MERCURY ON THE KUSKOKWIM
OLD AND NEW
Outline

- Kuskokwim Region
- Red Devil historic mercury mine
- Donlin proposed gold mine
Kuskokwim region
Red Devil and Donlin are on the Kuskokwim River in the Mineral Belt.
Both are located between two major faults.
Deposits of the central Kuskokwim Mineral Belt

- Epizonal Hg-Sb and Au
- Precious metal-bearing intrusion related

Map: Miller 2008
Epizonal Hg-Sb deposits – Red Devil

Cinnabar (HgS)
Stibnite (Sb$_2$S$_3$)
Realgar (As$_4$S$_4$)
Orpiment (As$_2$Se)
Pyrite (FeS$_2$)

Map: Miller 2008; Photos: McCrum 2011
Epizonal Au-bearing deposits - Donlin

Map and photos: Miller 2008
Red Devil site history

- Underground and surface mining
- Cinnabar processed in retorts, 1933-1971
- 2.7 million pounds of mercury
- Retort water, chemicals and tailings flowed into Kuskokwim

Photos: McCrum 2011
Remediation has occurred sporadically for 25 years, costing $10 million to date.
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- **1987 ID**
- **2001 - 2006 Demolition**
- Spread 50,000 yd³ of contaminated soil
- **2005 - 2009**
- **2010**
- **2012**
- **RI/FS**
- **Draft RI**

- Tailings with elevated levels of antimony, arsenic, and mercury were used throughout the site as fill. Tailings were placed in the monofill from unidentified areas around the site without sampling the soil left in place or assessing the remaining risk posed by residual contamination. Additional tailings piles are spread throughout the site, including Red Devil Creek, but their locations have not been documented or characterized.

- The heavily contaminated settling ponds have not been characterized or addressed but continue to leach contamination to the groundwater. DEC and EPA monitoring wells was 515 ug/L arsenic (compared to the state standard of 10), 1250 ug/L antimony (state standard is 6), and 49 ug/L mercury (state standard is 2).
Red Devil remediation

- Remediation has occurred sporadically for 25 years, costing $10 million to date.

- 1987 ID
- 2001 - 2006 Demolition
- Spread 50,000 yd³ of contaminated soil
- 2005 - 2009 fuels
- 2010 fish tissue
- Begin RI/FS
- 2012 draft RI
- DEC and EPA want NPL listing

In 2002, BLM submitted a plan to DEC to place building debris and other solid waste into two buried landfills on the site. One of the “monofills” would contain all of the hazardous waste from the site. The monofills did not comply with State Solid Waste guidelines for buried landfills and were partially placed on top of the most highly contaminated areas without addressing the contamination first. Due to these and other technical reasons, DEC did not concur with this action, however BLM conducted the work over DEC objections. Work that summer had not been characterized or addressed but continue to leach contamination to the groundwater.

DEC and EPA monitoring wells was 515 ug/L arsenic (compared to the state standard of 10), 1250 ug/L antimony (state standard is 6), and 49 ug/L mercury (state standard is 2).
Remedial Investigation

Contaminant Concentrations (mg/kg)

- Mercury
- Arsenic
- Antimony

Main Processing Area, Red Devil Delta, Surface Mine Area, Dolly Sluice Delta

McCrum 2011
Remedial Investigation

Contaminant Concentrations (mg/kg)

<table>
<thead>
<tr>
<th>Arsenic (mg/kg)</th>
<th>Mercury (mg/kg)</th>
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<tr>
<td>21</td>
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<tr>
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<tr>
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<tr>
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<tr>
<td>60</td>
<td>2</td>
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<td>1790</td>
<td>56</td>
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<td>15</td>
<td>0.1</td>
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McCrum 2011

sediment

Mercury Arsenic Antimony
Remedial Investigation

**Surface water**

DEC standard is 50-2,000 ng/L

Methyl Mercury (ng/L)

McCrum 2011
Two Alaska Native corporations own the land around the old mine site and want to develop it. BLM won’t transfer the 10 acres of the mine site until remediation is complete, but cleanup has been slowed by disputes with EPA.

- The BLM and EPA agree that the Site poses serious threats - including to Alaska Native communities.
- BLM does not want EPA to have final authority on the cleanup.

The Bureau of Land Management recommends that people NOT ENTER OR USE the Red Devil Mine site for any purpose, including subsistence activities.
Processing Gold

Rock with gold, sulfide, carbonate, and trace metals

Create high surface area

Neutralize

Get rid of sulfides, dissolve carbonates

Sulfide concentrate

Dissolve gold

Recover gold

$
Processing Waste

“A mine is a waste treatment facility with a little bit of gold at the end”

Arsenic
Manganese
Mercury

Capture

HazMat Waste

Tailings Storage

2012 Feasibility Study Section 1.18, 13.1
Operating a mine

tailings
(finely ground ore, process chemicals)

Mill – ore processing

Pit

waste rock

Arsenic, Antimony, Selenium, Moly, Manganese, Mercury Cyanide, Sulfate

Tailings Storage

Arsenic Antimony Selenium Sulfate

Waste Rock
Operation: Tailings storage facility

- **Processing plant waste** slurry goes to the TSF
  - “Tailings water...will contain elevated levels ..... of As, Hg, Mn, Mo, Se, and Sb...and could be elevated in sulfate >10g/L”;
  - “The capacity of the (carbon in leach) circuit to completely adsorb the mercury is limited and ...soluble mercury remains in the tails solution”. 2012 FS Section 1.14; Section 13.1.11

- **Waste Rock leachate** also goes to TSF
  - Arsenic, antimony, selenium, sulfate
Closure: Pit Lake repository

- **Tailings Pond** will be drained into Pit Lake
  - Tailings water will drain to pit lake over 52+ years
  - Reclaim and contour, leaving a small lake with vegetation around it. Cover will take 5 years.
  - Runoff water quality is to meet WQS within 5 years.

- **Waste Rock** leachate will drain into Pit Lake
  - Cover and route runoff to Pit Lake
“Advances in treatment technologies for dealing with post-closure water discharge should continue to be monitored, specifically with regard to selenium, arsenic, sulphate, and emerging passive treatment technologies.” 2012 FS Section 26.9
Is mercury an issue?

- The ore at Donlin has 1-3 mg/kg mercury
  - Pathway: fugitive emissions from waste rock and tailings
- The mercury vaporizes during processing
  - Pathway: worker risk, fugitive emissions
- Barrick is the world leader in capturing mercury from gold processing; storage as liquid Hg and calomel
  - Pathway: storage and transport accidents
- Mercury will be in tailings, kept mobile by cyanide
  - Leaks in tailings, groundwater pathways from pit lake
How much mercury?

- Captured:
  - In an in-region meeting on March 12, 2009, Donlin said they expect to capture 30-50 kg of mercury per day in their processing plant treatment system.
    
    ~12-20 tons per year

- It’s not clear how much of that would report to tailings and how much would be captured in liquid form for transport off-site
Mercury storage and transport

- DOE issued interim guidance on Packaging, Transportation, Receipt, Management, and Long-Term Storage of Elemental Mercury in November 2009

Several layers of protection have been added inside the drums: (1) The drums are lined with an epoxy-phenolic coating; (2) a cushioning material is located in the bottom of each drum; (3) the flasks are separated by a cardboard divider for additional cushioning; (4) the contents are sealed in a thick plastic bag; and (5) each drum lid is equipped with a half-inch rubber gasket and a steel-locking ring that is bolted to seal the drum. The drums are very secure and both airtight and liquid-tight.

HWAD Mercury Consolidation Project, Joint Munitions Command, July 2010
Chemical impacts on fish

- **Mercury**
  - Reduced reproduction, neurological effects in fish
  - Risk to pregnant women eating fish

- **Selenium**
  - Physical deformities, reduced survival, death in fish and waterfowl. Reproductive failure & population collapse.
  - Bioaccumulates & biomagnifies in aquatic food chains
  - Controversy over selenium thresholds; imperfectly understood, interacts w/ Hg

- **Arsenic**
  - Sublethal -- Reduced growth/hatch, avoidance
  - Acute – suffocation (increased mucus production)

References:
Northern Pike Locations with Mercury Gradient and Mineral Deposits

KEY
- Pike Sample Locations
- Total Pike Mercury (PPM)
  - 0.0000-0.21000
  - 0.21000-0.39000
  - 0.39000-0.60500
  - 0.60500-0.85600
  - 0.85600-1.35670
- Mercury Concentration Gradient (PPM)
  - High: 72.9377
  - Low: -0.02
- Mineral occurrences, prospects, or mines containing Hg, cinnabar or associated elements
- Major Rivers
- Lakes

Gulf of Alaska
Canada
Russia
Arctic Ocean

Department of the Interior
United States Geological Survey
Physical Science Technician: Dennis Frohbieter
Map Datum: GRS 80 North American Datum 1983
Map Projection: Alaska Albers Equal Conic

Frohbieter 2009
Frohbieter 2009

Mercury Levels in Northern Pike in Relation to Wetlands
Can Red Devil studies provide us with risk info for Donlin?

- Fish sampling locations in relation to Red Devil and Donlin
Primary reference material


- **Pike**: Frohbieter, D. 2009. Mercury in northern pike: changes due to climate, and health impacts on Native Alaskans. USGS.

- **General mine information**: GroundTruthTrekking
  http://www.groundtruthtrekking.org
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QUESTIONS?

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