DISCUSSION OBJECTIVE:

To show why I think the Megaton detector is do-able at the Homestake Site.
APPROACH

Present empirical and scientific evidence for project feasibility.

Empirical = 100 yrs operating experience.
Scientific = 20 yrs rock mechanics research.
100-kiloton detector cavern

Design Basis:

1. EXPERIENCE - underground swimming pool nearby.
2. ENGINEERING - with monitoring during construction.
10 100-kiloton cavern array (M. Laurenti)

4850 Level
(plan view)
(chlorine detector)
ROSS SHAFT – HOMESTAKE MINE
VERTICAL SECTION:

Geology & Pillar Reserve
Central pillar is a 60 ft section in the center of the original 200 ft pillar (brown).
Ross Shaft pillar view using mine planning software (Homestake fold limbs in brown.)

Four point MPBX’s near Ross Shaft pillar (Hole collars on 3350 L)
Projects at the Homestake Mine

• 1983-85  *Vertical Crater Retreat (VCR)* Pillars  [US Bureau of Mines Research Contract with the University of Utah & Homestake Mine]

• 1987-90  *Cable Bolts* (bird cage, conventional)  [Cooperative UU/ USBM/ HME & GMTC]

• 1987-2003+  *Ross Shaft Pillar* study  [Cooperative UU/ USBM/ HME ]
Cable bolt drift – cleaning borehole extensometer holes.
Top sill and hole collars with stemming bags in preparation for blasting.
INSTALLATION OF BOROUGHOLE EXTENSOMETERS
MPBX’s after installation

Mechanical reading check on electrical reading
Data acquisition system

Shaft station relay

Surface station control
HOMESTAKE PROJECT EXTENSOMETER DATA

HOLE NUMBER: 8            DATE: MAY 10, 1985

TABLE 22. - Anchor regression in the elastic range

<table>
<thead>
<tr>
<th>Hole</th>
<th>Anchor</th>
<th>Slope</th>
<th>Correlation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
<td>0.409</td>
<td>0.996</td>
<td>after 6 cuts</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>0.440</td>
<td>0.990</td>
<td>after 6 cuts</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>0.540</td>
<td>0.983</td>
<td>after 4 cuts</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>0.461</td>
<td>0.969</td>
<td>after 5 cuts</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>0.303</td>
<td>0.915</td>
<td>after 6 cuts</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0.201</td>
<td>0.984</td>
<td>after 6 cuts</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>0.249</td>
<td>0.980</td>
<td>after 5 cuts</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>0.271</td>
<td>0.965</td>
<td>after 5 cuts</td>
</tr>
</tbody>
</table>

Average slope = 0.36
Standard deviation = 0.12
Coefficient of variation = 33%

\[ y = 0.02 + 0.31x \]
\[ r = 0.84 \]
How does one get to a satisfactory correlation?
APPROACH to the PROJECT

• Mine measurements for monitoring (safety) and for data to compare with model calculations.

• Laboratory testing for rock properties, elastic moduli and strengths.

• FE modeling: stress, strain, displacements.

• Model calibration against displacements and extent of yield zones (constrained by anchor loss), elastic-plastic scale factors.

• Use of calibrated model for parametric design analysis.
Laboratory Testing
Laboratory $\sigma$-$\varepsilon$ testing (anisotropic)

Figure 58. - Pooeman formation laboratory stress strain curves.

TABLE 21. - Laboratory anisotropic rock properties

<table>
<thead>
<tr>
<th>Property *</th>
<th>Homestake Formation</th>
<th>Pooeman Formation</th>
<th>Ellinon Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_1$</td>
<td>$12.8 \times 10^6$</td>
<td>$13.5 \times 10^6$</td>
<td>$13.0 \times 10^6$</td>
</tr>
<tr>
<td>$E_2$</td>
<td>$9.3 \times 10^5$</td>
<td>$7.2 \times 10^6$</td>
<td>$9.2 \times 10^6$</td>
</tr>
<tr>
<td>$E_3$</td>
<td>$9.0 \times 10^6$</td>
<td>$13.7 \times 10^6$</td>
<td>$11.0 \times 10^6$</td>
</tr>
<tr>
<td>$\nu_{12}$</td>
<td>0.14</td>
<td>0.23</td>
<td>0.20</td>
</tr>
<tr>
<td>$\nu_{23}$</td>
<td>0.18</td>
<td>0.15</td>
<td>0.17</td>
</tr>
<tr>
<td>$\nu_{31}$</td>
<td>0.19</td>
<td>0.22</td>
<td>0.15</td>
</tr>
<tr>
<td>$G_{12}$</td>
<td>$4.8 \times 10^5$</td>
<td>$3.8 \times 10^6$</td>
<td>$4.6 \times 10^6$</td>
</tr>
<tr>
<td>$G_{23}$</td>
<td>$3.9 \times 10^5$</td>
<td>$3.9 \times 10^6$</td>
<td>$4.2 \times 10^6$</td>
</tr>
<tr>
<td>$G_{31}$</td>
<td>$4.3 \times 10^5$</td>
<td>$5.6 \times 10^6$</td>
<td>$5.1 \times 10^6$</td>
</tr>
<tr>
<td>$C_1$</td>
<td>20.75</td>
<td>13.00</td>
<td>11.94</td>
</tr>
<tr>
<td>$C_2$</td>
<td>11.50</td>
<td>10.00</td>
<td>11.10</td>
</tr>
<tr>
<td>$C_3$</td>
<td>13.270</td>
<td>12.270</td>
<td>8.150</td>
</tr>
<tr>
<td>$T_1$</td>
<td>1.380</td>
<td>2.990</td>
<td>2.350</td>
</tr>
<tr>
<td>$T_9$</td>
<td>1.140</td>
<td>0.20</td>
<td>0.90</td>
</tr>
<tr>
<td>$T_3$</td>
<td>1.920</td>
<td>1.910</td>
<td>1.650</td>
</tr>
<tr>
<td>$R_3$</td>
<td>2.050</td>
<td>1.500</td>
<td>1.150</td>
</tr>
<tr>
<td>$R_2$</td>
<td>2.470</td>
<td>2.800</td>
<td>2.120</td>
</tr>
<tr>
<td>$R_3$</td>
<td>2.100</td>
<td>1.200</td>
<td>1.250</td>
</tr>
</tbody>
</table>

*1- and 3-direction are parallel to the schistosity; the 2-direction is perpendicular to the schistosity. All units are psi (except for Poisson's ratios.)
Deep, wide vein mine – well developed foliation
Local direction of anisotropy following folding of the Poorman (yellow), Homestake (pink) and Ellison (orange) formations.

Colored portion is 1350 ft wide x 1830 ft high.
In situ stress measurement summary in terms of principal stresses and directions.

**TABLE 13. - In situ stress measurements**

<table>
<thead>
<tr>
<th>Source</th>
<th>Stress*</th>
<th>Magnitude</th>
<th>Rearing</th>
<th>Dip**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond (1970) 6200 Level</td>
<td>Major</td>
<td>8,000 psi</td>
<td>--</td>
<td>vertical</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>5,200</td>
<td>N50E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Minor</td>
<td>2,900</td>
<td>N40W</td>
<td>0</td>
</tr>
<tr>
<td>Hooker (1972) 3050 Level</td>
<td>Major</td>
<td>3,051</td>
<td>--</td>
<td>vertical</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>3,687</td>
<td>N43E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Minor</td>
<td>1,845</td>
<td>N47W</td>
<td>0</td>
</tr>
<tr>
<td>6200 Level</td>
<td>Major</td>
<td>7,720</td>
<td>--</td>
<td>vertical</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>5,349</td>
<td>N30E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Minor</td>
<td>3,624</td>
<td>N60W</td>
<td>0</td>
</tr>
<tr>
<td>USBM (1984)** 7400 Level</td>
<td>Major</td>
<td>7,985</td>
<td>N83W</td>
<td>53°</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>3,411</td>
<td>N08W</td>
<td>71°</td>
</tr>
<tr>
<td></td>
<td>Minor</td>
<td>1,927</td>
<td>N61E</td>
<td>43°</td>
</tr>
</tbody>
</table>

**Vein Stresses**

<table>
<thead>
<tr>
<th>Source</th>
<th>Dip</th>
<th>Strike Direction</th>
<th>Vertical</th>
<th>Vertical Shear</th>
<th>Vein Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hooker (3050 L)</td>
<td>N43E</td>
<td>N47W</td>
<td>1,845 psi</td>
<td>3,051 psi</td>
<td>0/0</td>
</tr>
<tr>
<td>(6200 L)</td>
<td>N30E</td>
<td>N60W</td>
<td>3,624</td>
<td>7,720</td>
<td>0/0</td>
</tr>
<tr>
<td>Bond (6200 L)</td>
<td>N50E</td>
<td>N40W</td>
<td>2,900</td>
<td>8,000</td>
<td>0/0</td>
</tr>
<tr>
<td>USBM (7400 L)</td>
<td>N45E</td>
<td>N45W</td>
<td>4,220</td>
<td>4,237</td>
<td>1925/2064</td>
</tr>
</tbody>
</table>

* compression positive down positive

**Notes:**
- Principal stresses and direction
- Dip and Rearing indicate the orientation of the principal stress axes
- Vein Stresses include direction, magnitude, and shear values
Stress Measurement

HI-cells
Figure 62. - Homestake Mine study stope region, geometry and geology in vertical section looking north.
OVERALL 3D VIEW OF MESH

LEGEND
EF Ellison Formation
HF Homestake Formation
PF Poorman Formation

Depth ~ 750 m

Scale, m
0 75 150

Shaft axis

730 m
8 m
488 m
849 m
46 m
Finite element excavation sequence (seven cuts shown).
INSTRUMENTATION and MINE MEASUREMENTS of DISPLACEMENTS
Main Conclusion

With adequate site investigation, large caverns can be reliably engineered and excavated at Homestake.
“site investigation”

• Exploration drill holes for geology and geologic structure (mapping).

• Drill core for laboratory testing to determine rock properties (moduli, strengths).

• In situ stress measurements.
Suggestion: Start “small” with a pilot-scale excavation.

• To confirm site exploration data.

• To allow for monitoring with MPBX’s, etc.

• To allow for FE model calibration leading to full-scale design.
Ross Shaft pillar view using mine planning software (Homestake fold limbs in brown.)

Four point MPBX’s near Ross Shaft pillar (Hole collars on 3350 L)
Ext 8: Displacement
Ross Pillar
3350 Level

First Reading Date: 6/24/94
DAY’S END (June, 1994)

Mike Stahl, Chief Rock Mech. E.
Bob King, SRL Tech.
Brett Pariseau
Mel Poad, SRL Mgr.
NUSL offers unique opportunities in a variety of disciplines – controlled experiments on an exceptionally large rock mass – over 350 miles of “tunnels” for access and instrumentation.

Rock mass scale (whole mine experiments)  \(-10^3\) m
Stope, cavity scale \(-10^2\) m
Tunnel, shaft scale \(-10^1\) m
Borehole, “laboratory” scale \(-10^{-1}\) m
Grain, sub-lab scale \(-10^{-3}\) m

CONNECTIONS, RELATIONS, INTERACTIONS, INFORMATION EXCHANGE BTWN SCALES?
THIS IS THE PLACE!

HOMESTAKE GOLD MINE
THE AMERICAS' LARGEST
SURFACE TOURS
MAY THRU OCTOBER
600 FT. AHEAD
Thank you!