Narrow Vein Mining Methods and Geologic Grade-Control on the JM-Reef Pd/Pt Deposit

Sarah Jensen
Pd/Pt (3.4:1) are our primary target elements, hosted as sulfide mineralization.

Byproducts: rhodium, copper, nickel, gold, silver
SMC is the only U.S. producer of PGMs and the largest primary producer outside of South Africa and the Russian Federation.
Comparative PGM Ore Grades

The J-M Reef is by far the highest grade PGM deposit of any known in the world!

34g/ton ~ 1oz/ton
Stillwater Complex Emplacement

The 2.7 by differentiated stratiform mafic to ultramafic intrusive igneous body was emplaced 6-9 miles under sedimentary rocks, resulting in a sub-horizontal inward-dipping cumulate layered lopolith.
The ore zone is a very thin layer within a thick package of rocks.
Original Stillwater Complex

- 2.7 Billion-Year-Old Intrusion
- Layering Develops Through Slow Cooling, Crystallization, and Other Processes
- Complex Subsequently Tilted and Eroded to Present Surface
7500W Cross Section

SSW

Sedimentary Rocks

Sioux Charly Fault

6.4 km
4 miles

Main Beartooth Fault

South Prairie Fault

Metamorphic Rocks

Feeder

NNE
West of Reed Point
I90
Stillwater Complex Mining History

**Nickel/Copper deposits**

About 1883 by Skookum Joe Anderson, but may have been as early as 1860’s

**Chromite deposits**

About 1890, with first test mining at Little Rocky Creek (Benbow) by T.C. Benbow in 1905

**Palladium/Platinum deposits**

Pt/Pd-bearing minerals in 1936, but J-M Reef economically mineable layer in 1973 by Johns-Manville
Benbow Chromite Mine Present Day
Moat Mine: Present Day
Lake Camp at the Mouat Mine
Lake Camp Present Day
J-M Reef Mineralogy

Major Minerals
- Plagioclase feldspar (bytownite)
- Orthopyroxene (bronzite)
- Clinopyroxene (augite)
- Olivine (chrysolite serpentinized with magnetite)

Minor Minerals
- Sulfides: chalcopyrite pentlandite pyrrhotite
  Associated Pd/Pt sulfides: braggite cooperite vysotskite moncheite
- Phlogopite
- Chromite
<table>
<thead>
<tr>
<th>Pd Source</th>
<th>Pt Source</th>
<th>Mineral</th>
<th>Formula</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>-</td>
<td>Pentlandite</td>
<td>(Fe, Ni)$_9$ S$_8$</td>
<td>¾ of the Palladium is in solid solution with Pentlandite</td>
</tr>
<tr>
<td>15%</td>
<td>-</td>
<td>Vysotskite</td>
<td>(Pd, Ni, Pt) S</td>
<td>2/3 of the Platinum and some of the Palladium is hosted as sulfides</td>
</tr>
<tr>
<td>65%</td>
<td>-</td>
<td>Braggite</td>
<td>(Pt, Pd, Ni) S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooperite</td>
<td>(Pt, Pd, Ni) S</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>25%</td>
<td>Isoferroplatinum</td>
<td>PtFe$_3$</td>
<td>¼ of the Platinum is in a metallic alloy</td>
</tr>
<tr>
<td>5%</td>
<td>10%</td>
<td>Moncheite</td>
<td>(Pt, Pd) (Te, Bi)$_2$</td>
<td>Some Platinum and Palladium are hosted as Telluride</td>
</tr>
</tbody>
</table>
PGMs in base-metal pathfinder sulfides
Diamond Drilling, Definition of the Ore

Performed at 50’ centers along the FWL

J-M Reef

300’ vertical spacing

Looking NW

Extensive Diamond Drilling!
Longsection View & Related Mining Widths

- ~45 Degree Dipping Contact: 8’
- ~60 Degree Dipping Contact: 6.5’
- ~90 Degree Dipping Contact: 6.5’
Ramp and Fill: Overhand & Underhand
Underhand Ramp and Fill: cross section
Jumbo Single Boom Drill

For ramp and fill & access tunnels
Captive Stope – Ladder Access
Captive Stope – Alimak Access
Jackleg: For drilling narrow headings & bolting
Sub-level Mining
Sub-level - Pillar Extraction

Sand Backfilled Floors

Crown Pillar
Ore Body and Drill Holes

Pillar Pull Backstope
Looking Northwest

Uphole Drill

Access Ramp

Inverse Raise

Overhand Ramp & Fill
Sub-level Longhole Drilling
SMC has utilized geologic grade-control since continuous production commenced in October 1985
Geology Grade-Control Mark up

- Keep mining on reef and in ore
- Maximize ounce production
- Minimize dilution & deletion
- Advise production & engineering on stope planning and geologic issues
- Communicate with the production department to ensure accurate muck handling
- Increase Proven Reserve
- Provide ore width information for contracts
Lower Off- Shaft: 23W7000

Hanging Wall Contact

Mineralized Zones

"Lower Off- Shaft"
Thin Ore Widths - 0 - 10'
High Grade - 0.5 - 4.0 opt
Magmatically Undisturbed

Stillwater Mining Company
2562 Nye Road
Nye, MT 59061

TITLE: 23W7000
Floor 2
Overlay Floor 1
DRAWN BY: SCALE: 1"=20'
APPROVE: NUMBER:
DATE: 03/18/2011
FILE:\Documents and Settings\籍者\
Upper Offshaft: 35W11000

“Upper Offshaft”
Wide Ore Widths - 0 - 100’
High Grade - 0.5 - 7.0 opt
Structurally Disturbed

Hanging Wall Contact

Mineralized Zones

“JM Reef”

TAZ Zone 1

GN Zone 1
Upper West: 50W18000A3

“Upper West”
Wide Ore Widths - 0 - 40’
Low Grade - 0.3 - 1.0 opt
Magmatically Disturbed
Dilution and Deletion at the Face

Dip
- Offshaft = 60° N
- Upperwest = 45° N
- East Side = 70° S

Cuts are ~ 10’ High
Ballrooms

40W4300/40W4800 Stope
Center Ballroom as Viewed From Above Looking Northeast
Approximate Vertical Scale: 1 inch = 20 Feet
From 1 Ton of Ore:
40 lb (2%) is concentrated, producing ½ ounce of PGM

1 TON OF ORE
mined and sent to the mill

= ½ OUNCE of PGM
(½ of this coin)