FERROMANGANESE CRUST MINING DEVELOPMENT SCENARIO

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International Seabed Authority
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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

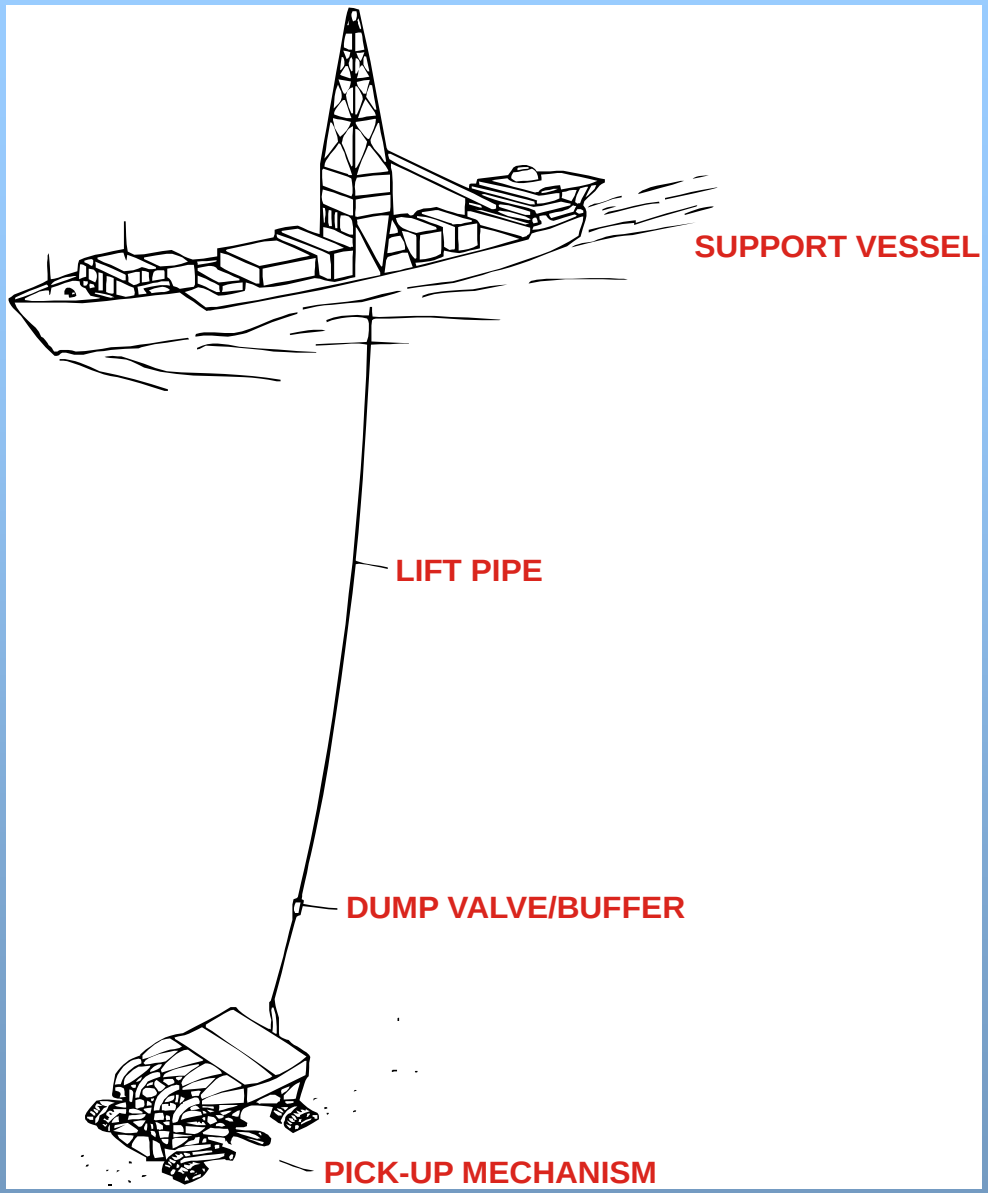
- **LIMITATIONS**

  - PUBLISHED IN 1990
  - DRAFTED FOR U.S. OCS REGULATION
  - SITE SPECIFIC TO HI & JOHNSTON IS

DEPOSIT CHARACTERIZATION

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

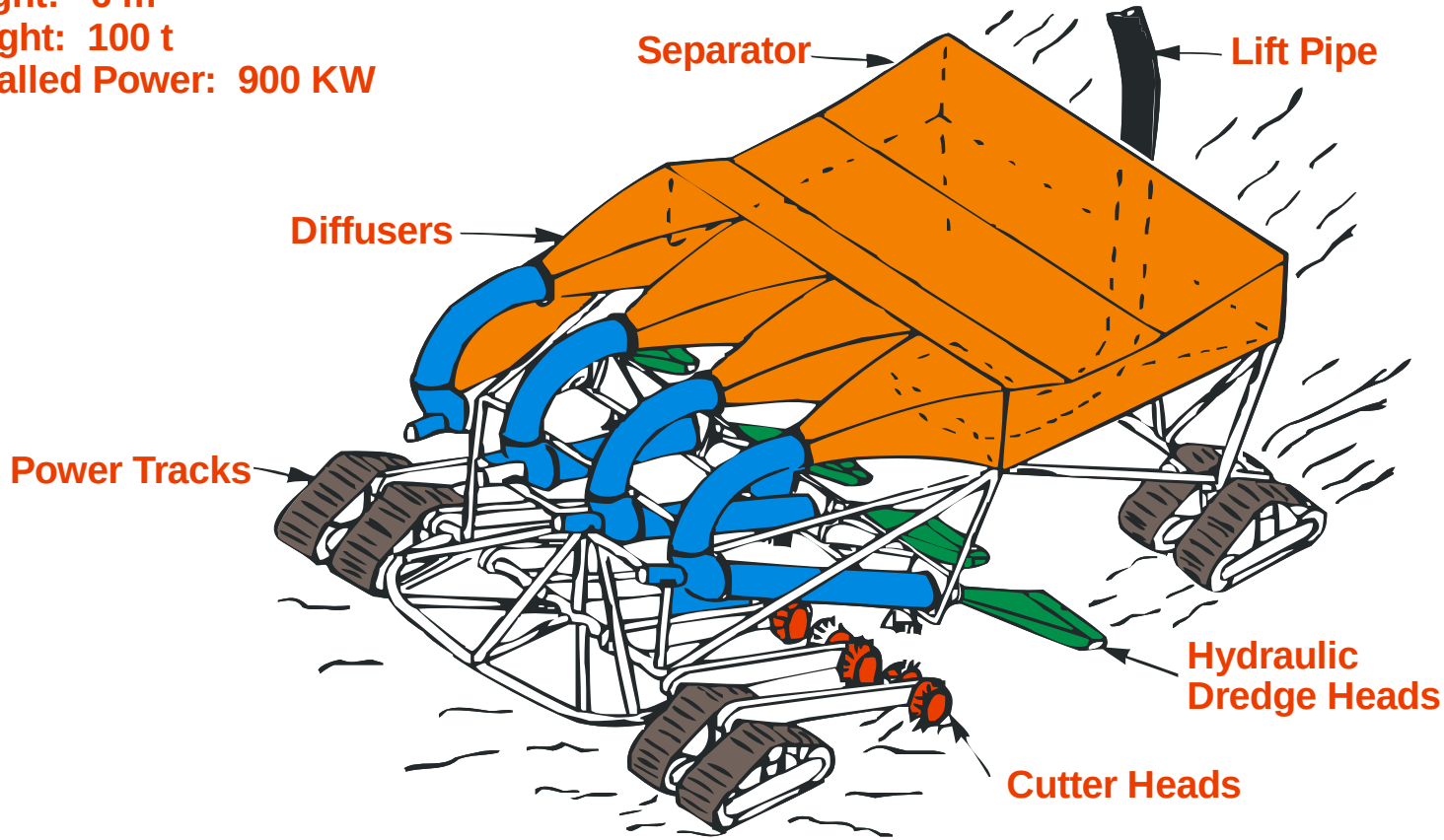
MINING SYSTEM COMPONENTS



MAJOR SPECIFICATIONS

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

PICK-UP SYSTEM



MANGANESE CRUST MINER (HALKYARD 1987)

SYSTEM DOWN TIME

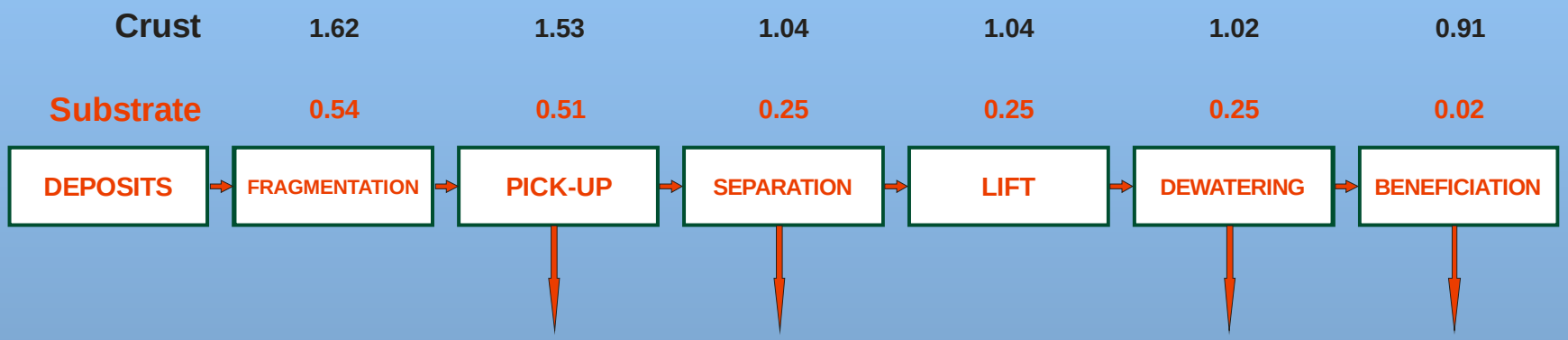
- CUTTER-HEAD REPLACEMENT
- OTHER MECHANICAL FIXES
- 10% WEATHER
- 10% DRY DOCK, ETC.

➔MAX. WORKING DAYS: 245

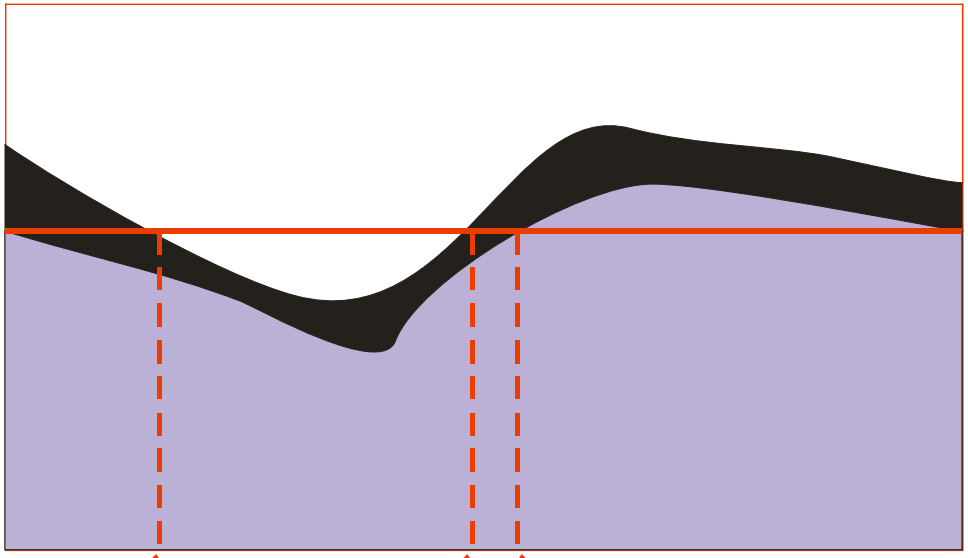
➔206 DAYS ASSUMED FOR SCENARIO

MATERIAL FLOWS

MILLION METRIC TONS PER YEAR (206 DAYS)



SUBSTRATE ENTRAINMENT



Cutting Surface (m - t)

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

Recovery Efficiency: E	E = 0	E = [h-(m-t)]/t	E = 1
Crust Purity: P	P undefined	P = 1	P = t/[h-(m-t)]

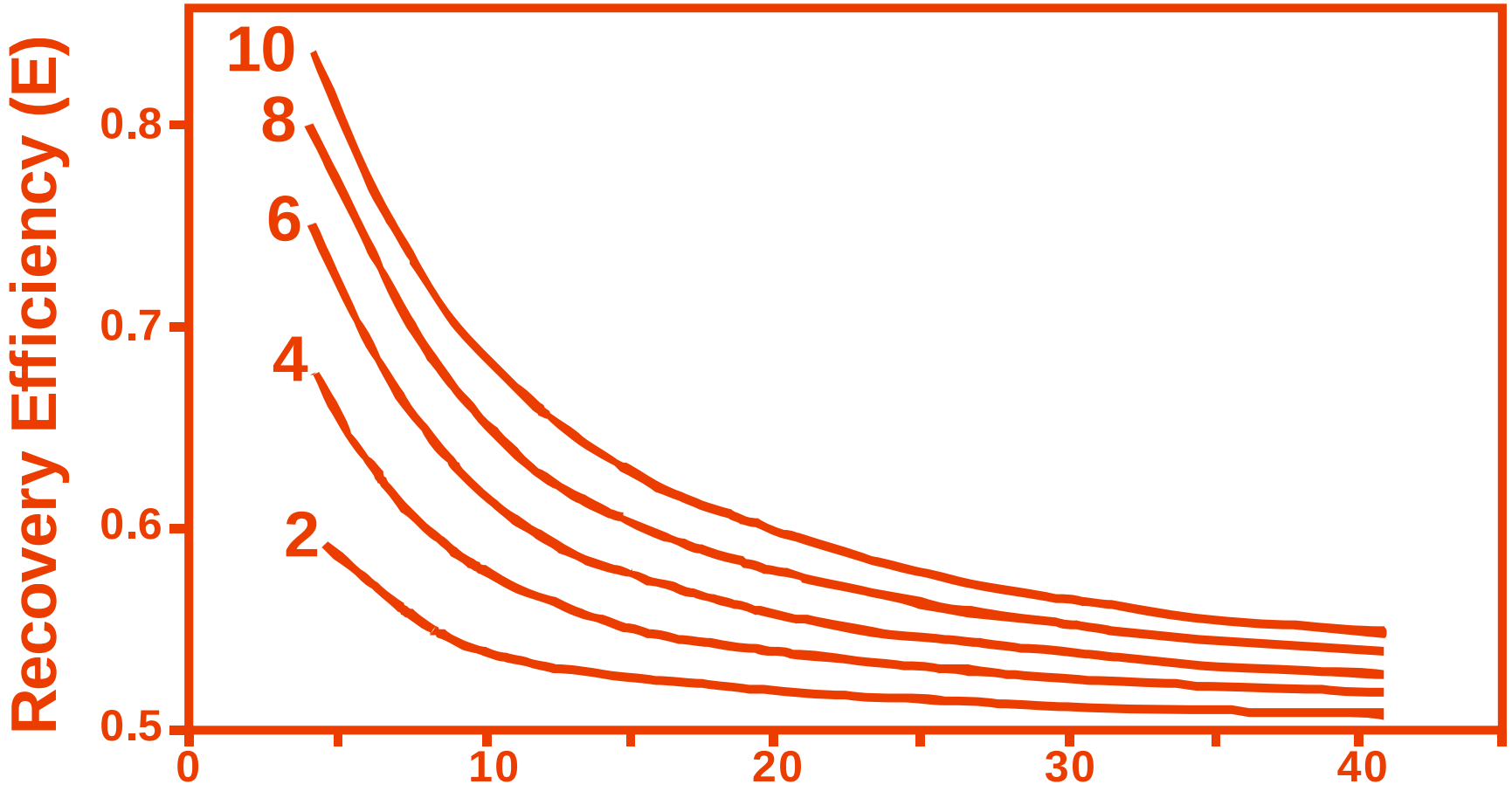
MINING SIMULATION: CROSS SEAMOUNT

RMS Roughness (cm)	*Recovery Efficiency (%)*		*Crust Purity (% crust)*	
	20 cm	*50 cm*	*20 cm*	*50 cm*
8	76	63	72	52
9	80	68	78	64
10	80	66	79	62
12	85	71	85	69
14	82	71	82	68
16	72	63	67	46
38	66	57	58	36
43	65	56	55	32

Crust Thickness: 4 cm

Recovery Efficiency vs. Roughness

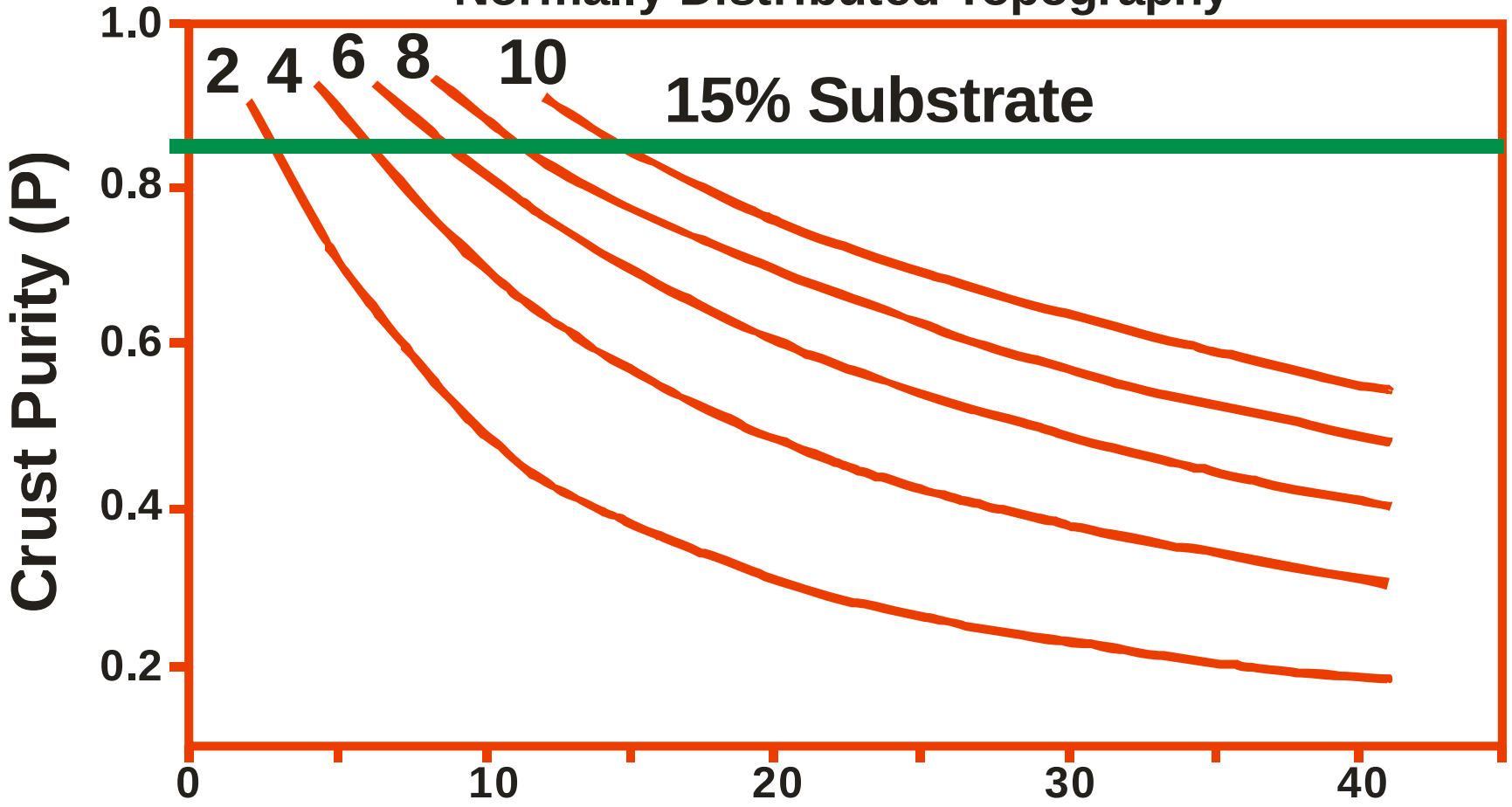
Normally Distributed Topography



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

Crust Purity vs. Roughness

Normally Distributed Topography



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