOGAMIER, was taken on behalf of the plaintiffs on this 7th day of April, 2015, at the law offices of Ramsden & Lyons, LLP, Coeur d'Alene, Idaho, before M & M Court Reporting, LLC, by Patricia L. Pullo, Court Reporter and Notary Public within and for the State of Idaho, to be used in an action pending in the District Court of the First Judicial District of the State of Idaho, in and for the County of Kootenai, said cause being Case No. CV 13-8793 in said Court. (Whereupon, Deposition Exhibit No. 31 was marked for identification.)


AND THEREUPON, the following testimony was adduced, to wit:

SCOTT HOGAMIER, having been first duly sworn to tell the whole truth, and nothing but the truth, said cause, deposes and says:
1 EXAMINATION
2 QUESTIONS BY MR. ROSSMAN:
3 Q. Mr. Hogamier, have you been deposed before?
4 A. Yes.
5 Q. How many times?
6 A. Once.
7 Q. Was that in an MSHA proceeding or was that in a civil case?
8 A. MSHA.
9 Q. You have not been deposed in the Marek civil case?
10 A. I don't think so.
11 MR. RAMSDEN: Yeah, you were.
12 THE WITNESS: Was I? Was that the Marek case?
13 MR. RAMSDEN: Yeah.
14 THE WITNESS: It was in this room.
15 MR. ROSSMAN: Okay.
16 BY MR. ROSSMAN:
17 Q. Well, the purpose of a deposition is for me, as plaintiffs' counsel, to ask you questions, find out what, if any, relevance knowledge or recollection you may have that may relate to this case. Okay?
18 A. Okay.
19 Q. You're under oath just as though you're testifying in court. Penalties of perjury apply equally here as they would if you were testifying in court. Do you understand that?
20 A. Yes.
21 Q. We have a court reporter. If you can make her life easier by trying to let me finish my question before answering?
22 A. I will do my best.
23 Q. All right. If you don't understand a question I ask, ask me to rephrase it. I'll be happy to do so. Okay?
24 A. Okay.
25 Q. You're under oath just as though you're testifying in court. Penalties of perjury apply equally here as they would if you were testifying in court. Do you understand that?
26 A. Yes.
27 Q. We have a court reporter. If you can make her life easier by trying to let me finish my question before answering?
28 A. I will do my best.
29 Q. All right.
30 A. No promises.
31 Q. Okay. All I can ask is your best.
32 If you'll always give us an audible response. A shake of the head or a grunt doesn't read very well. Okay?
33 A. Okay.
34 Q. If you don't understand a question I ask, ask me to rephrase it. I'll be happy to do so. Okay?
35 A. Okay.
36 Q. Need a break, let me know.
37 A. Okay.
38 Q. You ready?
39 A. Okay.
40 Q. All right. I want you to tell me your educational background, please.
41 A. I went through high school and then a year and a half of junior college over here at NIC.
42 Q. Did you get a degree?
43 A. No.
44 Q. Do you have any particularized training or education beyond NIC?
45 A. No, just in the work field, the mining industry.
46 Q. When did you start with Hecla?
47 A. 2006.
48 Q. Where did you work before that?
49 A. At the Galena Mine.
50 Q. What were you doing for the Galena Mine?
51 A. Mining.
52 Q. How long did you work there?
53 A. Ten years.
54 Q. Okay. And you came to Hecla in 2006?
55 A. Correct.
56 Q. What job title did you obtain when you first came to Hecla?
57 A. Miner.
58 Q. How long did you work in that position?
59 A. Roughly a year and a half.
60 Q. And then what position did you...
61 A. Safety technician.
62 Q. How long were you a safety technician?
63 A.

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Docket No. 43639
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1. position was an hourly position. And I was still union
2. through that first year. So in 2009, when I officially
3. went salary, then I ceased to be in the union.
4. Q. Are you still a member of the safety
5. commission -- committee? Excuse me.
6. A. Yes, I am.
7. Q. How long have you been a member of the safety
8. committee?
10. Q. And as a safety tech one of your
11. responsibilities was to attend meetings?
12. A. Correct.
13. Q. And to take notes during meetings?
15. Q. What was the purpose for taking notes during
16. meetings?
17. A. To capture what was said and then type it all
18. up, send it around to the members and then post it on
19. the bulletin board for all to see.
20. Q. And were these minutes verbatim statements or
21. were they general summaries?
22. A. Well, we try to capture pretty much
23. everything that was said, you know, within reason. If
24. someone was (demonstrating) like that, you may not get
25. the whole thing. But you got the gist of it.

1. Q. Okay. And did you take notes during every
2. meeting during your period employed as a safety tech?
3. A. Well, not if I didn’t attend the meeting or
4. sometimes Steve would take the notes.
5. Q. So one of you would take the notes at every
6. meeting?
7. A. Correct.
8. Q. To what position were you promoted in 2010?
9. A. They called it safety foreman.
10. Q. Are you still a safety foreman?
11. A. Yeah.
12. Q. What are your responsibilities as safety
13. foreman?
14. A. Pretty much the same -- the same kind of
15. responsibilities. The audits, the safety committee,
16. getting out into the work areas, dealing with MSHA only
17. as the -- and I started attending the staff meeting.
18. There’s a weekly staff meeting I attended. I’m also
19. mine rescue. I’m the mine rescue coordinator. So it’s
20. a big part of my job.
21. Q. Anything else?
22. A. No.
23. Q. So you said you started attending staff
24. meetings. What are staff meetings?
25. A. That is a meeting called by the general
1. A. No.
2. Q. Were you ever involved in rockburst planning?
3. A. Uh-uh.
4. Q. No?
5. A. No.
6. Q. You said one of your responsibilities was to deal with MSHA, correct?
7. A. Correct.
8. Q. If MSHA had issues regarding rockburst planning, how would you have handled those?
9. A. They would have went and talked to the other management members that dealt with that.
10. Q. Who in particular?
11. A. Mine -- maybe mine superintendent, mine foreman, chief engineer.
12. Q. Did you have any responsibility for development or implementation of the safety manual?
13. A. That manual was developed in I believe 1994. And in 2009, when I was a safety technician, I rewrote it and updated it with help from management. So I -- I would give out certain parts of it. It was broke down into different parts. Like the mill had a section in there, track mining, mechanized mining.
14. Q. And so I would take that section to, say, a mine superintendent or the foreman or the mill -- mill superintendent and give them those pieces and say please read this. Make sure it's accurate. Put additions or subtractions that are needed in there. And then I rewrote it in 2009 -- or updated it.
15. Q. Did you have any involvement in development of the ground control plan?
16. A. No, no.
17. Q. Have any involvement in the development of the rockburst plan?
18. A. No, I did not. Those were there before I was.
19. Q. As of December 14, 2011, had you ever read the rockburst plan?
20. A. I'd looked at parts of it that we had -- you know, but -- yeah, I guess I'd read some of it.
21. Q. So in part of your responsibility -- well, in your responsibilities as safety manager, you were --
22. MR. RAMSDEN: Safety foreman.
24. BY MR. ROSSMAN: Q. (Continuing.) -- you were aware that there was a history of rockbursts at the Lucky Friday silver mine, correct?
25. A. There was a history of rockbursts at the Lucky Friday when we mined the Lucky Friday side. When I came to the Friday in 2006 and they were mining the Gold Hunter vein, it was not as active, or the history I'd heard of at the Lucky Friday wasn't anything like that. So rockbursts were fairly uncommon when I hired out there.
26. Q. Fairly uncommon in the Gold Hunter vein?
27. A. Correct.
28. Q. And at the 5900 level, there was a drift pillar that provided access to the Gold Hunter vein, correct?
29. A. Correct.
30. Q. That drift pillar extended through the Lucky Friday Mine, correct?
31. A. It came off the station and you go to your left and it's a mile-long drift back to the Gold Hunter. So part of it was -- might have been the Lucky Friday, I guess, original Lucky Friday workings and then you got back to the new workings in the back end.
32. Q. Okay. Were you responsible at all for seismic monitoring?
33. A. No.
34. Q. Had you read any seismic monitoring for the Gold Hunter or Lucky Friday mines?
35. A. No.
36. Q. Did management communicate the results of seismic monitoring?
37. A. When -- if we had an event, yeah, then we would -- we would -- part of my job is if we had an event was to call MSHA. And then they would show up and then I would deal with MSHA. And I would -- we would, you know, always hear what -- what millimeter it was or -- or, you know, where it hit and stuff like that.
38. Q. Was there typically any communication by management with union employees regarding seismic activity?
39. A. Not that I'm aware of.
40. Q. Was there ever -- well, you're aware that there was stress monitoring going on at certain -- in certain portions of the mine, correct?
41. A. Yes.
42. Q. Were you responsible at all for stress monitoring?
43. A. No.
44. Q. Were you aware of the results of any stress monitoring?
45. A. Not that I saw or remember.
46. Q. Do you ever see any stress monitoring data or reports?
47. A. Not that I remember.
Q. Did management ever disseminate or communicate any stress monitoring data or reports to you as safety foreman?

A. Not that I can recollect.

Q. Do you recall them disseminating any safety data or reports to union employees?

A. I wouldn't be aware of that.

Q. Are you aware there was closure monitoring going on at certain portions of the mine?

A. I had seen it in certain stopes where they I think -- yeah, one of them I remember them doing some closure monitoring.

Q. Do you have any responsibility for closure monitoring?

A. No.

Q. Did you ever see any data reports regarding closure monitoring?

A. I may have, but I don't remember what they were.

Q. Was it a typical practice for you to be provided data or reports regarding closure monitoring?

A. No.

Q. To your knowledge were union employees ever or as a matter of practice provided closure data?

A. Not that I'm aware of.

Q. At the safety meetings was there ever discussion regarding rockburst risk?

A. Not -- there may have been, but I do not remember. And if it's not in a note, then no.

Q. Let's have you look at Exhibit 19 in front of you.

A. (Complying.)

Q. Do you recognize those documents?

A. Yeah. This is what we would put out prior to the next upcoming.

Q. Is this an agenda for safety meetings?

A. Yeah.

Q. Okay. If you look at the third page, appears to be an agenda for a safety meeting for a meeting scheduled Thursday, December 8, 2011 at 3:30 p.m.

A. Mm-hmm.

Q. This one's from Jeff Hunter. Do you know why he sent it out instead of you?

A. No. I don't know why he -- we share responsibilities. After Steve left, Jeff came in. Or no. After Steve left, I had another guy come in. He was there about a year. And then Jeff Hunter came into the safety department. So we share duties. Whoever did it first did it.

Q. What was Jeff's job title in December 2011?
A. That they were rehabbing the pillar?
Q. Yes.
A. Yes.
Q. And do you recall at the December 8, 2011, meeting certain representatives of the miners or miners that were involved in that rehabilitation project expressing concerns?
A. No, I don't. I can't even remember if I was there or not.
Q. Do you recall any miners ever expressing concerns about what they were observing in the --
A. During the --
Q. -- 15 --
A. During the repair? No, I do not.
Q. Remember any concerns being raised by Bruce Baraby?
A. Not to me directly. Didn't talk to me.
Q. Do you recall Bruce Baraby raising concerns to someone else that you became aware of?
A. If he did, I -- I don't know about it. Most those guys wouldn't come to me. They would go to maybe the mine foreman or mine superintendent, something like that. They...
Q. Do you remember having any discussions where concerns were expressed by Rick Valerio --
A. No, I don't.
Q. -- regarding the observations during that rehabilitation process?
A. No. 1. -- I went down. I took MSHA down there. Several times they would want to come visit it. And we would talk with the miners. And I do not remember a time in talking with the miners as they were working, you know, repairing that area that there was any -- because I was with -- I was with MSHA. He was there to find that stuff out. And we did not get anything like that, any kind of comments or concerns.
Q. You say MSHA. Who's MSHA?
A. The one inspector I can remember is Scott Amos.
Q. How many times do you recall going into the 5900 pillar with Scott Amos after the November rockburst?
A. I can remember the one -- well, when he showed up the first time and we went down, I remember that time and then one other time. And I remember us going in and they were -- they were advancing towards the area that had blown up.
Q. Okay. Do you know what work had been done at that point in time?
A. They were -- yeah, they had started at the chevron, roughly around the chevron area and were working their way towards the -- towards the area that had been damaged by the rockburst. And I can't remember how -- they weren't to that area yet, but they were maybe halfway. Something like that. That's when we walked in.
Q. The tunnel liner hadn't arrived yet?
A. No.
MR. RAMSDEN: Be sure and let him finish his question before you start your answer.
MR. ROSSMAN: Thanks.
BY MR. ROSSMAN:
Q. Had they installed any bolts or Dywidags by the time you had this visit?
A. Yeah, they were -- they were installing split sets as well as Dywidags in the back when we made that visit.
Q. When you say in the back, what are you referring to?
A. Ceiling, roof.
MR. ROSSMAN: Let's pull out an exhibit here.
(Whereupon, Deposition Exhibit No. 32 was marked for identification.)
BY MR. ROSSMAN:
Q. Show you Exhibit 32. Appear to be a map of the 5900 pillar?
A. Yeah.
Q. It identifies a liner and it says liner completed. Obviously when you -- your testimony is that when you took Mr. Amos down into the pillar that liner was not there yet, correct?
A. No. I did not go underground on the day the liner showed up.
Q. But you said when you arrived with Mr. Amos on the particular occasion that you recall they had done some work at the back of the pillar. What are you referring -- maybe you could refer me on this map to where --
MR. RAMSDEN: Object. It mischaracterizes his prior testimony. Go ahead and answer.
THE WITNESS: So in the back. So we started somewhere in here. (Indicating.)
BY MR. ROSSMAN:
Q. Okay.
A. And they were working towards the area that had been damaged. So they were somewhere in this area (indicating) prior -- they'd hadn't reached the area that had been -- they had not reached the pillar yet. But when the rockburst occurred, it had done some damage to the -- to the rock strata, I guess, from the
Q. All right. Let me try to summarize that so we have a record. When you said they started here, you're referring to a green line --
A. It was somewhere in there, yes.
Q. -- toward the bottom of the exhibit; is that correct?
A. Correct.
Q. Basically at the intersection between the substations and the pillar, correct?
A. Correct.
Q. When you refer to a chevron, there's an identifier --
MR. RAMSDEN: It's an intersection between the substations and the drift, isn't it?
MR. ROSSMAN: Right.
THE WITNESS: Correct.
MR. RAMSDEN: Not the pillar.
MR. ROSSMAN: The drift.
THE WITNESS: Yes.
BY MR. ROSSMAN:
Q. So there's a label 5900 chevron. What is that?
A. The chevron is our chilling and electrical substation cutout.
Q. And then there -- it says 5900 substations. What is that?
A. It's electrical cutout where our large subs that provide power to the level.
Q. And then there's a green line with some very small writing that I can't read. But that's where the rehabilitation efforts had begun to your recollection?
A. Pretty close to that area, yeah. I'm not going to say that was spot on. But it's got to be right in that area.
Q. And then there's some green lines drawn for a distance into the drift; is that correct?
A. That's what it appears.
Q. And how far between the green X and the pillar itself had they progressed at the time that you visited the drift?
A. Maybe halfway.
Q. So about where the green lines end?
A. Maybe somewhere in there. I'm not entirely positive on the exact footage, but...
Q. So they hadn't reached the pillar yet?
A. No.
Q. All right. Did you ever visit the drift at any time after they had rehabbed up to the pillar?
A. Yeah. Once they had -- once they had gotten done with that, then we were able to travel through it to go back into the Gold Hunter area and resume mining activity.
Q. So once they had done the ground preparation, before the liner had arrived, you visited -- or you went down through that --
A. I drove through there, yes.
Q. How many times did you drive through there at that time period?
A. I don't -- I don't know an exact number.
Maybe a couple. I don't know.
Q. Did you go down there with Mr. Amos at any time other than the one you've mentioned?
A. Not that I can remember. I do remember those two instances, the right after the rockburst when they showed up and then the one time when we went down and saw the work being done.
Q. When Mr. Amos went down with you as they were doing the rehabilitation work, did he interview any of the miners?
A. He talked to some of the miners, yeah, that were in there bolting.
Q. Do you recall who he talked to?
A. I want to say one of them -- the two that stick out to me that I believe were there were Wally Lambot (phonetic) and George Houch (phonetic). I remember those two for some reason.
Q. George Houch?
A. Mm-hmm.
Q. Yes?
A. Yes.
Q. Did you have any responsibility for dealing with safety concerns raised by union members?
A. Yes, I did.
Q. Did you have any responsibility for dealing with concerns by union members regarding stability or rockburst risk?
A. If they came to me then I would go to the appropriate person. Be it the mine superintendent -- mostly the mine superintendent is who I would go deal with.
Q. And your testimony at this point has been that you didn't have really any responsibilities with regard to rockburst management, correct?
A. Correct.
Q. Had you ever read any modeling for the 5900 drift pillar?
Q. Had you ever read any consultants' reports regarding that pillar?
A. No, I hadn't.

Q. Do you recall what the occasion was for you to review the report that Mr. Blake issued after the November burst? Why were you provided a copy of that report?
A. I don't know if it was after the first burst -- I believe it was the Wilson Blake report after -- after the fact.

Q. Do you recall the occasion for you to review the report that Mr. Blake issued after the November burst? Why were you provided a copy of that report?
A. I don't know if it was after the first burst -- I don't know if it was after the first but I -- just because he issued it to the mine to whomever got it received it first and then -- and then it passed around through many different departments.

Q. And you don't recall which report that was?
A. No, I don't.

Q. Do you recall any of the contents of that report?
A. No, I don't.

Q. Do you recall reviewing and reading the report?
A. I might have, but I don't remember.

Q. Do you recall being in any meetings or discussions with management regarding the report?
A. No, I don't.

Q. Do you recall the November rockburst?
A. Yes.

Q. What do you recall about it?
A. That it had blown up I believe on -- at or near blasting time on night shift, I believe. I believe it was night shift. And did considerable damage to the drift. And I called -- when I was notified I called MSHA. And they shut that section down. They put a (j) order on it and dispatched one of their inspectors.

They came over. And we went down and looked at it. He immediate -- well, then he modified it to a (k) order. And that's when the upper management would -- we would work with MSHA to devise a plan to rehab the area and bring it back into order.

Q. Were you involved at all in development of the rehab plan?
A. Not that I remember, no.

Q. Were you involved at all in any meetings or discussions regarding the development of the rehab plan?
A. I could have been. That was quite sometime ago and I don't ...

Q. I'm just asking if you recall.

---

Q. And you don't recall which report that was?
A. No.

Q. Do you recall the November rockburst?
A. Yes.

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A. Not that I remember, no.

Q. Were you involved at all in any meetings or discussions regarding the development of the rehab plan?
A. I could have been. That was quite sometime ago and I don't ...

Q. I'm just asking if you recall.
THE WITNESS: Okay. So your question was again?

BY MR. ROSSMAN:
Q. Where did you obtain the information from which you developed this document?
A. Through what I saw when I went down there.
The measurements are just a guesstimate because we were not allowed to go in there. And from what I know on the -- like the direct causes.
Q. Okay.
A. And then recommendations would have came from engineering or mine operations as to if they were going to add more geophones or anything like that. And the centralized blasting, I believe I mention in here, that would be a decision that, you know, somebody -- your mine ops or something -- you know, someone like that would decide maybe to look at. So we went with that.
Q. How did you first -- after you first became aware of the rockburst, what involvement did you have?
A. I was with MSHA when they arrived. I was -- 21 I dealt with them.
Q. That was after you submitted this incident report, correct?
A. No. This...
Q. Okay.

A. This incident report would have came maybe the next day or so. MSHA would have showed up first and then we would have -- this document has to be submitted -- you have ten days to fill out a 7000-1 form that says we had something happen at the mine, right.
And then after that you have to do what -- this is called a 50.11 report. You're required to do this by law. And so it would have been done after -- after we kind of saw what happened and decided what we were going to do to fix it.
Q. Do you know when this particular report was prepared?
A. Well, I would have started it on the 16th with just the basic information on the front page and then worked on it -- yeah, you can -- I worked on it the next day or two.
Q. Okay. Did you have any meetings with anyone before -- or with management before submitting -- or first notifying MSHA of the November burst?
A. I would have consulted the mine superintendent.
Q. Doug Bayer?
A. Correct.
Q. Do you recall consulting Doug Bayer?
Q. All right. And when they arrived -- as of
the time MSHA arrived, had you been down into
the pillar to observe the damage?
A. Not that I recall. I probably did. I would
guess I did, just to go down and see. Yes. I would
think I did, just because it was a pretty large event
that ...
Q. Okay. When they arrived did you go down in
the pillar with them?
A. Yes.
Q. Do you recall who showed up from MSHA?
A. I believe it was Scott Amos.
Q. Was there anyone else?
A. No.
Q. Do you recall any discussion with Scott Amos
during your observation of the pillar?
A. Not anything that jumps out at me.
Q. Okay. So if we look back at Exhibit 18,
noticing there are -- in Part B, Corrective Actions
To Prevent Reoccurrence From Incident Investigation.
Was there an incident investigation after the November
burst?
A. That's what this is right here. (Pointing.)
Q. So that's what the third page is?
A. Correct.
Q. Where did you understand that blasting to
have been performed?
A. Back the Hunter area, in the
stopes or drifts. I don't know which ones exactly.
Q. Did you have an understanding as to which
stope or drift the blasting had occurred
within seven minutes of the rockburst?
A. Most of them. That was blasting time. So
all of the stopes would --
they would come in at 4:00
o'clock in the afternoon; mine their cycle; so muck,
bolt, drill, blast. And 1:00 o'clock was the blasting
time. So any stope or drift that was ready to blast at
1:00 o'clock then shot their round.
Q. So they would all -- all the stopes would
blast at approximately the same time?
A. 1:00 o'clock.
Q. 1:00 o'clock. And do you know was there
blasting going on at each of the stopes where active
mining was being conducted?
A. I don't -- I guess I don't know how to answer
that. If we were mining the heading and they were able
to blast, they would have blasted. But I don't know
which stopes that was.
Q. And discussion with management after the
If you could read under Direct Causes in your investigation report, what did you write?

A. No. I think John added --

you added the third line down in the Action to Control Causes.

Somebody added that because it's not my writing.

MR. RAMSDEN: Object, calls for speculation.

THE WITNESS: I don't know what -- I don't -- what we talked about was, like, the use of centralized blasting, re-bolting the area, getting it fixed up, implement some kind of remote blast -- or not remote blast; that's what it says -- but centralized blasting so they would be away from the work area up in a different location when the round went off.

BY MR. ROSSMAN:

Q. If you could read under Direct Causes in your investigation report, what did you write?

A. "Blasting can and will trigger rock bursts."

Q. Did you circulate this investigation report before submitting it to MSHA?

A. Correct.

Q. Where is that at?

A. It says, "Implement remote blasting capability." That is not my handwriting.

Q. That's on the second page?

A. Correct.

Q. And that's a -- it says assigned to M. Achord and Scott Hogamier?

A. Correct.

Q. What is centralized blasting?

A. All the stopes and all the work headings would be hooked up to an electrical circuit. So you tie in your round. You tie your electric primers into your electric lead wire. That ties into an electric line that was run to your heading. And it runs all the way out to a centralized location, so be it a station, the shifter shack, something like that. And then once you come out -- if you were my supervisor, I'd come in and see you, let you know that I was out. Once all work headings, work -- all the miners were out of the work headings and it became 1:00 o'clock, or whatever blasting time might be, then the supervisor -- or depending on, I guess, where you work -- at our mine currently right now the supervisor throws the hammer, for lack of a better word, right, and all the rounds go off.

Q. And how is that different than the blasting that was occurring in November of 2011?

A. So we were using fuse primers at that time, 12-foot. I think they were 12-foot fuse primers. And you lit those with some poppers is what they're called. They're little igniters. And then you stood outside the slot of your heading or up the drift, depending. Normally somewhere near the fan. And you waited for your round to go off and then you started your fan up and then headed for the station.

Q. You indicated under Indirect Causes, "Ground speculate on."
movement will cause the build-up of pressure in the rock." What does that mean?

A. So a lot of times along faults -- if you've got two faults like this (indicating) and it slips or moves, it will cause an -- I guess an outburst or something in the opening of the -- in any opening of a mine.

Q. And did you believe that was an indirect cause of the rockburst on November 16, 2011?

A. Well, that's what I wrote down.

Q. What information did you base that indirect cause on?

A. The information that I believe I would have got from Doug, Karl, management that -- that mapped faults and stuff like that. There was a -- this rockburst, this 11/16 rockburst also did damage in the 54 ramp. And there was a fault system that ran through that ramp system. And so the correlation with the 59 main line as well as the 54 ramp would have been some kind of a fault-slip event up there that caused that intersection to see some damage.

Q. Do you recall inspecting the 54 ramp after the November burst?

A. I did go up there, yeah. I went up there with -- after which one? This one?

Q. November burst.

A. Yeah, I went up there with MSHA.

Q. And were you able to inspect or observe the fault lines at that level?

A. No, not right at that level, not where the damage occurred.

Q. Was there discussion with management before preparing this report about potential indirect or direct cause of the pillar damage at 5900 being the result of a fault-slip?

A. That information would have came out after it was looked at by the rock mechanics that Hecla uses and as well as our engineering would have deduced that.

Q. And the reason you included it on this document is that someone would have communicated to you -- management would have communicated to you -- somebody would have told me that, yeah.

Q. -- management would have communicated to you that they believed that was an indirect cause of this particular incident, correct?

MR. RAMSDEN: Object to form, foundation, speculation.

BY MR. ROSSMAN:

Q. Go ahead.

A. Correct.
1. before or after the completion of the investigation?
   2. A. I do not know.
   3. Q. Did anyone on behalf of management ever tell you prior to December 14, 2011, that they felt the November burst was a pillar burst or a foundation burst at the S900 pillar?
   4. A. They may have.
   5. Q. Do you recall anyone telling you that?
   6. A. Not specifically.
   7. Q. Do you recall a specific discussion with -- well, strike that.
   8. It says under Recommendations, "Continue to install and monitor geo-phones in areas of the mine."
   9. What are geophones?
   10. A. Listening devices that the engineering department puts out in certain locations to try to be able to pinpoint where a rockburst had occurred.
   11. Q. It says, "Look into the possibility -- under Recommendations, "Look into the possibility of using centralized blasting." Do you know whether or not the mine looked into the possibility of using centralized blasting after the November burst?
   12. A. We implemented centralized blasting, but I do not remember the date in which it was implemented. But we currently use that now.

1. Q. Do you recall whether centralized blasting was implemented before the December 14th burst?
   2. A. No.
   3. Q. That injured the plaintiffs?
   4. A. No.
   5. Q. Do you recall whether there were any efforts made to implement centralized blasting before the December 14th incident?
   6. A. So as part of the recommendation from this, Mike Achord, who was our lead electrician -- maintenance -- I don't know what you'd call him -- maintenance supervisor, started researching centralized blasting.
   7. Q. Did you ever see a report or recommendation from Mike Achord as to --
   8. A. No.
   9. Q. -- what would need to be involved in implementing centralized blasting?
   10. A. I have never seen a report.
   11. Q. And you don't recall when centralized blasting was first initiated?
   12. A. I do not know the exact date. It took a while to research and then implement. It's quite an undertaking to run that through the entire mine. And so I don't know the exact date that we put that in.

1. Q. Do you recall how long it took to actually wire the centralized blasting?
   2. A. No.
   3. Q. Were geophones installed in the mine after the November burst?
   4. A. We've installed geophones since -- since the November burst?
   5. Q. Yes.
   6. A. We've installed quite a few to date.
   7. Q. Were any installed before the December 14th burst?
   8. A. I do not know that.
   9. Q. And how did geophones help the mine in ensuring the safety of employees?
   10. MR. RAMSDEN: Object to the form, calls for a conclusion. Go ahead and answer, if you can.
   11. THE WITNESS: My understanding of a geophone is that it picks up not only blasting, the waves that move through rock during blasting, but also during a rockburst so that you can pinpoint where that rockburst hit. Because not -- not every rockburst does damage, so you may not know. If it didn't do damage in this room, where did it happen? And that's the idea beyond the geophone is to try to understand where that happened.

1. Q. Do geophones help, to your understanding, identify cracking or popping or other indications of stress buildup?
   2. A. That I don't know.
   3. Q. Then it says Conclusion, "Rock bursts can and will happen without warning. Ensuring our employees are in a safe place during blasting will aid in our goal of sending everyone home safe and sound. Continued monitoring of the working areas is a must."
   4. Where did you obtain that information?
   5. A. Well, that -- I've worked in a lot -- well, I've worked in mines that have rockburst issues. I know that they happen without warning. Been physically there when they have happened. I know from my work experience that a lot of them happen during blasting time. And so that's where I came up with this.
   6. Q. Did you have any discussion or communication with management before developing that, the Conclusion section of your report?
   7. A. No. I would have sent it to John. John would have looked at it, gave it back to me if he had any recommendations or anything that he did not like. I would have changed it and off it would have went.
   8. Q. Do you know if John asked you to make any changes after you submitted your initial report?
understand, guess, where be geophones, in geophones. Were you including stress monitoring in that statement?

A. I don't know much about stress monitoring. The only what I know of it is what we had done once -- once a quarter. A guy named Ted Williams from NIOSH would come over and him and the engineering department, a member of that, would go down and read stressmeters.

Q. Do you know whether stress monitoring was -- monitoring gauges were installed during the rehab efforts at the 5900 pillar?

A. I do know they were installed.

Q. Did you know how many monitoring gauges were installed?

A. I thought three.

Q. Did anyone tell you that additional monitoring gauges were intended to be installed?

A. No.

Q. Did you ever see the data or reports relating to that monitoring during the rehab process?

A. No, I didn't.

Q. If you'll look at page 2 of Exhibit 18, Corrective Actions To Prevent Reoccurrence From Accident (sic) Investigation. It says Action to Control Causes. The first is "rebolt affected area" and assigned to John Lund. And that's November 23rd, 20011. Do you know what that means?

A. Yeah. Fix it.

Q. Looks like this dated December 2nd, 2011, and signed by Rodney Gust. Do you know who that is?

A. I do.

Q. Did you have any dealings with Rodney during this time period?

A. Yes, I did.

Q. What dealings did you have with Rodney?

A. Rod was there -- Rod showed up for a -- a separate -- I took him, I believe -- either me or somebody, I don't remember who, would have took him down and showed him the rockburst area when he was on site.

Q. Do you recall being involved in that?

A. I may have been.

Q. Do you recall being involved in that?

A. No.

Q. Okay. This particular modification, the second paragraph says, "Three of the six stress gauges have been installed where the rock burst had occurred. At least three additional stress gauges are on order and will be installed as soon as they are received."

Q. Do you recall reading that portion of the modification?

A. I would have, yes.
Q. Did you have any involvement in the ordering of additional stress monitors?
A. No, I did not.
Q. Do you know if they were ever received by Hecla?
A. No, I don't.
Q. Do you know if they were ever installed by Hecla?
A. No, I don't.
Q. If you look at the next page, this is -- it's labeled 8605614-03. But I think that's redundant with a prior modification for some reason. It's dated December 6, 2011. Do you recall reviewing this particular modification?
A. (Witness examining document.) Yes.
Q. Did you have any responsibility for carrying out this modification?
A. Like what?
Q. Well, let's start up at the top. It specifically says, "This modification is based upon no movement of the affected area has occurred since monitoring began." Did you have any involvement in the closure monitoring during that time period?
A. No, I didn't.
Q. Did you ever see the closure monitoring data?
A. No.
Q. Do you know if that data was ever provided to MSHA?
A. It probably was, but I --
Q. I'm not asking --
A. -- I can't say for sure.
Q. -- you to speculate. Do you know whether that --
A. No.
Q. -- data was ever provided to --
A. I don't know.
Q. -- MSHA?
MR. RAMSDEN: Be sure and let him finish his question before you start your answer.
MR. CLARY: It's hard. You'll get it, Scott.
MR. ROSSMAN: Every witness I depose has the same problem. But if you can just consciously try to work with me on that.
BY MR. ROSSMAN:
Q. It says, "Stress monitors indicate the area is destressed as compared to other active areas of the mine." You were not seeing monitoring data at that point in time, correct?
A. Correct.
Q. Do you know whether that monitoring data was ever provided to MSHA?
A. I don't know.
Q. Did someone tell you that stress monitors were indicating the area was de-stressed as compared to other active areas of the mine?
A. Repeat that, please.
Q. Did anyone on behalf of management tell you that the stress monitors as of December 6, 2011, were indicating that the S900 pillar was de-stressed as compared to other active areas of the mine?
A. I don't remember.
Q. Was that your understanding at the time?
A. That's what somebody told MSHA because that's what's right here.
Q. Well, you knew employees were going down into the 5900 pillar to perform rehabilitation efforts, correct?
A. Correct.
Q. And as safety foreman one of your responsibilities is to take steps to ensure their safety while they're performing that work, correct?
A. Correct.
Q. Did you make any effort to determine whether or not there was stress buildup in that pillar during that project?
A. I may have.
Q. Do you recall doing that?
A. I could have seen -- I don't know. There were lots of people working on this over the course of a month. So someone may have mentioned it. I don't want to speculate though. So I don't -- I don't know.
Q. Did you have the understanding at the time these employees were performing that rehab project as of December 6, 2011, that the stress monitors were indicating that the pillar was de-stressed?
A. I did not hear anybody say that it was building stress. I did not hear that.
Q. So as of December 6, 2011, to your recollection nobody had told you that the pillar was building up stress?
A. Correct.
Q. If you had been informed of that, would that have been a concern for you as safety foreman?
MR. RAMSDEN: Object, speculation.
THE WITNESS: I believe it would have.
(Brief pause.)
THE WITNESS: Can we take a break?
MR. ROSSMAN: Absolutely.
(A short break was taken.)
MR. ROSSMAN: Back on the record.
1 BY MR. ROSSMAN:
2 Q. Looking back at Exhibit No. 33, specifically
3 the 03 modification -- dash 03 modification dated
4 December 6, 2011. If you look at the seventh paragraph
5 down, it says, "This modification is based upon the
6 mine has developed a written plan to address any
7 cracking or closure of the main haulage, and that the
8 mine will stop travel in the affected area should
9 detectable movement, distortion, cracking or damage
10 occur."
11 Did you understand that was a requirement of
12 the 614-03 modification?
13 MR. RAMSDEN: Object, calls for a legal
14 conclusion and a conclusion. Go ahead and answer.
15 THE WITNESS: If it was in here then it was a
16 requirement.
17 BY MR. ROSSMAN:
18 Q. And you would have read this, correct?
19 A. Correct.
20 Q. Do you recall having an understanding that if
21 there was detectable closure, cracking, movement or
22 distortion that there were certain responsibilities on
23 Hecla at that time?
24 MR. RAMSDEN: Object, calls for a legal
25 conclusion and a conclusion.

1 BY MR. ROSSMAN:
2 Q. Go ahead.
3 A. As I stated, if it was in here and we noticed
4 any of this, then we would have had to act on it.
5 Q. You understood that at the time, correct?
6 A. Correct.
7 Q. Were you involved at all in -- well, strike
8 that.
9 Did you understand as part of the
10 rehabilitation plan that certain employees were to be
11 observing or looking for indications of stress buildup
12 at the 5900 pillar?
13 A. Yes.
14 Q. Who was responsible for that?
15 A. Employees who went through the area.
16 Q. So any employee that went through the area
17 was supposed to look for indications of stress buildup?
18 A. Correct.
19 Q. Do you recall any employees informing you of
20 indications of stress buildup?
21 A. No.
22 Q. Would you have documented it if an employee
23 had communicated to you indications of stress buildup?
24 A. Probably not.
25 Q. Why not?
Let's start with Exhibit 35.

Q. Do you recognize Exhibit 35?
A. Yes.
Q. What is that document?
A. It is a contesting letter sent to Mr. Perez.
Q. Was it a responsibility of yours to issue contesting letters regarding citations issued by MSHA?
A. Normally.
Q. Let's start with Exhibit 35. There's a date at the bottom of 12/12/2011. Would that be approximately the date this was prepared?
A. Yeah.
Q. Where did you obtain the information from which you prepared this document?
A. I'm going to take a second to read it. All right?
Q. Yes.
(Significant pause.)
THE WITNESS: This would have came from my management. That's where I would have got this information.
BY MR. ROSSMAN:
Q. You say your management. Who is that?
A. My superintendent, my manager, people from the engineering department.
Q. Do you recall meeting with those individuals?
A. Not that I can remember.
Q. Do you recall being provided any documentation by those individuals?
A. Not that I remember.
Q. Did they provide you the specific language to include in this letter?
A. Yeah. And I would have -- I would have written out whatever I knew and then I'd send it to Doug and John and maybe Karl, before it went off to Mr. Perez, for their editing.
Q. Look in the middle of the first paragraph. Starts with "Stress gauges."

1 Stress models indicated the pillar was large enough to remain stable and a burst of this size would not be possible." Where did you obtain that information?
A. Doug.
Q. Did Doug show you any stress modeling?
A. No.
Q. Did you speak to any consultants that prepared any stress modeling?
A. No.
Q. Did you know what the geometric dimensions were of that pillar?
A. No.
Q. Do you know what factors the original modeling had been based on?
A. No, I did not. All that -- all that work was done prior to me even working for Hecla, so ...
Q. So that's information that would have been given to you by Doug Bayer?
A. (Nodding.)
Q. Yes?
A. Yes. Sorry. Yes.
Q. Let's look at Exhibit 34, please.
A. (Complying.)
Q. Where did you obtain the information for this letter?
A. I am going to read it. Okay?
Q. Okay.
(Brief pause.)
THE WITNESS: This would have came from my superintendent and I collaborating to send this out.
Q. You and Doug Bayer?
A. Correct.
Q. Do you recall collaborating with Doug Bayer on this particular document?
A. I believe so, yeah. We got together to discuss the reasons that we felt the citation was issued without warrant. We felt we had never had a -- through any previous rockbursting that may have happened at the Lucky Friday or the Gold Hunter, or even my time at the Galena, no citation had ever been written for a rockburst until this one.
Q. You wanted to express that to MSHA?
A. Well, most of the information came from Doug. I don't -- lot of this information in here. Most of this information came from Doug.
Q. Do you know where Doug obtained this information?
A. Doug has an extensive history in engineering in mining industry and very familiar with the Lucky Friday. Served as the chief engineer for quite sometime, so he was -- that is where.
Q. Did he tell you where he obtained this information?
A. No.
Q. Third paragraph says, "The area pillar where the rock burst occurred was designed with a 50 foot pillar of solid rock all the way around the drift."
1. A. Mm-hmm.
2. Q. It says, "Stress gauges had been installed in the pillar and measurements were taking (sic) to monitor the stress after the first burst on 11/16/2011. We saw normal stress build-up during that period and it had begun to stabilize before the burst." Where did you obtain that information?
3. A. Management.
4. Q. Management told you --
5. A. Management would have put that in here.
6. Q. So management would have provided you information regarding the stress readings from the stress gauges, correct?
7. MR. RAMSDEN: Object to the form.
8. THE WITNESS: Yeah, I -- or they just would have put this in here themselves. That would have been a modification they made.
9. BY MR. ROSSMAN:
10. Q. And you don't recall management ever showing you stress monitoring data, correct?
11. A. Correct.
12. Q. There's a reference to, "A report written by Wilson Blake, rock mechanic, stated 'While it was clear that nearby mining was no longer stressing the pillar, it was known that the pillar was still being loaded by stope closure as a result of continued mining in the Gold Hunter.'" Where did you obtain that information?
13. A. I didn't put that in here.
14. Q. Somebody else would have --
15. A. Yeah.
16. Q. -- provided it?
17. DOWN IN THE SECOND PARAGRAPH, MIDWAY THROUGH it says, "The stress gauge was working, but was reading a negative stress after it was installed. We feel the gauge was working properly after installation until the burst occurred on 12/14/2011." Do you know where you obtained that information?
18. A. Management.
19. Q. That's not something that you would have provided?
20. A. No.
21. Q. And you don't recall who specifically on behalf of management provided that information?
22. A. No.
23. Q. Do you recall ever seeing a report by Wilson Blake and Mark Board after the December 14th incident?
24. A. Yeah, I did get it after the December 14th.
25. Q. Do you recall why you received that report?
26. A. To file it. I keep all those -- it had to do with these two rockbursts, so I kept -- put it in the file with these two rockbursts.
27. Q. The file for dealing with MSHA?
28. A. Yes. Yeah. The one that would have the (j) and (k) order in it and stuff like that.
29. Q. Do you recall becoming aware of the rockburst on December 14, 2011?
30. A. I do.
31. Q. Do you recall where you were when you were made aware of that?
32. A. At my son's Christmas concert.
33. Q. Do you recall what you did after becoming aware of it?
34. A. Drove my family home and then went to the mine.
35. Q. Do you recall what was done once you arrived at the mine?
36. A. I called MSHA, the 1-800 number, reported the rockburst and got my diggers on -- diggers are work clothes you would wear underground -- and headed over to top station.
37. Q. And were there efforts to extract the miners at that point?
38. A. It was already under way.
39. Q. Had they been extracted at that point?
40. A. Some of them.
41. Q. Were you involved at all in investigating the December 14th rockburst?
42. A. Not at that time.
43. Q. Do you recall developing an understanding as to what caused that burst?
44. A. I believe some sort movement on 5300 sill pillar.
45. MR. RAMSDEN: I'll object, foundation.
46. BY MR. ROSSMAN:
47. Q. Do you recall at some point in time developing an understanding as to what caused that burst?
48. A. I believe some sort of movement on the 5300 sill pillar.
49. MR. RAMSDEN: I'll object, foundation.
50. BY MR. ROSSMAN:
51. Q. Do you know where you obtained that information?
52. A. Mine management.
53. Q. Who on behalf of mine management?
54. A. I don't remember.
55. Q. Do you recall was it written or was it
A. I don’t -- most likely verbal, I would guess.
Q. Prior to the December 14th burst had anyone
told you that the dimensions of that pillar had changed
as a result of the November burst?
A. No.

Q. Had anyone told you that the changed
dimensions compromised the stability of the pillar
after the November burst?
A. No.

Q. Do you know if management had told any of the
miners that the pillar dimensions had changed after the
November burst?
A. I don’t know.

Q. Were you involved at all in the decision to
mine the Gold Hunter vein during the rehab efforts at
the 5900 pillar?
A. To mine our normal work headings, is that
what you’re talking about?

Q. On or about December 6th the company started
mining again in the Gold Hunter vein. Did you develop
that understanding?
A. Yeah. We went back to mining after the
 initial rehab was done.

Q. Were you involved at all in the decision to
restart mining?
A. No.

Q. Did anyone communicate to you why the company
decided to restart mining?
A. No.

Q. You understood that restarting mining
involved blasting, correct?
A. Yes.

Q. And you also understood that the 5900
rehabilitation efforts had not been completed, correct?
A. Correct.

Q. Did that cause you any concern as the safety
foreman?
A. No.

Q. Why not?
A. Because the rehab had been done. The area
had been fixed. And it had -- no one was indicating
that anything was taken weight, stress and there was no
talk of that, that I was aware of. And so it, I
guess -- it was time to go back to work until -- the
tunnel liner was a little ways out.

Q. So you knew the tunnel liner had not been
installed at the 5900 pillar --
A. Correct.

Q. -- at the time mining restarted, correct?
A. Correct.

Q. And you knew that a purpose -- the purpose
for the tunnel liner was to provide stability at the
5900 level, correct?

MR. RAMSDEN: Object to the form. Calls for
speculation on the part of this witness. Go ahead and
answer.

THE WITNESS: It was stability along with the
bolts, the shotcrete, the repair work that was done.
It was all one big part of it.

BY MR. ROSSMAN:
Q. And that one big part of it had not been
completed when mining was restarted, correct?
A. Correct.

Q. And you understood that the tunnel liner was
a safety measure at that level, correct?
A. Correct.

Q. Did you have any communications with anyone
about the fact that the rehabilitation had not been
completed?
A. No. We had submitted a plan to MSHA, told
them what we were going to do. They looked at it,
okayed it, signed off on it. And we were back to
mining in the Gold Hunter.

Q. You understood MSHA had signed off on it
based upon the information provided by Hecla, correct?
A. Correct.

MR. RAMSDEN: Well, object to the form. That
assumes this witness knows why MSHA signed it -- or
signed off on it.

BY MR. ROSSMAN:
Q. You were Hecla’s primary contact with MSHA,
correct?
A. Correct.

Q. You knew when mining was restarted that
immediately additional blasting would be occurring?

MR. RAMSDEN: Object. It’s been asked and
answered.

BY MR. ROSSMAN:
Q. Correct?
A. Correct.

Q. Yet you didn’t have any concerns regarding
the safety of the miners performing the rehab at the
5900 pillar?

MR. RAMSDEN: Object. It’s been asked and
answered.
BY MR. ROSSMAN:
Q. Go ahead.
A. No.
Q. Did anyone express to you concerns about the safety of those miners?
A. No.
MR. RAMSDEN: It's been asked and answered.
BY MR. ROSSMAN:
Q. At that point in time. Go ahead.
A. No.
Q. Were you aware that Wilson Blake had recommended to Hecla that the rehab efforts proceed with caution?
A. No. I didn't see his report at that time.
Q. Had anyone told you that Hecla's consultant had recommended that they proceed with caution through the rehabilitation efforts?
A. I don't remember that.
Q. Had anyone told you that a consultant had communicated to Hecla that he did not believe that the pillar had completely de-stressed after the November burst?
A. No. I don't remember that. I knew Wilson was up there. I had seen him around the facility, but...
Q. But management never shared with you any of the contents or communications or opinions that Mr. Blake provided to it?
A. No.
Q. Did you have any involvement in the MSHA litigation over the December 14, 2011 burst?
A. I don't think so. The only thing I've --
Q. Did you have any involvement in the decision to settle with MSHA over some of the citations they had issued?
A. On the December 14th rockburst?
Q. Yes.
A. I don't believe so. I...
Q. Were you aware of the extent to which mining was being conducted at stopes 10, 11 and 14 during the rehabilitation efforts?
A. "To the extent," what do you mean by that?
Q. Did you know how much they were mining at those particular stopes?
A. Normal mining activity, I suppose.
Q. Normal mining activity meaning they were mining to same extent they were mining before the November burst, to your observation?
MR. RAMSDEN: Object to the form, foundation.
THE WITNESS: I don't know. I -- I guess I can't say with any certainty that I know exactly what they -- the rate at which they were mining. But I know that they did go back to work in those headings.
BY MR. ROSSMAN:
Q. Did anyone communicate to you that Hecla had limited in any way its mining activities during the rehabilitation efforts?
A. Well, there was no mining during the initial rehabilitation efforts. And then once we got the okay to go through the culvert and go back -- or go through the area and go back to the back end, then whatever stopes were mining prior to went back to work.
Q. Did anyone indicate to you after December 6, 2011, that Hecla was limiting in any way its mining activities until the rehabilitation efforts had been completed?
A. No, not that I remember.
Q. Do you know how many shifts the mining crews were performing at that time?
A. Two shifts a day.
Q. And at each shift there was blasting occurring, correct?
A. I would -- yeah.
Q. That's how you mine, you blast?
A. Correct.
Q. Did anyone ever tell you that the stress monitoring was revealing negative readings at one of the locations during the rehabilitation efforts?
A. Not until after the second rockburst.
Q. So someone told you that after the second rockburst, the December rockburst?
A. Yep.
Q. Who told you that?
A. It was someone out of the engineering department.
Q. Did that cause you concern when you heard that?
A. I didn't understand it.
Q. Why didn't you understand it? What part of it did you not understand?
A. I don't know really anything about the stress gauges. I didn't -- I don't know how they work. I'm not familiar with them. And I didn't understand what that meant.
Q. According to the unopposed motion to approve settlement signed by MSHA and Hecla -- and this is paragraph 17 of the unopposed motion -- respondent or Hecla had 111 violation over 345 inspection days in the 15 months prior to the issuance of citation No. 8605620 and 162 violations over 416 inspection days in the 15
months prior to the issuance of order Nos. 8559614, 8559615, 616 and 617.
Is that consistent with your understanding at the time?
MR. RAMSDEN: Object, calls for speculation on the part of this.
THE WITNESS: My understanding of what?
BY MR. ROSSMAN:
Q. Let me ask you this. You were the primary contact between Hecla and MSHA, correct?
A. Correct.
Q. Were you made aware each time that MSHA issued a citation to Hecla?
A. Yes.
Q. Were you aware that MSHA had issued 111 violations over 345 inspection days?
A. I was aware anytime they issued a citation.
Q. Were you aware that they'd issued 162 violations over 416 inspection days leading up to the citations?
MR. RAMSDEN: Same objection, foundation.
THE WITNESS: Like I said, every time they issued a citation, I knew about it.
BY MR. ROSSMAN:
Q. Did the number of citations cause you any concern as the safety foreman?
A. Yeah. That -- it was quite a few.
Q. Did you take any steps to address why this number of citations had been issued?
A. We did work to mitigate all the citations.
Q. So each time a citation was administered to Hecla, you were involved in doing work to address those citations?
A. Well, I would bring -- I would come up from underground with the inspector. He would give me the paperwork. And then I would go to most -- mine ops, because that's where most of the citations -- mine ops, mill ops, surface, I would go to whoever was in charge and tell them it needed to be fixed.
Q. Were you ever involved in any efforts to prevent -- develop a plan to prevent further citations?
A. No.
Q. Look at Exhibit 3, if you would.
A. (Complying.)
Q. You're not listed as a recipient of this e-mail. But on April 4, 2011, Wilson Blake was forwarding an e-mail to Hecla management indicating -- and the first sentence says, "There is no question that the large seismic events have really picked up over the last couple of years."
CERTIFICATE OF WITNESS

1, SCOTT HOGAMIER, being first duly sworn, deposite and say:
That I am the witness named in the foregoing deposition; that I have read said deposition and know the contents thereof; that the questions contained therein were propounded to me; and that the answers therein contained are true and correct except for any changes that I may have listed on the Change Sheet attached hereto.

DATED this ______ day of ________, 20____.

SCOTT HOGAMIER

SUBSCRIBED AND SWORN to before me this ______ day of ________, 20____.

NAME OF NOTARY PUBLIC

NOTARY PUBLIC FOR

RESIDING AT

MY COMMISSION EXPIRES

REPORTER'S CERTIFICATE

I, Patricia L. Pullo, Certified Shorthand Reporter, do hereby certify:
That the foregoing proceedings were taken before me at the time and place therein set forth, at which time any witnesses were placed under oath;
That the testimony and all objections made were recorded stenographically by me and were thereafter transcribed by me or under my direction;
That the foregoing is a true and correct record of all testimony given, to the best of my ability;
That I am not a relative or employee of any attorney or of any of the parties, nor am I financially interested in the action.

IN WITNESS WHEREOF, I have heretounto set my hand and seal this 20th day of April, 2015.

PATRICIA L. PULLO, C.S.R. #697
Notary Public
816 Sherman Avenue, Suite 7
Coeur d'Alene, ID 83814
Exhibit 16
<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Crew Name</th>
<th>Task</th>
<th>Location</th>
<th>Equipment</th>
<th>Notes</th>
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<tbody>
<tr>
<td>12/21/72</td>
<td>12 PM</td>
<td>13-15</td>
<td>North Pole</td>
<td>550-11</td>
<td>52-68</td>
<td></td>
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<tr>
<td>11/21/72</td>
<td>11 PM</td>
<td>13-15</td>
<td>Tungsten Mine</td>
<td>550-11</td>
<td>52-68</td>
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<tr>
<td>10/21/72</td>
<td>10 PM</td>
<td>13-15</td>
<td>North Pole</td>
<td>550-11</td>
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<tr>
<td>08/21/72</td>
<td>08 PM</td>
<td>13-15</td>
<td>North Pole</td>
<td>470-11</td>
<td>52-68</td>
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<tr>
<td>07/21/72</td>
<td>07 PM</td>
<td>13-15</td>
<td>Tungsten Mine</td>
<td>470-11</td>
<td>52-68</td>
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</tbody>
</table>

**PM Crew**

- Crew 13-15
- Tungsten Mine
- North Pole
<table>
<thead>
<tr>
<th>Heading</th>
<th>Crew</th>
<th>Equip</th>
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</thead>
<tbody>
<tr>
<td>5900 North</td>
<td>81 North</td>
<td>84 North</td>
</tr>
<tr>
<td>5900 South</td>
<td>81 South</td>
<td>84 South</td>
</tr>
</tbody>
</table>

90 Vein East - Muck Drill Blast - 5' Leg
80 Vein West - Muck D& Blast 5' x 6' x 6' x 10

From to chute 3 Hrs

Heading 54 & Rehab Crew Magee Miller Equip

Rehab Beltings

5950

Mainline & Branch Barbery Rehab Equip

Haul Back Liners Installed Headers - Guide wire installed

Installing Timber

Ronnel E. Barrette, et al vs Heica Mining Co., et al Docket No. 42607 DOL 781-M-A (Evt# 1159243 A) - 0037
J Angle

Date Dec 12, 2011

AM PM

Crew: L. M. AUX

Equip: 41 64

Helper: M. FRASER

550 - 11 west - muck, Bolt, D & B

Need wire cutters

550 - 11 east - muck, Bolt, D & B

610 - 12

Crew: L. M. AUX

Equip: 41 64

Helper: M. FRASER

610 - 12 west - muck, Bolt

610 - 12 east - muck, Bolt, D & B

555 - 14 west - muck, Bolt, D & B

555 - 14 east - muck, Bolt, D & B & slab north wall 4' x 2' D x 8'

Need 2 - 8' steel

620 - 15

Crew: L. M. AUX

Equip: 55 67

Helper: M. FRASER

620 - 15 west - Bolt, D & B

620 - 15 east - Pour sand (done & full)

Single heading

650 - 55

Crew: L. M. AUX

Equip: 32

Need the new map for #4 access

650 - 4 access

650 - Runaround - D & B

3308 up shop

615 - 16

Crew: L. M. AUX

Equip: 44

Helper: M. FRASER

615 - 16 west - muck, Bolt, D & B

615 - 16 east - muck, Bolt, D & B

5900 North

81 North

84 North

11 Inline

5900 South

81 South

84 South

14 Inline

Did you know we were out of fuse

Princess were me 190 and I brought a box

200
<table>
<thead>
<tr>
<th>Heading</th>
<th>Crew</th>
<th>Equip</th>
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<tbody>
<tr>
<td>550-11</td>
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<tr>
<td>11-East - Muck Bolt Drill Blast</td>
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<td></td>
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<tr>
<td>11-West - Muck Bolt Drill Blast</td>
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<tr>
<td>610-12</td>
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<td></td>
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<tr>
<td>12-East - Muck Bolt Drill Blast</td>
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<td></td>
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<tr>
<td>12-West - Muck Bolt Drill Blast</td>
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<tr>
<td>555-14</td>
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<tr>
<td>14-East - Muck Bolt Drill Blast</td>
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<tr>
<td>14-West - Muck Bolt Drill Blast</td>
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<tr>
<td>620-15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-East - Resecure 59 and 50, Repair leak - Pour 59 and 50</td>
<td>Need split set driver head</td>
<td></td>
</tr>
<tr>
<td>615-16</td>
<td></td>
<td></td>
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<tr>
<td>16-East - Muck Bolt Drill Blast</td>
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<tr>
<td>615-55</td>
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<tr>
<td>Runaround - Bolt Muck Jumbo down 3 hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4 Access - Muck &amp; Bolted (3305 Service Shop) Down</td>
<td></td>
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<tr>
<td>Load Trucks 8 hrs.</td>
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</table>

5900 North 81 North 84 North 11 Inline
5900 South 81 South 84 South 14 Inline
550-11 WEST - MUCK, BOLT, DRILL, BLAST
550-11 EAST - MUCK, BOLT, DRILL, BLAST

610-12 WEST - DRILL, BLAST - I DRIFT
610-12 EAST - DRILL, BLAST

555-34 SLOT - MUCK, BOLT, DRILL, BLAST (NEEDED TO BLAST THROUGH)
30 VEIN - 5' ROUND

620-15 WEST - DRILL, BLAST - I DRIFT
620-15 EAST - FINISH SIDE WALL - READY TO POUR GRAVE YARD NEEDS TO MAKE CHANGE OVER IN MAINLINE ON 5900 AND CHECK 4900, I THINK THAT CHANGE OVER WORKED OUT TOO.

615-16 WEST - MUCK, BOLT, DRILL, BLAST
615-16 EAST - MUCK, BOLT, DRILL, BLAST.

5900 North | 81 North | 84 North | 11 Inline
5900 South | 81 South | 84 South | 14 Inline

NEED ROCKLOC - 1 PALLET - WE'RE OUT
NEED BOLTS OIL
52-UP - 11Q AREA
<table>
<thead>
<tr>
<th>Heading</th>
<th>Crew</th>
<th>Equip</th>
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<tbody>
<tr>
<td>550-14</td>
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<td>5-3-12</td>
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<tr>
<td>610-12</td>
<td></td>
<td>6-5-41</td>
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<tr>
<td>555-14</td>
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<td>7-3-02</td>
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<td>620-15</td>
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<td>6-7-03</td>
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<tr>
<td>615-16</td>
<td></td>
<td>4-9-59</td>
</tr>
<tr>
<td>5' Rehab</td>
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<td></td>
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<td>5900 North</td>
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<td>5900 South</td>
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<tr>
<td>14 Inline</td>
<td></td>
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</tbody>
</table>

**Notes:**
- **12-West:** Muck Bolt Drill Blast
- **12-East:** Muck Bolt
- **12 West:** Muck Bolt - shot Miss Hole
- **12 East:** Muck & Bolted
- **12 East:** Pick up 3304
- **12 East:** Jumbo down 2 hrs
- **14 East:** Drill & Blast, Hoist Jack Leg 6'
- **14 West:** Drill & Blast
- **15 West:** Bolted, shot Miss Hole
- **15 East:** Building Sand Wall
- **16 West:** Muck Bolt Drill Blast
- **16 East:** Muck Bolt Drill Blast
- **16 East:** From Ore - 2 hrs
- **5' Rehab:** Crew Director, Rehab Bolt & Move Supplies
- **Move Gravel from Surface to MBay #2**
- **Move Shotcrete to 52 Ramp**
- **Haul ore from 12-15 #16**
- **Haul waste from 55 Ramp**

5900 North
81 North
81 South
84 North
84 South
14 Inline

Haul ore from 12-15 #16
Haul waste from 55 Ramp

3307 - 54 Ramp
3307 - 54 Ramp
3307 - 54 Ramp
Heading 550-11

550-11 - WEST - MUCK, BOLT, D&B

This heading was bolted with BELTED

610-12 - WEST - MUCK, D&B

610-12 - EAST - MUCK, BOLT, D&B - BOLTED SOUTH WELL WITH 6' SHOULDERS

Go to 10 store room get 41 CONES

Heading 555-34

555-34 - SLOT - WORK ON HUNG 84 SOUTH

(CHUTE IS DOWN)

Heading 620-15

620-15 - WEST - MUCK

620-15 - EAST - PREP, HANG, SECURE SANDLINE

SALVAGING PIPE FROM AROUND THE MINE TO GET ENOUGH TO FINISH MINE

Heading 615-16

615-16 - WEST - MUCK, BOLT, D&B

615-16 - EAST - MUCK, BOLT, D&B

WE MOVED MUCK FROM 12 & 16
16 STILL HAS LOTS OF MUCK AND 81S AND 84S BOTH HAVE ORE

3307 IS IN 54 RAMP AT 5900
(needs steel)

<table>
<thead>
<tr>
<th>5900 North</th>
<th>81 North</th>
<th>84 North</th>
<th>5900 South</th>
<th>81 South</th>
<th>84 South</th>
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<tbody>
<tr>
<td>8</td>
<td>11</td>
<td>14</td>
<td>11</td>
<td>14</td>
<td>11</td>
</tr>
</tbody>
</table>
11-East - Muck Bolt DB

11-West - Muck Bolt DB

(Clean up area - Hal) Supplies, Tema To Chute 3# 41

12-East - Muck DB

12-West - Muck Bolt DB

34 slot - Muck Bolt DB = Ore
(84 south - Is ore now)

355-84 - Red Paint 9.5 Hooks

15-West - Drill Blast

Muck to upper Ray

12-West - Muck Bolt DB

5750 - Installing Post - Work on Water line 4900

54 Rehab - Reasn/Steven

Rehab Bolting - Cleanup Ramps

<table>
<thead>
<tr>
<th>59000 North</th>
<th>61 North</th>
<th>84 North</th>
<th>11 Inline</th>
</tr>
</thead>
<tbody>
<tr>
<td>59000 South</td>
<td>81 South</td>
<td>84 South</td>
<td>14 Inline</td>
</tr>
</tbody>
</table>

Hauled ore from 20.9.15

Hauled Waste from 84500 L. 33 94400 L.
550-11 - West - Muck, Bolt, D & B

550-11 - East - Muck, Bolt, D & B
Loader down 2 hours

610-12 - West - Finish Bolting, D & B

610-12 - East - Muck, Bolt, Slab ore off South wall
3' D x 10' H x 12' L

555-34 - Slot - Muck, Bolt, D & B
This round will put us at the start of the stop intersection.

620-15 - Finish installing sandline on 6100
Installed dump valve & 100' of thickwall
Need to finish piping to existing stope line

650-55 - #4 Access - Muck, D & B

Runaround - Muck, Bolting
Load trucks 5 hours

615-16 - West - Muck, Bolt, D & B

615-16 - East - Muck, Bolt, D & B

5900 North
81 North
84 North
5900 South
81 South
84 South

MB #2 in mainline is cleaned out
Superviser: Pati Meaval  Date: 12-8-2011  AM/PM  Crew: C

550-11 - West: Muck Bolt, Drill Blast
550-11 - East: Muck Bolt, Drill Blast

510-12 - West: Muck Bolt
510-12 - East: Muck Bolt, Drill Blast

555-14: Bolt Drill Blast

650-55: Access - Muck Bolt
650-55: Run Around Drift, Drill Blast

615-16 - West: Muck Bolt, Drill Blast
615-16 - East: Muck Bolt, Drill Blast

Working on Sand Hole
DATE 5/15/2012         CIT/ORD No. 8559619       EVENT No. 1159243  
TIME 10:45

VIOlATION

DESCRIBE: CONDITION/PRACTICE/HAZARD/LOCATION 57.3401

- Stress were installed as part of a daily examination to monitor
  stress levels in the I-Drift Pillar while repair work was
  completed in Pillar from 11/16/12 to 11/20/12.
- The East low monitor never worked, readings were taken twice a
  day and negative readings were documented.
- Management reviewed these readings and did not withdraw
  miners from area.
- Stress meters were a precautionary fail to ensure safety of
  miners working in I-Drift Pillar.
- The installation of these monitors is part of a modification
  to 1/18/12 order from MU/16/12, and outlined in submitted plans
  provided to MSHA to show that miners had that level of protection.

GRAVITY

No Likelihood ()  Unlikely ()  Reasonably Likely ()  Highly Likely ()  Occurred (/)  
Justification: ____________________________________________________________

No Lost Workdays ()  Lost Workdays or Restricted Duty ()  Permanently Disabling ()  Fatal ()  
Justification: ____________________________________________________________

Persons affected: ________________________________________________________

NEGLIGENCE

None ()  Low ()  Moderate ()  High ()  Reckless Disregard ()

Justification: Management, Doug Bauer told us on 12/18/12 that the miners
never read stress and thought it may have been broke. These meters
were safeguarded installed to ensure the safety of miners.

Area/Equipment (Orders):

Page 1 of 4
CITATION/ORDER DOCUMENTATION

DATE ___ C1T/ORD No. 8554615 EVENT No. 1159243
TIME ___ CONTRACTOR ID No. ___

VIOLATION

DESCRIBE: CONDITION/PRACTICE/HAZARD/LOCATION

- Company was warned to proceed with caution by Holian,
  contracted consultant, Wilson Blake.
- 3 were installed for tri-level readings (it took 3)
- If working properly increased stress would of been identified
  prior to 12/14/15 kept that injured 7 miners.
- The defective sensor was the Eastlow which is same
  part of pillar that blew out

GRAVITY

No Likelihood () Unlikely () Reasonably Likely () Highly Likely () Occurred ()

Justification: 7 Miners injured.

No Lost Workdays () Lost Workdays or Restricted Duty () Permanently Disabling () Fatal ()

Justification: The extent of injured miner is still to be determined

Persons affected: 7

NEGLIGENCE

None () Low () Moderate () High () Reckless Disregard ()

Justification: was aware that the Eastlow monitor was not working
and carelessly directed miner to be work in pillar that blew out due
to stress build up.

Area/Equipment (Orders):
11 East - Muck Drill Blast
11 West - Muck Bolt Drill Blast

Tram To Pocket 3 Hrs.

Pump Water
- Work on spray chamber, clean nozzles
- Silicone Doors
- Repair Water leak (Spray Chamber Tripped twice)

Haul Supplies

5900 North
81 North
84 North
64 North

8.51
8.51
8.51
8.51

9000 South
81 South
84 South
64 South

9.51
9.51
9.51
9.51

550-11 - West, muck, slab are off south wall 8' x 11' x 3' thick

550-11 - East, muck, bolt, D&B

610-12 - West, D&B

610-12 - East, muck

555-3A - Crew: Allen, C. Hanabury, Equip # 4-3, Helper: S. Mitchell, D. Ghielmetti

555-3A - Slab two, Relaying braces, hang fencing in back in two places, looks good, after this cut, we may want to bring slab sand wall out an extra 20'

# 41 in 54 ramp

620-15 - West, muck, bolting

620-15 - East, hang secure sandline, wash walls, checked out

Store is very hot 80° water

650-56 - Ramp # 4, access D&B

Hang drisc for services

650 - 1B - Crew: A. Henning, M. Sawyer, Equip # 33, Helper: C. Sleezer

Jumbo down 3 hours

60° Water


615-16 - West, muck, bolt, (oil wrap on north wall) D&B

615-16 - East, muck, bolt, D&B

80° Chiller water

Condenser water lost over evening to 6020, probably

All day, burped the line & tank pump started pumping
Exhibit 17
At 02:25 p.m., the mine safety representative contacted MSHA to inform them that a fall of ground had occurred in two separate travelways of the mine. A verbal 103(j) order was issued by MSHA Boise f/o supervisor to withdraw miners from the affected areas.

The affected areas of the mine are hereby withdrawn from service to include the 5700 intersection on the #54 ramp from the spray chamber cut out to down ramp of the affected area (at the old day box cut out). This order also includes the 5900 main haulage which experienced substantial roof fall. The 5900 main haulage is ordered out of service from the intersection of the lateral on the 5900 level to 30 feet before the chevron which is currently taped off.

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This Order is issued to ensure the safety of any person in the mine until an examination or investigation is made to determine that the affected areas are safe. Only those persons selected from company officials, state officials, the miners' representative and other persons who are deemed by MSHA to have information relevant to the investigation may enter or remain in the affected area.

The intersection of the 5900 main haulage and lateral and the south side of the fall of ground to approximately 30 feet before the chevron.
MSHA has determined the mine operator can institute minimal repairs. This action is to modify the issued 103(j) order to a 103(k) order. This action is to modify the order to allow only those miners necessary to complete repair work to operate inside the affected area addressed by this action.

Based upon the mine operator's written plan of operation, this order is hereby modified to allow miners to conduct work including roof bolting, scaling, and removal of pipe to assess damage and clear the way for repairs. It allows limited mucking only to build bolting pads from which to conduct initial assessments of the damage up to the brow. It is based upon miners will work only under supported ground and will not begin mucking operations until all repairs up to the brow have been conducted and a representative of MSHA has reviewed the activities to ensure mucking can continue safely.

This action does not include any work being done at the 54 ramp. This action is based upon the mine's stated goals of repairing damage at the 5900 haulage to ensure needed utilities are available before conducting repair work at the 54 ramp.
Based upon bolting and scaling work conducted by the mine near the groundfall, and the report by miners that the 12 feet long roof bolts are going into solid ground, and a written plan of action submitted by the operator to MSHA addressing work to be done, this order is hereby modified.

This modification allows the operator to follow the plan submitted to scale, bolt and repair through the fall of ground at the 5900 haulage way. Only persons necessary to complete work in area are allowed to enter the affected zone previously established.

Based upon the written plan submitted to MSHA, this order is also hereby modified to allow repairs to be conducted at the 5700 sublevel of the 54 ramp. Provided only those miners necessary to complete work travel in the affected area.

The mine operator has established a set bolting, moiling, and scaling plan which involves the installation of wire mesh and a minimum of 3 inches of fibermesh style shotcrete.
This 103(k) order is hereby modified to allow the mine operator to drill the required holes and install 3 stress gauges in the 5900 main haulage where the rock burst occurred on November 16, 2011. At least three additional stress gauges are on order to install in this location as well.

The mine operator has rehab bolted the bursted area by following the Lucky Friday Mine, 5900 drift pillar rockburst repair plan. The area has been bolted with 20 foot cable bolts, 12 foot dywidags, 8 foot dywidags, and 4 & 6 foot friction bolts. The bolts secured wire mesh and then it was all coated with 3 inches of shotcrete.

At this time, the installation of the stress gauges is the only work that can be conducted in the 5900 main haulage burst area. All the areas under the original order will continue to be barricaded and remain under the order.
This 103(k) order is hereby modified to allow the mine operator to reinstall the utilities though the 5900 main drift where the rock burst had occurred.

Three of the six stress gauges have been installed where the rock burst had occurred. At least three additional stress gauges are on order and will be installed as soon as they are received. Management has been monitoring these gauges on a shift to shift basis, until NIOSH completes the build on the data collector. The data collector with take readings every two hours and the data and that data will be reviewed weekly, unless the current data dictates the readings should be evaluated on a shorter or longer basis.

At this time, the only work that can be conducted in the 5900 main haulage burst area is to re-establish the utilities through this area. All the areas under the original order will continue to be barricaded and remain under the order.
This modification is to allow limited travel through the affected area of the 5900 main haulage and of the 54 ramp at the 5700 level.

This modification is based upon no movement of the affected area has occurred since monitoring began (about four days) after shotcrete and bolting following the mine's level three bolting plan were followed. Stress monitors indicate the area is destressed as compared to other active areas of the mine.

This action is to allow very limited activities utilizing the 5900 main haulage based upon the temporary repairs already conducted by the mine until the engineered culvert arrives and more permanent repairs are made.

Upon arrival of the culvert from the manufacturer, the mine will stop work to install the culvert and only those miners working on the culvert will travel in the affected area.

This modification is based upon the mine will conduct two daily surveys at the start and end of the 1st shift to determine whether movement is occurring at the survey stations of the 5900 main haulage near the chevron.

This modification is based upon no foot travel will occur in the affected area and that each mobile equipment operator will conduct a visual inspection of the affected area before travel occurs.

This modification is based upon the mine has developed a written plan to address any cracking or closure of the main haulage, and that the mine will stop travel in the affected area should detectable movement, distortion, cracking or damage occur.

This modification is to allow further repair work at the 5700 level of the 54 ramp to include the installation of utilities through the affected area and to allow miners to conduct timber repairs at the 5700 level of the 54 ramp.

This modification is to allow backfilling of parts of the 5700 level.
intersection at the 54 ramp as to provide strain relief and to prevent miners from going into areas unnecessary to their daily work.

Any significant changes will be reported to MSHA to include additional stressing, closure, cracking or squeeze and deformity.

This modification allows approximately 3 trucks per shift to make 10 rounds each per shift. It allows mechanics/electricians to travel through the area if required to repair equipment. It allows only miners necessary to conduct normal mining activities to travel through the area.
Order #8605614 is terminated. Conditions that contributed to the accident (rock burst) have been corrected and normal mining operations can resume.
Exhibit 18
MEMORANDUM TO: John Jordan, Doug Bayer, John Lund, Karl Hartman, Eric Carlson, Zach Thomas
FROM: Wilson Blake and Mark Board, Consultants
SUBJECT: Recent Bursting in Gold Hunter and its Implications

INTRODUCTION

Mark Board’s Memo is presented first, followed by Wilson Blake’s analysis of the bursting, damage, and ground support requirements for new 5900 level access.

Introduction (Mark Board)

A tour of the eastern footwall ramp development from 5700 to 5900 levels at the Gold Hunter Mine was held on December 20, 2011. Evidence for the rockburst source mechanism was examined in the footwall as well as the damage to the 5900 pillar. The following memo describes the observations, conclusions regarding the source mechanism of the November 16 and December 14 events, and recommendations regarding the bypass drift for the 5900 footwall access and ground support for the footwall ramps and future development.

Observations

The tour group included Lucky Friday engineers and geologists, an MSHA representative, a Lucky Friday worker’s representative, and Hecla consultants Rad Langston, Wilson Blake and Mark Board. The tour began on the 4900 level Silver Shaft and progressed to the footwall and down the east footwall ramp to the 5900 footwall access drift and pillar damage zone. The repaired damage in the ramp at 5700 level was inspected initially. Here, damage from the Nov. 16 seismic event at the electrical substation cutout and 5700 14 stope access had been repaired, consisting of scaling of the excavation surfaces, rebolting with Dywidags and split sets, and erection of posts beneath the brow of the substation cutout. The posts had taken no additional load as evidenced by no observable squeeze on the wedges used to tighten the posts in place. The trace of the F3 fault, which had been painted previous to the event, could be seen to have undergone recent movement. As seen in Figure 1, the fault showed both dilation and shear movement within relatively small vertical distance. A thin crack with white rock powder was observable, as was some minor flaking of rock chips from the tunnel surface. The direction of movement was difficult to determine from the observations, although it appeared to me to be footwall movement toward the orebody.

At 5750 sub, the F3 or F4 fault showed significant dilation in the ramp (Figure 2). This fault was intersected by two bolts which showed only dilation – no shear. Little additional damage or movement on these faults was observable below about 5800 level. Thus, the primary damage zone observed on the faults was from about 5700 (most intense) to about 5800 level.
The 5900 pillar damage (Figure 3) resulting from the December 14 seismic event consisted of a rock expelled from the east rib and shoulder of the drift. Although it was not possible to get a close-up look of the damage, the ejected rock consisted of particles from fine, crushed material to perhaps a foot or so on a side. The volume of the cavity created was around 15' high by 15' deep into the wall, and about the width of the orebody. Several broken cables could be seen protruding into the cavity from the roof. This damage is different than the damage in this area that resulted from the November 16 event, which appeared to be shakedown from the roof of the drift in the orezone. The particle size from this event was large, with no evidence of rock powder or finely crushed rock. The damage zone was contained within the ore pillar, and appeared to stop abruptly in the wall rock on the footwall side. Although difficult to see from a distance, it did not appear that the bolts were heavily loaded.

![Image of fault intersections on 5700 ramp showing dilation of the fault (top) and shear movement (bottom).]
Figure 2. *F3 or F4 fault intersection with ramp at 5750 sub showing dilation along the fault in the lower rib of the ramp. No shear movement was observed as seen by the split bolt intersecting the fault plane.*
Figure 3. Damage to 5900 footwall access drift from December 14 rockburst. Damage consisted of rock expulsion from east wall and shoulder of the drift. The rock was contained by the liner which was under construction.

Rockburst Mechanism

November 16 Event

The November 16 event was located by the ESG seismic system to be in the footwall of the 5700-14 stope, above and to the east of the 5900 pillar. Damage from this event was centered in two locations: a) in the east footwall ramp at the 5700 elevation, and, b) in the back of the 5900 drift within the 5900 pillar. The actual event location appears to have been in the footwall near 5700 level, which induced shakedown damage in the 5900 pillar. This event was not located in the 5900 pillar, otherwise intense fragmentation of the rock would have occurred rather than the observed large fragment shakedown. Additionally, observations by Wilson Blake after this event indicated that the back was still stressed and working, indicating that the pillar itself had not failed and unloaded, and the event likely ejected already yielded and loosened material from the back of the drift. Observations from this site visit showed ample evidence of recent movement on the F3 and F4 faults and their splays, particularly in the area directly at and below 5700 level. A schematic of the proposed mechanism of the event is shown in Figure 4.
This event appears to be a result of shearing along the F3/F4 north-dipping fault system and their splays. The overall mechanism is driven by closure of the orebody, and the inward movement of the bedded argillitic wall rock. This closure extends to significant depth in the wall rock due to the anisotropic behavior of the thinly-bedded argillite/siltite. This wall rock displacement toward the stope causes differential displacement across the footwall faults. Since the faults are complex in topography, with splays and discontinuous nature, they do not readily slip in response to this deformation. Instead, the movement may “hang up” on discontinuous solid portions of the faults and suddenly slip when these fail in shear. This can result in the 2.5+ ML events experienced in the footwall. The fault movement will result in emission of a seismic wave from the source focus which will travel in all directions. The backfill in the stopes will retard wave transmission to the hangingwall and force wave travel down the footwall side of the stope. In this case, the wave encountered the 5700 level development, causing shakedown damage there, and the stressed 5900 pillar. Due to the interaction of the wave with the stressed nature of the pillar, the pre-yielded rock in the roof of the flat-back 5900 drift was ejected in large blocks. The resulting size of the 5900 pillar drift was significantly increased, reducing the width:height ratio of the pillar and increasing the pillar stress. The large size of the ejected blocks and the continued obvious high stress in the pillar after the event (evidenced by breakage to a solid, arching back and popping of the rock) indicate that this event occurred remotely from the pillar.

**December 14 Event**

The December 14 event appears to have occurred directly in the 5900 pillar, in the immediate east rib of the 5900 drift. Damage was finely-fragmented and crushed rock and bolts and cables appearing to be broken in tension at the drift east shoulder and rib.
This appears to be a typical strain burst mechanism resulting from the solid pillar in the wall of the 5900 drift reaching its peak strength. It appears that the causing mechanism of this event was the November 16 event:

- The November 16 event ejected rock from the 5900 drift, expanding the drift size, reducing the width:height ratio of the pillar (to around 3:1), and increasing the mining-induced stress in the pillar.
- The pillar failure was centered in the strong, non-failed core of the pillar of reduced w:h ratio, resulting in expulsion of the finely-fragmented rock into the drift.

Re-establishing Footwall Access

The 5900 pillar drift will not be rehabbed and therefore a new footwall access drive is required. There are two general choices for drift access location: a) through the orebody (and previous stope paste) on the 5900 level, either west or east of the current 5900 drift and pillar, and, b) extended to the east through the orebody abutment on the 5900 level. In our opinion, option a) – driving the access through the orebody and existing stope paste fill west of the existing 5900 pillar drift is the preferred option for the following reasons:

- The drift through the orebody will be located in a stress-shaded and relaxed zone in the hangingwall.
- The bypass drift to the west is outside the main burst zone along the Gold Hunter vein.
- The drift will be more stable under possible seismic conditions than a drift through solid abutment. The fill is not as stiff as solid rock, and has no block structure, thus is able to withstand greater seismic strain than a drift in solid. Drifts through fill in other mines (e.g., Brunswick) have proven to be stable under seismic loading.
- The drift through fill should be easier to support than a drift in hard rock. The fill can be supported using liner plate backfilled with Tekfoam or paste should perform well under static or dynamic loading. Since the liner is not fixed to rock and is backpacked with a soft and plastic material, it should easily accommodate additional closure of the stope walls.
- The immediate footwall and hangingwall contacts can be supported heavily with bolts, cables and shotcrete to provide a stable entry to the tunnel section through paste.
- Unless located far from the end of the orebody, a drift in the abutment stress zone may be in a highly-stressed zone and more prone to strain events during driving.

Figure 5 shows a photo of the current crosscut, west of the existing 5900 pillar drift. As seen, muck has been stowed into the entrance to the crosscut, but the crosscut itself is in good condition, with no apparent effects from the recent seismic events, even though the ground support is relatively light. The by-pass would presumably connect to this crosscut.
Figure 5. View of X crosscut, west of the existing 5900 pillar drift, which would be the location of a new west by-pass for the 5900 pillar drift. No seismic-related damage was visible.

Introduction (Wilson Blake)

In my Memo of 11/27/11, I concluded that the November 2.8 rockburst was a foundation failure. After the underground tour of footwall openings on December 20, 2011, it became clear that this rockburst was not a pillar burst in the 5900 pillar, but was a fault-slip event associated with closure of the of the mined out zone off of the 5900 level. This Memo will go into further details regarding the cause of this burst, its association with the December 14th burst, as well as the impact of any future bursting on the new 5900 level access drift.

November 16, 2011 2.8 Rockburst

The mine’s MP 250 microseismic monitoring system did not locate the 2.8 burst as it occurred during afternoon shift blasting. The mine’s new ESG seismic monitoring system did locate the burst in the footwall, to the east and above the 5900 pillar, as shown on figure 6. The installation and calibration of this system has not yet been completed. The location error for this burst was given as 141 ft. Because the source solution was near the pillar, the burst was initially presumed to be associated with the 5900 pillar.
Figure 6. - Location of 2.8 Burst Calculated by ESG System.

After viewing the major damage on the 5700 sublevel during the 12/20/11 mine visit, including the stope access drift being cut off, it must be concluded that the actual burst epicenter was between the 5700 sublevel and the intersection of the 5700 slot access with the 5700 14 stope. Further, the damage to the 5900 pillar now appears to be the result of the seismic shockwave traveling down in the hard, silicified, footwall zone adjacent to the fill and impacting the stressed back of this pillar. The mechanism for this burst was shown on figure 4.

The last cut of 5700 14 overhand stope was instrumented to measure both stress in the main sill pillar above and closure from the mining below. This instrumentation was to help us determine the behavior of the sill as a result of mining. The instrumentation layout and closure readings are shown on figure 7. The data indicates reduced closure between W3 to E3. It should be pointed out that the increased closure between E3 to E5 was likely due to a 2.5 magnitude burst that occurred on 2/22/10 out in the footwall from the E4 station, on a north dipping structure. This burst occurred during mining of the last overhand cut in this stope. Prior to taking planned instrument readings in September 2011, a 1.9 magnitude burst on 8/2/11 occurred in the main sill pillar some 50 ft above and some 50 ft to the west of the 5700 stope/slot access intersection. This burst damaged the back of the intersection, as well as the stope back going out both east and west. Access was lost to take any further readings, hence, the 5700 stope access drift was blocked off. The stress gage readings were inconclusive. Only gage C went up significantly, but dropped to zero when the instruments were read on the 6/8/11. The closure data appears to support the conclusion that the 2.8 burst was closure driven, as discussed previously by Board.
While it appears clear that the 2.8 burst was a fault slip event, it was not a classic double couple earthquake type shear failure. The failure zone was not likely movement along a single fault structure, such as the F3 fault, but rather shearing type movements along and across a number of structures moving toward the mined out vein. For this reason, it is not possible to use the standard earthquake equations that relate burst magnitude to a fault radius and to the fault displacement. It is also not possible to determine a point source epicenter for the burst since the fault movements took place simultaneously throughout an unknown volume of rock.
Rockburst Damage

Rockburst damage is a function of the magnitude of the burst and the distance to the mine structure or opening that is impacted by the seismic shock wave. The amount of damage to any nearby structure or opening is related to the peak particle of the shock wave as it impacts the structure. Rockburst research by CANMET in the mid 1990’s showed that for Canadian rockbursts, the peak particle velocity is related to burst magnitude by the equation:

\[ v = 4000 \times \left[ \frac{R}{(10^M/3)^{1/3}} \right]^{-1.6} \]

where,  
\( v \) = the peak particle velocity in mm/s  
\( R \) = distance from source in m  
\( M \) = rockburst magnitude.

This relationship was based on well established blasting damage criteria which uses a cube root scaling factor.

It is not straightforward to determine the distance from the burst to any structure or opening when the burst epicenter is not a point source, as is the case with the 2.8 burst on November 16th. Hence, some best guess judgment was used to determine distances to the mine structures listed below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance from Burst, m</th>
<th>Peak Particle Velocity, mm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>5900 Pillar</td>
<td>42</td>
<td>326</td>
</tr>
<tr>
<td>5700 Sublevel</td>
<td>15</td>
<td>1635</td>
</tr>
<tr>
<td>5900 Access at Lateral</td>
<td>57</td>
<td>200</td>
</tr>
<tr>
<td>Reroute 1 at vein Intersection</td>
<td>103</td>
<td>77</td>
</tr>
<tr>
<td>Reroute 2 at vein Intersection</td>
<td>34</td>
<td>458</td>
</tr>
<tr>
<td>Reroute 1 at Lateral</td>
<td>109</td>
<td>71</td>
</tr>
</tbody>
</table>

Figure 8 shows a plot of this damage criteria. It should be pointed out that the Nuttli magnitude, \( M_n \), is used by the Canadians instead of the local Richter magnitude, \( M_l \), which we use. The Nuttli magnitude corresponds to the Richter magnitude minus 0.3. Hence, our 2.8 burst would correspond to a 3.1 burst on this plot.

It was apparent from our underground visit that there was no damage observed at the intersection of the 5900 access drift and the 5900 lateral, which was subjected to a shock load of 200 mm/s. There was also no damage observed at the 5900 lateral and the intersection that would connect to Reroute 1, which was shock loaded by 71 mm/s. Figure 5 is a photo if this intersection indicating no damage of any kind from the 2.8 burst. It should also be pointed out the only damage observed to any opening along the 5900 level from the 2.8 burst was in the immediate 5900 pillar location. The back and walls beyond the pillar in either footwall or hanging wall were not damaged.

It is apparent, as previously recommended by Board, that Reroute 1 is the best location for the new 5900 bypass access from the Silver Shaft to the existing 5900 lateral. The reroute locations are shown on Figure 9.
Figure 8. – Damage Criteria from Blasting Studies and Some Observed Rockbursts Damage. (Rockburst Handbook for Ontario Hardrock Mines.)

2.2 December 14 Rockburst in 5900 Pillar

The 2.8 burst shockwave damage to the 5900 pillar reduced the size of this pillar, as well as its height to width ratio, in effect, increasing the stress in this pillar and making it more burst prone. For this reason the culvert was being installed through this pillar to provide additional resistance to possible shock loading.

From the intense damage to the east wall of the 5900 drift through the pillar it is presumed that this burst was located some 5 m from this wall. The shock loading on this wall was therefore some 4500 mm/s. The ground support required to contain damage from this burst would have to be some 27 kJ/m². With Teckfoam surrounding the culvert it was presumed that the culvert would have been deformed from the 2.2 burst, but would have remained serviceable.
Figure 9. – Reroute Options for 5900 level Bypass Drift

Ground Support Requirements for 5900 Bypass Drift

Stress conditions surrounding the 5900 bypass drift will be basically biaxial since the horizontal stress parallel to the drift is cut off by the mined out Gold Hunter vein. Hence, the vertical stress will some 8400 psi and the horizontal stress will be equal to the vertical stress, resulting in a hydrostatic stress (Based on depth to surface and previous in situ stress measurements carried out at the Lucky Friday and Cd’A District.) This stress field is very favorable for opening stability, and this bypass drift normally would not require additional ground support beyond the standard Lucky Friday drift support.

Drifting through the backfill is not really a problem, as it was routinely done along the Lucky Friday vein during mining of the 05 hanging wall vein split. Further it is routinely done at a number of Canadian mines.

However, because of the 2.8 burst, the ground support installed along the 5900 level bypass drift in the immediate vicinity of the vein will have to be reinforced to contain the effects of another burst of this magnitude occurring above this drift. It should be pointed out that the majority of all bursts induced by mining in the Gold Hunter have occurred along a well defined zone in the footwall that is located to the east of this bypass drift location. Since we cannot presume that this bypass drift near the vein intersection is in a safe location with respect to future bursting, it will have to be reinforced to contain a shock loading of 500 mm/sec. Further, for an increased factor of safety, the ground support for this bypass drift in the vicinity of the vein should be able to contain the effects of a shock load of some 1000 mm/sec.
The standard Lucky Friday ground support for the 5900 bypass drift can be installed up to and beyond the 'burst prone' zone - some 20 ft before and after the vein intersection. Within this 20 ft zone the bypass drift back and ribs should be sprayed with at least 2 inches of steel fiber reinforced shotcrete with advance, followed by the usual reinforcement of Dywidag bolts, split sets and chain link mesh. This reinforcement should be supplemented by rows of 6.5 ft SS46 split set bolts and 0 gage steel straps along the back and ribs as shown on figure 10. Further, at least 2 12 ft Dywidag bolts should replace 8 ft bolts in the back, and all the reinforcement should be carried down to the floor.

Figure 10. - Kidd Creek Drift on 7000 ft Level some 30 m from 3.8 Mn Rockburst. Note Minor Damage below Ground Support.

The paste backfill should be sprayed with shotcrete and reinforced with split sets and chain link mesh, followed by the installation of a culvert backfilled with Techfoam.

**SUMMARY**

The November 16, 2011 2.8 burst was a fault slip type burst, caused by normal wall closure being impeded by 'locked up' fault structures. This burst occurred near the 5700 sublevel close to the 14 stope access. The shockwave from this burst damaged the footwall access ramp system down to the 5800 sublevel, as well as damaging the top of the 5900 access pillar. The damage to this pillar reduced its size, as well as its width:height ratio, hence, leading to the 2.2 burst in this pillar on December 14, 2011. A culvert to provide increased resistance to shock loading was being installed through this pillar when the burst occurred.
Reroute #1 is the preferred drift to bypass the 5900 pillar and connect to the 5900 lateral and the footwall infrastructure. Because the high principal horizontal stress along the bypass is cut off by mining, the stresses surrounding this drift will basically be hydrostatic and equal to the overburden stress. In addition, the location of this bypass drift is to the west of the main zone of bursting at Gold Hunter. Hence, the usual Lucky Friday drift ground support standards will provide adequate ground support. Enhanced ground support should be utilized some 20 ft before and 20 ft beyond the intersection of the mined out vein. The paste backfill of the vein can be supported with shotcrete, split sets and chain link mesh, and supplemented by a culvert and Techfoam.
Exhibit 19
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Note: These values represent the change in stress from the baseline established after temperature stabilization on 12/2/11.
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