FERROMANGANESE CRUST MINING DEVELOPMENT SCENARIO
PRIMARY DISCUSSION ITEMS

• PURPOSES OF SCENARIO

• SOURCE & LIMITATIONS

• CHARACTERIZATION OF DEPOSITS

• SEAFLOOR MINING SYSTEM & SUBSTRATE COLLECTION
ALSO IN SCENARIO

- LIFT & BUFFER SYSTEMS
- AT-SEA BENEFICIATION
- TRANSPORTATION
- METALLURGICAL PROCESSING
- HAZARDOUS MATERIALS
PURPOSES OF SCENARIO

- IDENTIFY KEY DEVELOPMENT ISSUES
- PROVIDE BASELINE FOR IMPACT ANALYSIS & POLICY DEVELOPMENT
SCENARIO SOURCE & LIMITATIONS

• **SOURCE**
  
  “PROPOSED MARINE MINERAL LEASE SALE: EXCLUSIVE ECONOMIC ZONE ADJACENT TO HAWAII AND JOHNSTON ISLAND”

  A Joint Effort of the U.S. Department of the Interior Minerals Management Service and the State of Hawaii

• **LIMITATIONS**
  
  - PUBLISHED IN 1990
  - DRAFTED FOR U.S. OCS REGULATION
  - SITE SPECIFIC TO HI & JOHNSTON IS
## DEPOSIT CHARACTERIZATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Expected Range</th>
<th>Scenario Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Crust Thickness</td>
<td>&lt; 1 – 15 cm</td>
<td>3.5 cm</td>
</tr>
<tr>
<td>Crust Specific Gravity</td>
<td>1.95 (wet)</td>
<td>1.95 (wet)</td>
</tr>
<tr>
<td>Co</td>
<td>0.8 – 1.1%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Ni</td>
<td>0.4 – 0.6%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Mn</td>
<td>20 – 25%</td>
<td>22%</td>
</tr>
<tr>
<td>Pt</td>
<td>0.4 grams/ton</td>
<td>0.4 grams/ton</td>
</tr>
<tr>
<td>Seamount Slope</td>
<td>5 – 20°</td>
<td>10°</td>
</tr>
<tr>
<td>Crust Coverage</td>
<td>60 – 90%</td>
<td>75%</td>
</tr>
<tr>
<td>Water Depth</td>
<td>800 – 2,400 m</td>
<td>800 – 2,400 m</td>
</tr>
<tr>
<td>Recovery Percentage</td>
<td>50 – 70%</td>
<td>70%</td>
</tr>
<tr>
<td>Production (dry t/yr)</td>
<td>550,000 – 1,000,000</td>
<td>700,000</td>
</tr>
</tbody>
</table>
MINING SYSTEM COMPONENTS

SUPPORT VESSEL

LIFT PIPE

DUMP VALVE/BUFFER

PICK-UP MECHANISM
MAJOR SPECIFICATIONS

Length: 13 m
Width: 8 m
Height: 6 m
Weight: 100 t
Installed Power: 900 KW

PICK-UP SYSTEM

Separator
Lift Pipe
Diffusers
Power Tracks
Hydraulic Dredge Heads
Cutter Heads

MANGANESE CRUST MINER (HALKYARD 1987)
SYSTEM DOWN TIME

- CUTTER-HEAD REPLACEMENT
- OTHER MECHANICAL FIXES
- 10% WEATHER
- 10% DRY DOCK, ETC.

→ MAX. WORKING DAYS: 245
→ 206 DAYS ASSUMED FOR SCENARIO
MATERIAL FLOWS

MILLION METRIC TONS PER YEAR (206 DAYS)

Crust 1.62 1.53 1.04 1.04 1.02 0.91
Substrate 0.54 0.51 0.25 0.25 0.25 0.02

DEPOSITS → FRAGMENTATION → PICK-UP → SEPARATION → LIFT → DEWATERING → BENEFICIATION
SUBSTRATE ENTRAINMENT

\[
E = \frac{h-(m-t)}{t}
\]

\[
P = \frac{t}{h-(m-t)}
\]

m = mean seafloor elevation
h = seafloor elevation
t = mean crust thickness

Recovery Efficiency: \( E \)
Crust Purity: \( P \)

\( E = 0 \) \( P \) undefined
\( E = \frac{[h-(m-t)]}{t} \) \( P = 1 \)
\( E = 1 \) \( P = \frac{t}{[h-(m-t)]} \)
## MINING SIMULATION: CROSS SEAMOUNT

<table>
<thead>
<tr>
<th>RMS Roughness (cm)</th>
<th>Recovery Efficiency (%)</th>
<th>Crust Purity (% crust)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 cm</td>
<td>50 cm</td>
</tr>
<tr>
<td>8</td>
<td>76</td>
<td>63</td>
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<td>9</td>
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<td>43</td>
<td>65</td>
<td>56</td>
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</tbody>
</table>

Crust Thickness: 4 cm
Recovery Efficiency vs. Roughness

Normally Distributed Topography

Recovery Efficiency (E)

RMS Roughness (cm)
(crust thickness: 2-10 cm)
KEY CONCLUSIONS

• SIZE OF OPERATION WOULD IMPACT RELATIVELY SMALL AREA

• PRODUCTION SIGNIFICANT % OF WORLD PRODUCTION

• INCORPORATION OF SUBSTRATE KEY ISSUE