

Placer Deposits



OCN 631/ORE 678

Gary McMurtry

Placers Outline

- Placer Deposit Types
- Environments of Placer Mineral Occurrence
- Exploration Methods in Shallow Waters
- Sand & Gravel, Mineral Aggregates
 - Sources and Uses of Major US Nonmetallic Construction Raw Materials
 - Projected US Sand & Gravel Demand
 - Sources & Fates of Offshore Sand & Gravel Deposits
- Exploitation (Mining) Methods
 - Dislodgement Needs for Mining Marine Minerals
 - Depth of Marine Minerals & Equipment Capability
- Marine Diamond Exploration & Mining Areas of Southern Africa

Target Commodities



Seafloor massive sulfides



Manganese crust



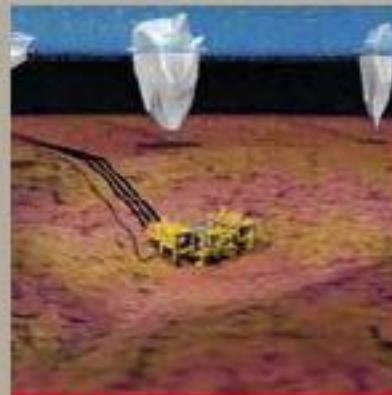
Diamonds



Gas hydrates



Glory hole (conventional dredging equipment)



Glory hole



Gorgon project, Australia

Source: IHC Deep Sea Dredging & Mining

IHC Deep Sea Dredging & Mining



Dredging technology has been expanding its horizons since the discovery of the treasures of the deep sea. Deep Sea Dredging or Mining is a greenfield activity since no proven technology is available for deep sea activities. A serious transition is needed in order to develop new excavation techniques and vertical transport systems for deep sea activities. The main challenges are the hyperbaric conditions, the slurry transport, the remote control and maintenance aspects.



Head Office – The Netherlands

Sliedrecht

Shipyards – The Netherlands

Hardinxveld-Giessendam
Hendrik-Ido-Ambacht
Heusden
Kinderdijk

Offices – UK

Blandford Forum
Riding Mill

Office – US

Wayne, NJ

Representative offices

Placer Deposit Types

From: D. S. Cronan,
Underwater Minerals (1980)

Table 1. Examples of placers, aggregates and other minerals.

Commodity	Ore mineral	Specific gravity
<i>Non-metallic</i>		
Silica	quartz sand	2.65
Lime	shells and shell sands	2.7
Sand and gravel	various	3.0
Topaz	topaz	3.4-3.6
Spinel	spinel	3.5-4.0
Corundum	corundum	3.9-4.1
<i>Heavy mineral sands</i>		
Beryllium	beryl	2.75-2.8
Titanium	rutile	4.18-4.25
Titanium	ilmenite	4.7
Chromium	chromite	4.6
Zirconium	zircon	4.68
Manganese	hausmannite	4.72-4.84
Manganese	braunite	4.72-4.83
Iron	magnetite	5.18
Thorium	monazite	5.0-5.3
Nb, Ta	columbite, tantalite	5.2-7.9
Rare-Earths	group of 15 REE oxides	
Tin	cassiterite	6.8-7.1
Mercury	cinnabar	8.10
<i>Precious and rare</i>		
Diamond	diamond	3.5
Copper	native metal	8.9
Silver	native metal	10.5
Gold	native metal	15-19.3
Platinum	native metal	14-19

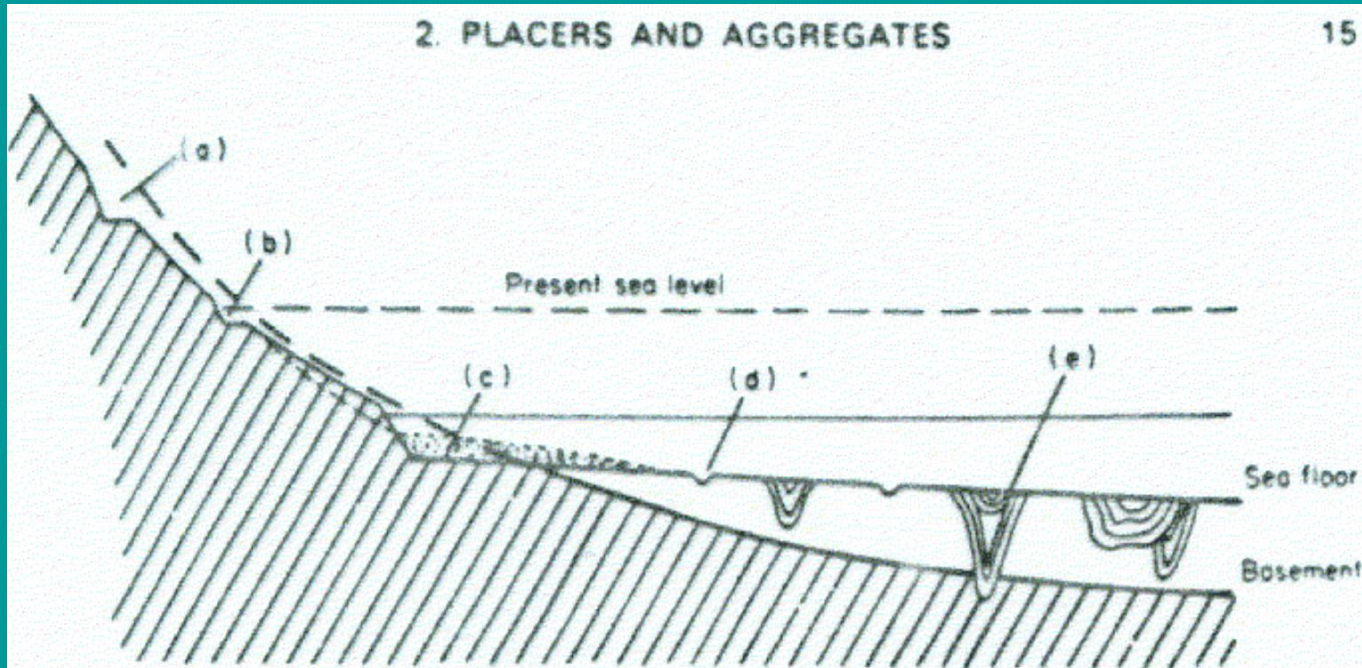
Hot Industrial
Metal

Future Energy,
High-Tech Metals

Industrial,
Economic

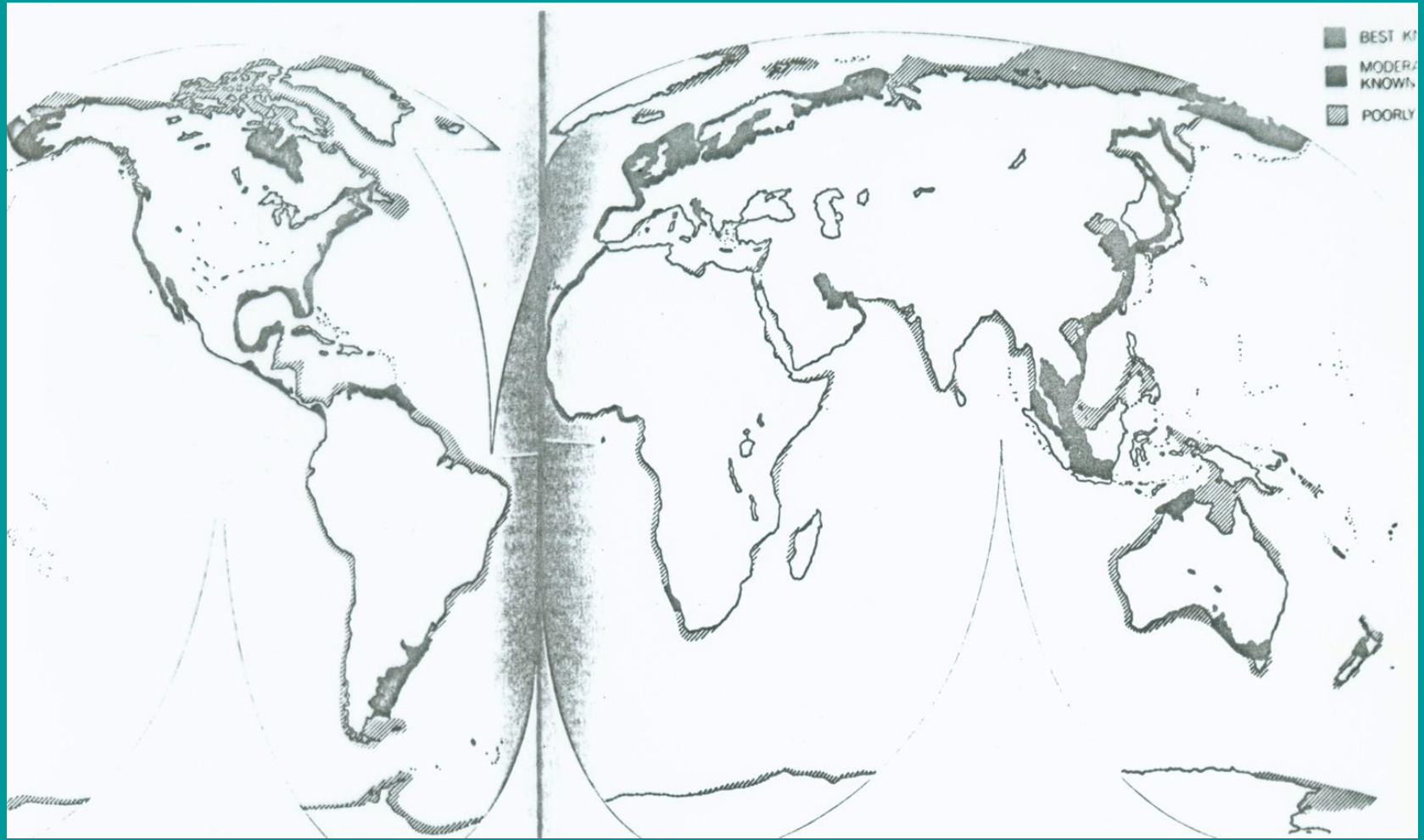
Where Specific Gravity = Density relative to H₂O (=1.00) in cgs units of g/cm³

Environments of Possible Placer Mineral Occurrence

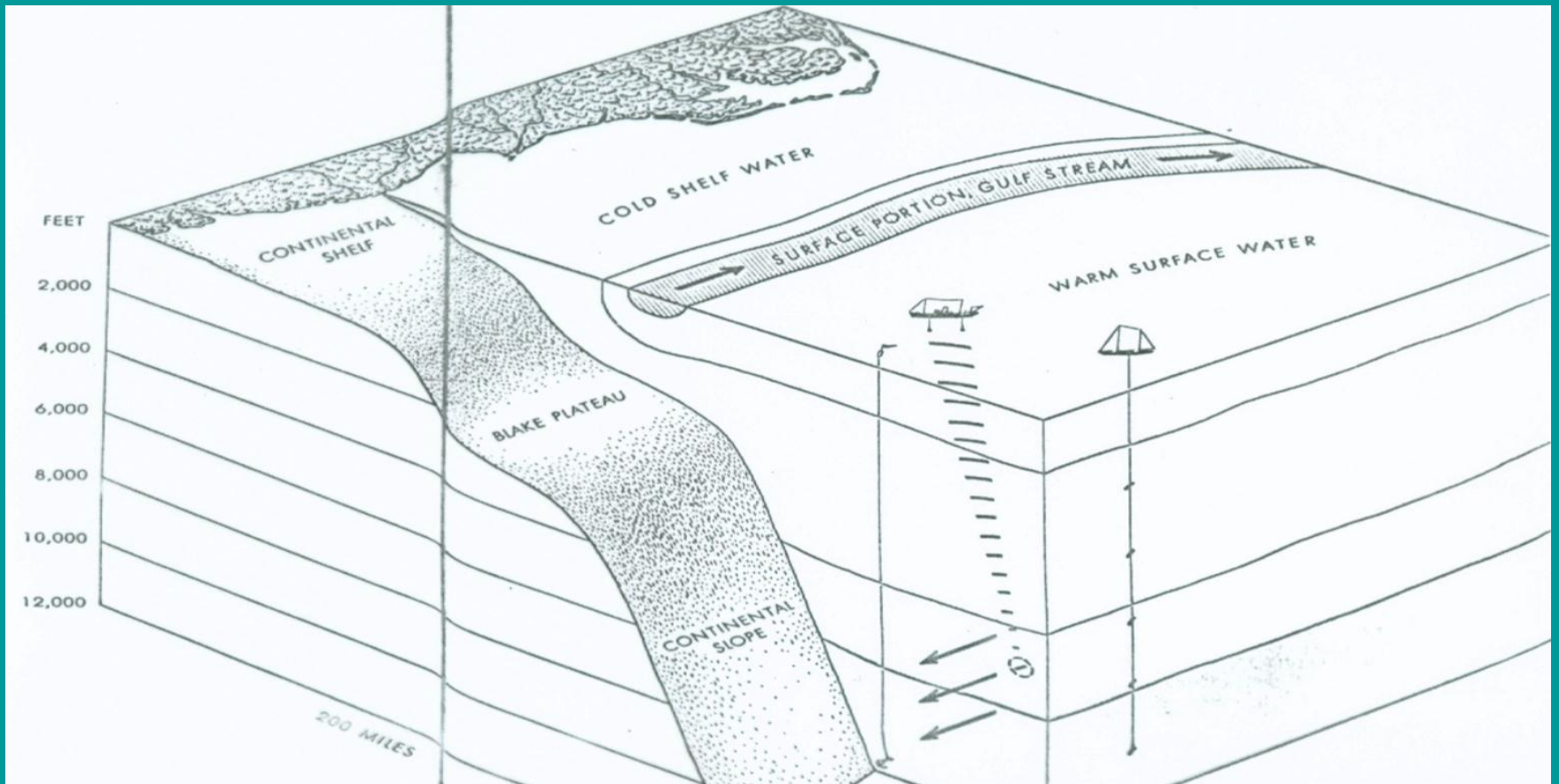


Cronan (1980)

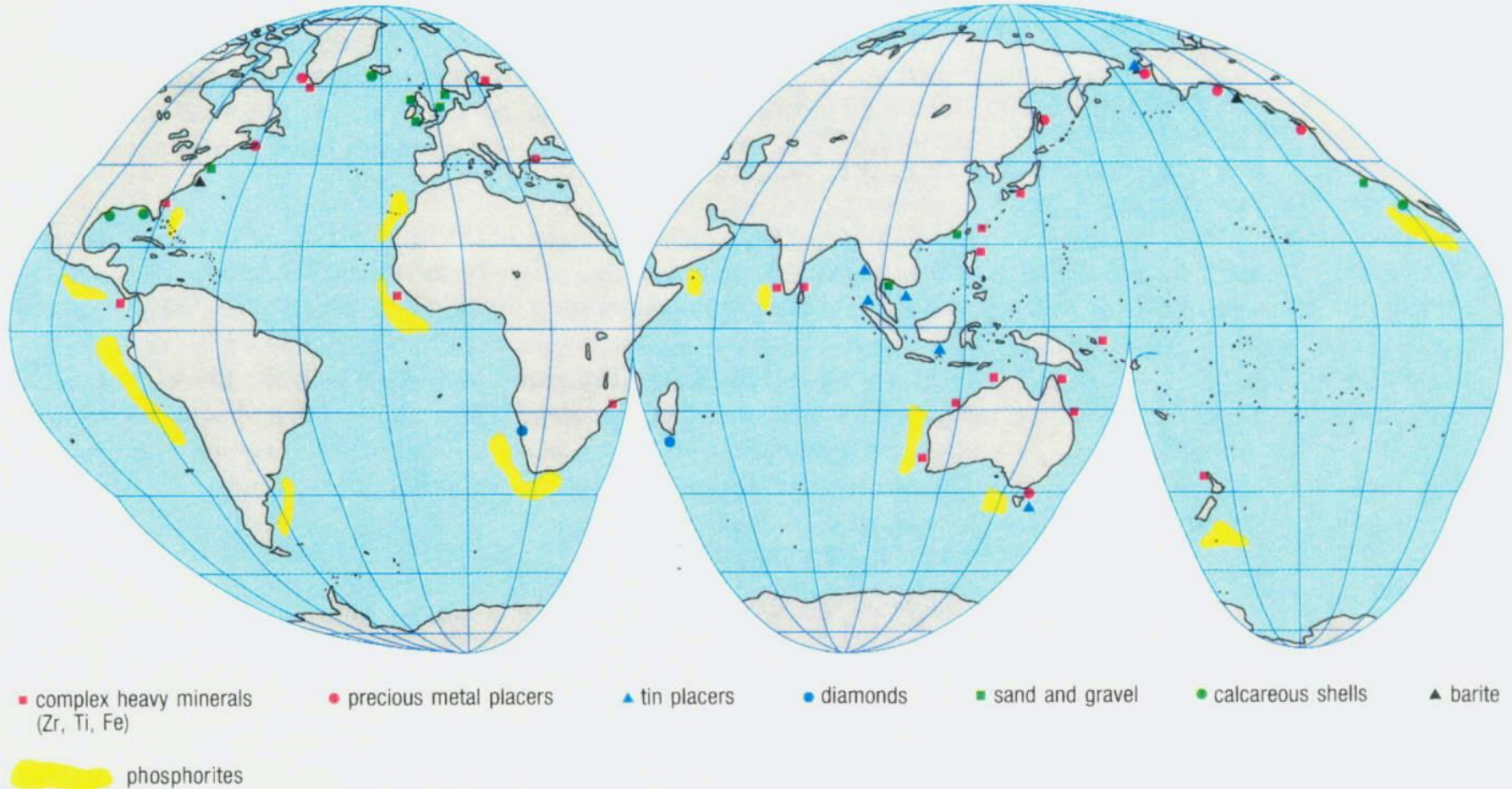
Global Distribution of Continental Shelves, with Extent of Knowledge



Continental Shelf and Slope off East Florida: The Blake Plateau

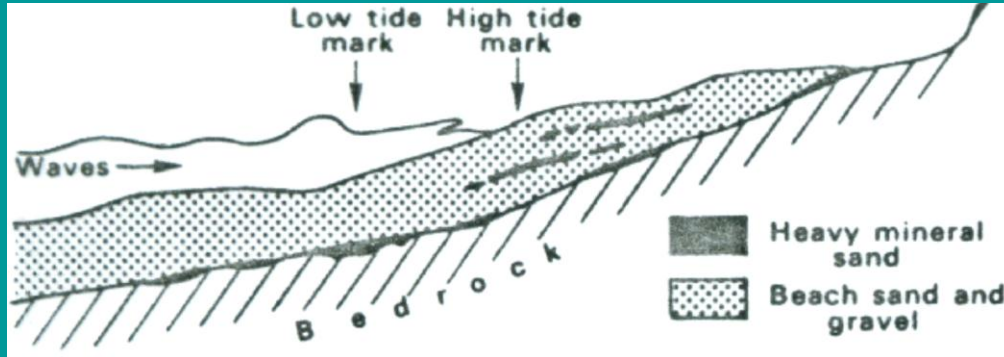


Earth's Future Resources: The Sea



Known global coastal distributions of phosphorites (P), heavy minerals, & various native metal & diamond placers (from US Minerals Management Service, 1990).

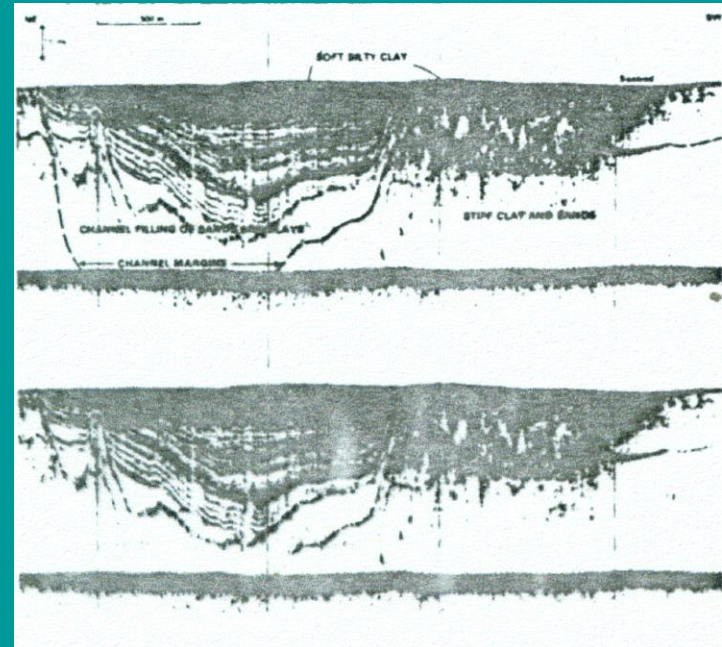
Exploration Methods in Shallow Waters



- SCUBA/NITROX Diving
- Sediment Sampling
- Geophysical Surveys
ROV, AUV, shipboard

With contacts interpretation

Raw seismic



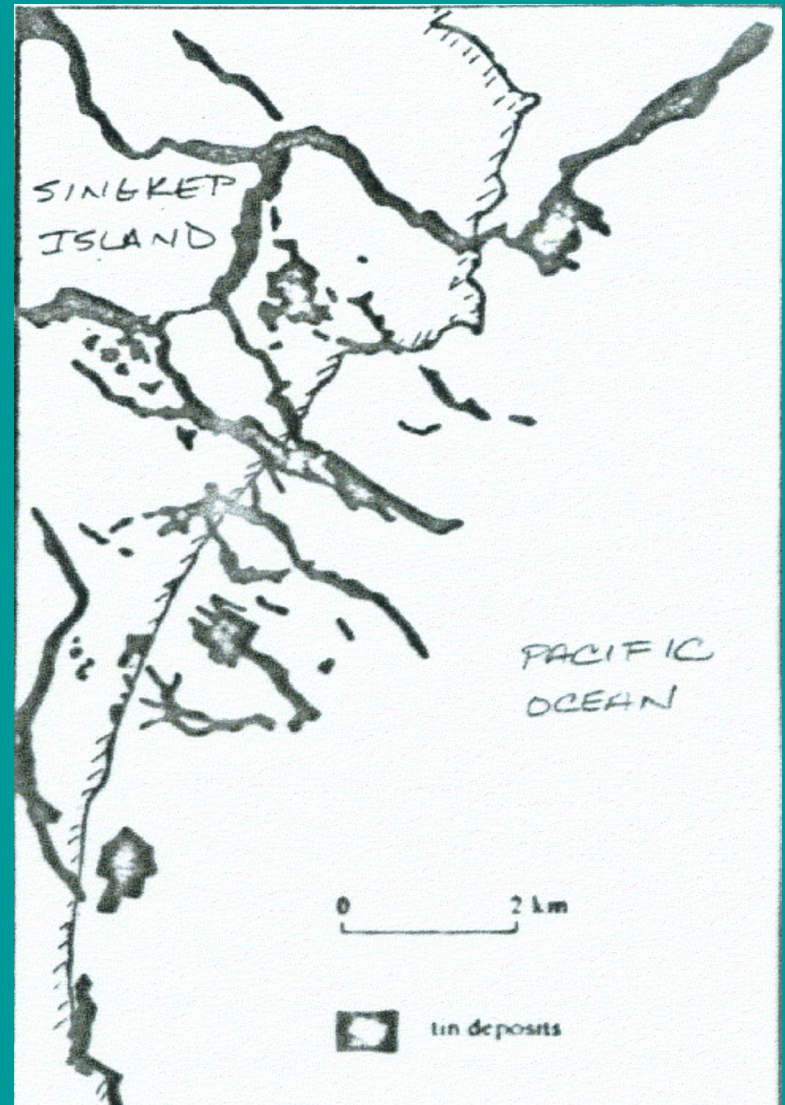
Example of Geology
Leading to Possible
Location of Tin (Sn,
Cassiterite) Placers
in Indochina (SE Asia)

Note location of “tin belts”,
or SnO₂-bearing granites
(source rocks) on land, and
possible seaward extension
into Gulf of Thailand



Seaward extension of cassiterite (SnO_2) placers formed in streams off Sinkep Island, Indonesia

Can you suggest a simple method of delineating potential areas of offshore placer deposits?

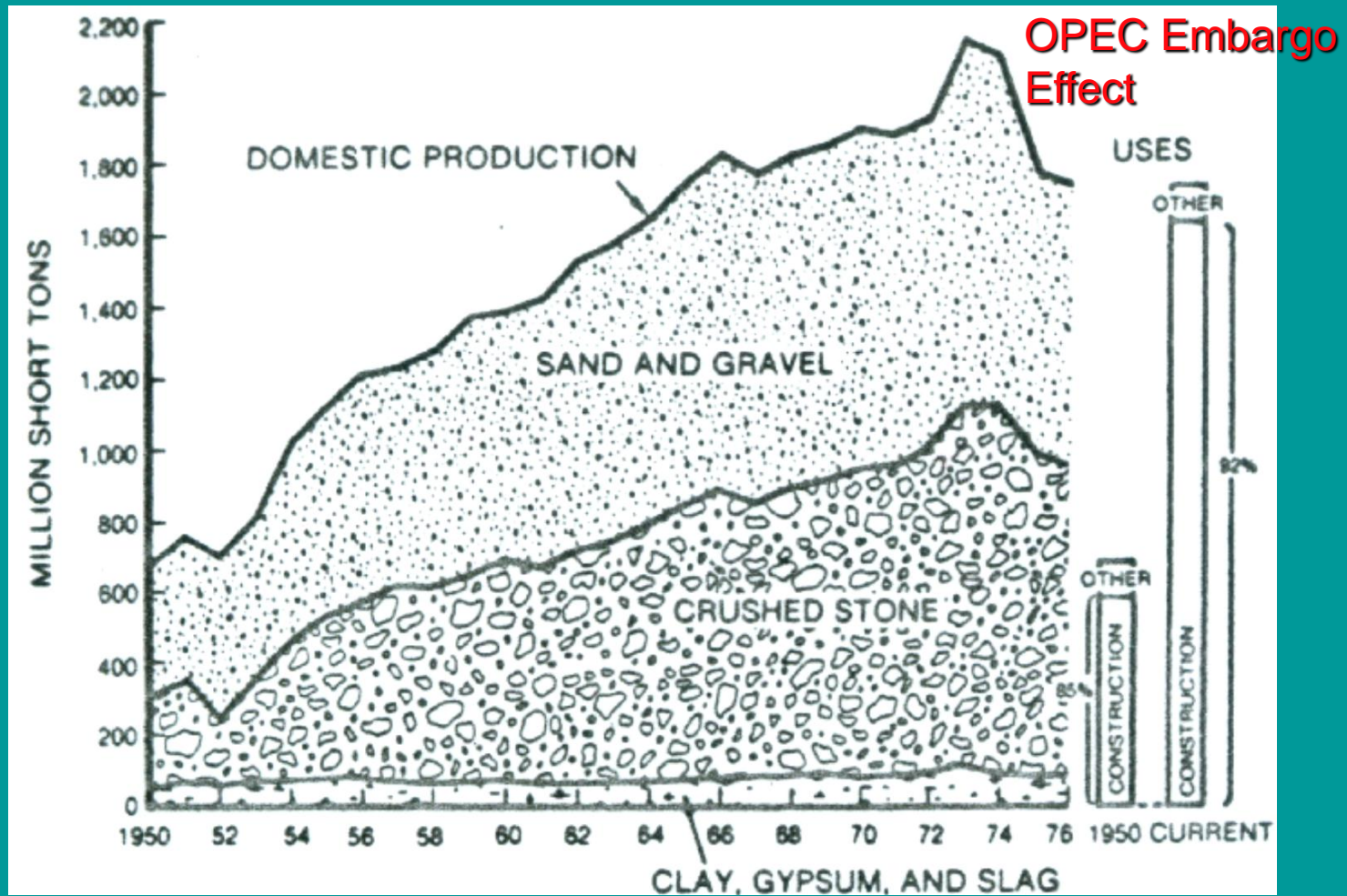


Consumption of mineral aggregates by the US construction industry, for the periods 1959 and 1972 (in millions of tons)

<i>Construction use</i>	<i>1959</i>			<i>1972</i>		
	<i>Sand</i>	<i>Gravel</i>	<i>Crushed stone</i>	<i>Sand</i>	<i>Gravel</i>	<i>Crushed stone</i>
Building	123	114		188	153	
Paving	105	313		131	280	
Fill ^a	16	17		49	43	
Railroad ballast	1	5		1	2	
Other	6	7		10	13	
Concrete aggregates						134
Bituminous aggregates						83
Macadam aggregates			357			33
Road-base aggregates						337
Surface treatment aggregates						52
Other						113
Total construction	250	456	357	378	492	752
Cement manufacture			91			109
Percentage of total production used in construction	92.9	98.9	12.2	92.8	97.3	81.6
Total production	269	461	582	408	506	922

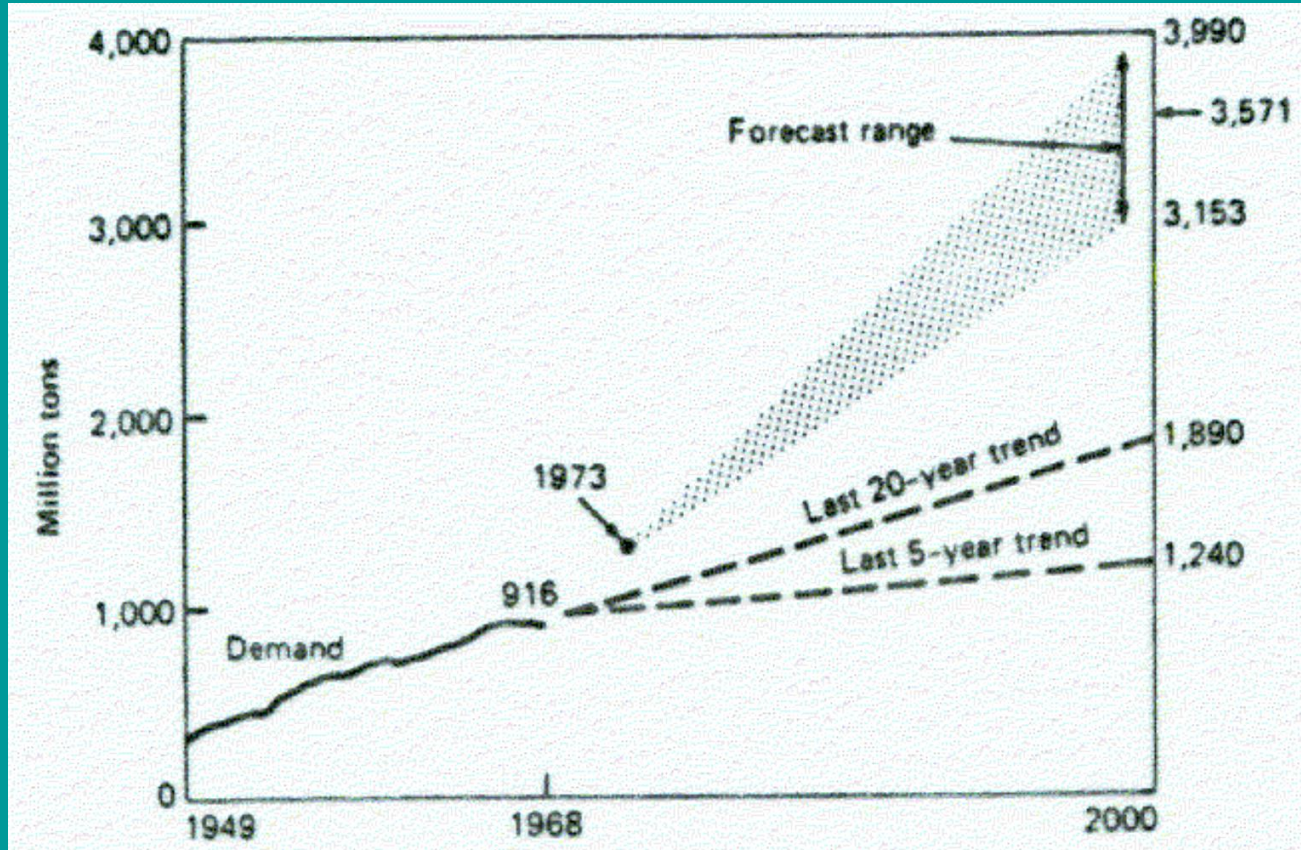
Source: Baram et al. (1978)

US Sources and Uses of Major Nonmetallic Construction Raw Materials



Source: Morgan (1973)

Projected US Sand & Gravel Demand



Source: Cooper (1972)

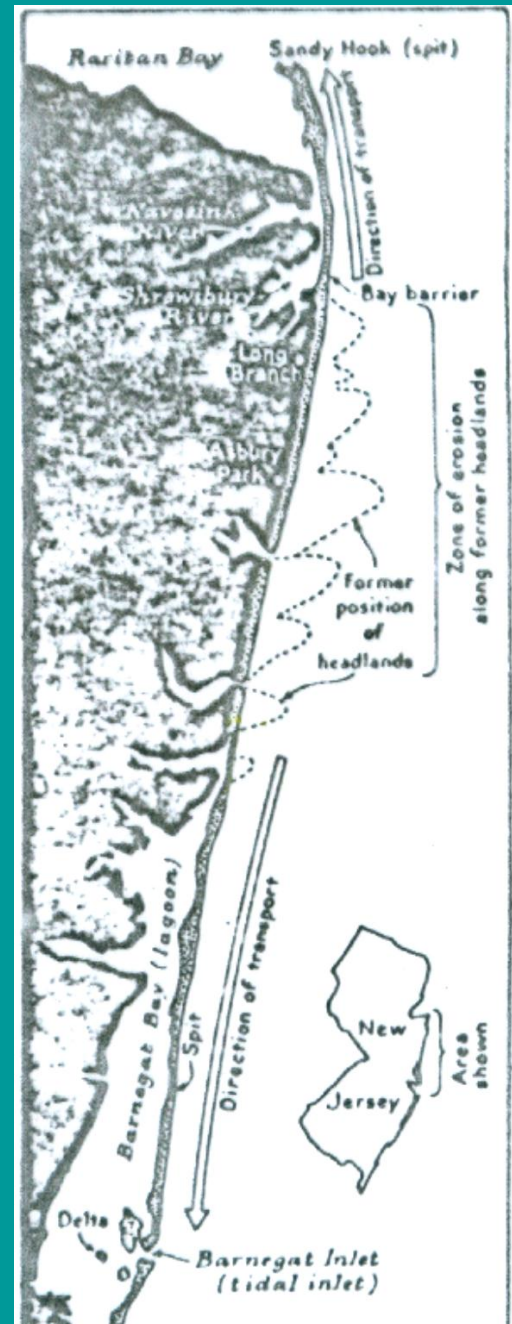
Which trend was correct?

Sources & Fates of Offshore Sand & Gravel Deposits: West Coast USA

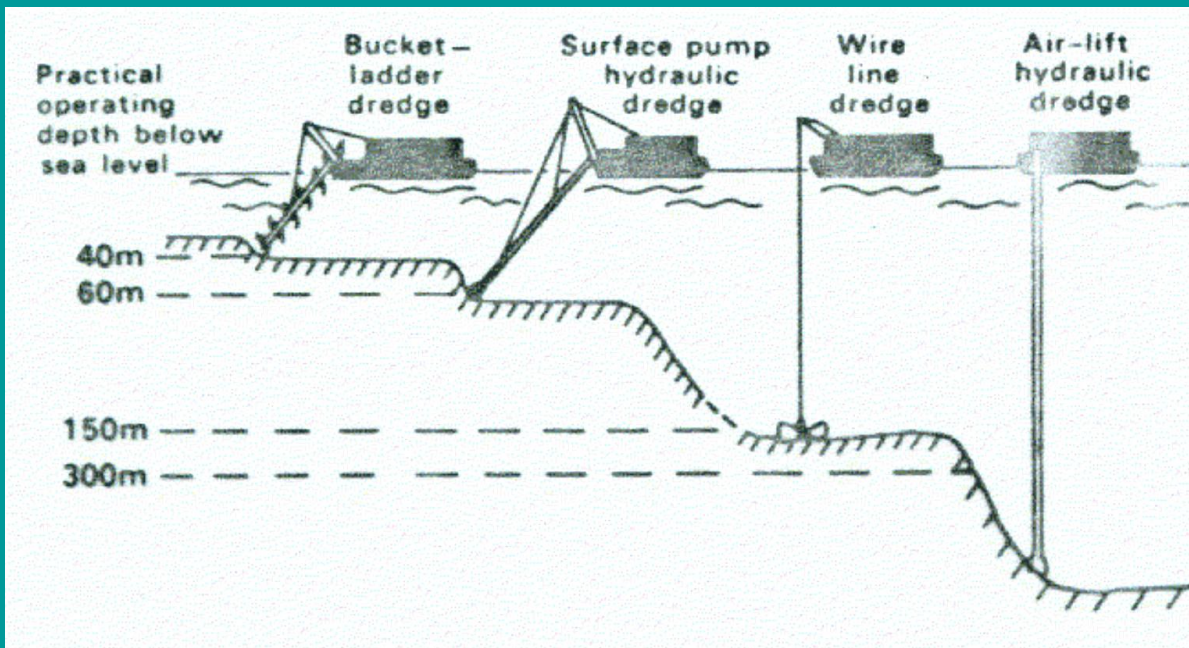
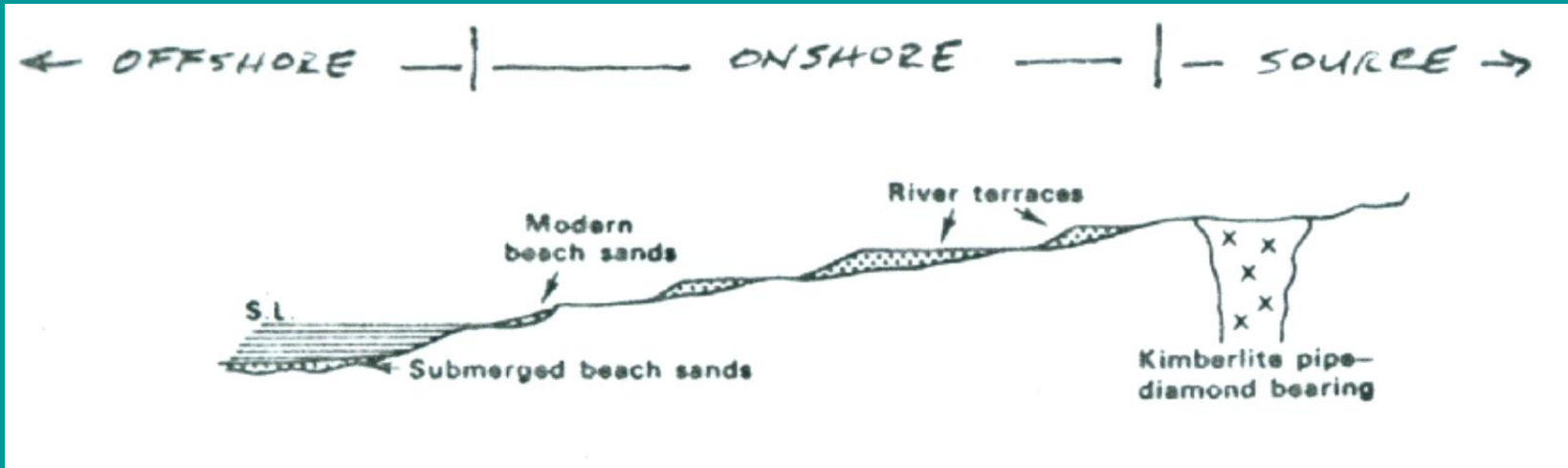


Sources & Fates of Offshore Sand & Gravel Deposits: East Coast USA

Note formation of longshore barrier islands from headland erosion



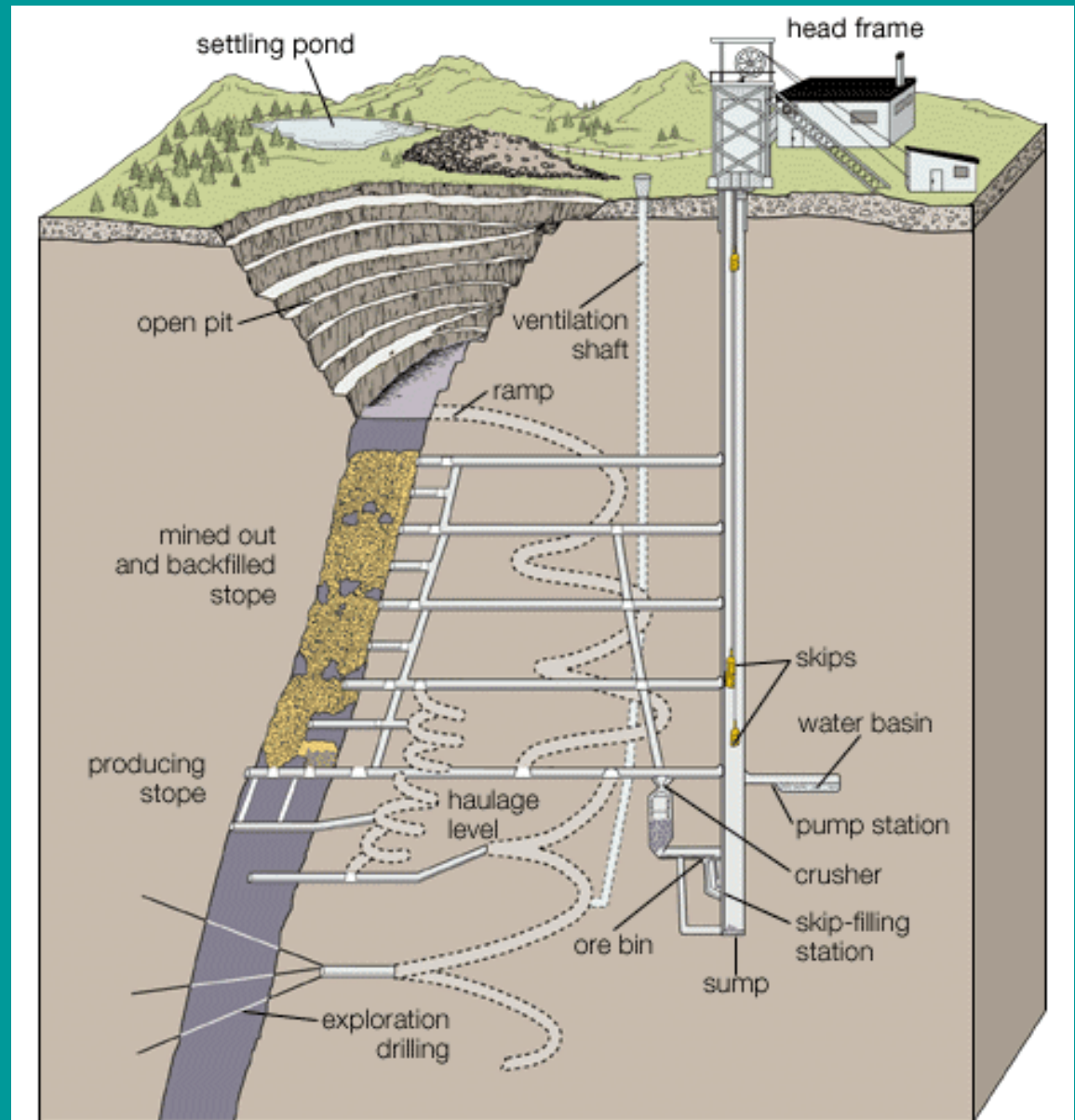
Placer Exploitation (Mining) Methods



Dredging methods at different water depths

Kent (1980)

Basic Mining Strategies & Techniques



© 2007 Encyclopædia Britannica, Inc. Source: H. Hamrin, *Guide to Underground Mining Methods and Applications* (Stockholm: Atlas Copco, 1997)

Placer Mining on Land

Open-Pit Iron Ore Mining,
Brazil



Alluvial Diamond Mining, Africa



Bolivian Tin Mine



Hydraulic Gold Mining, Alaska

Placer Mining at Sea



Source: IHC Deep Sea Dredging & Mining

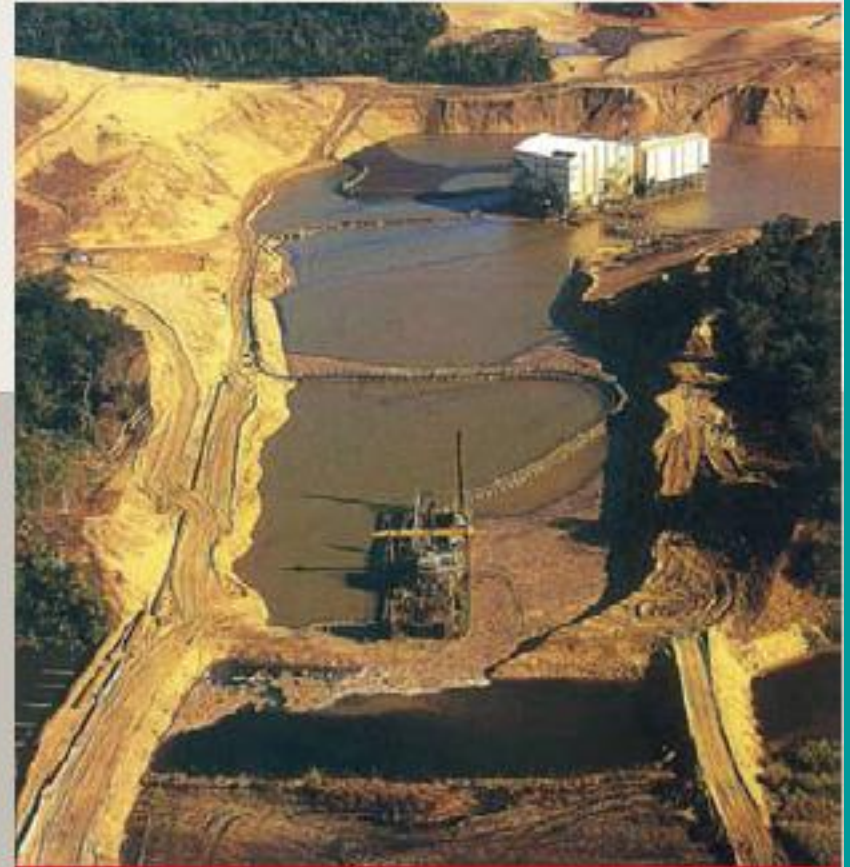
Mining Industry Aspects



Dredging and Mining Training



Cutterhead



Dredge mining



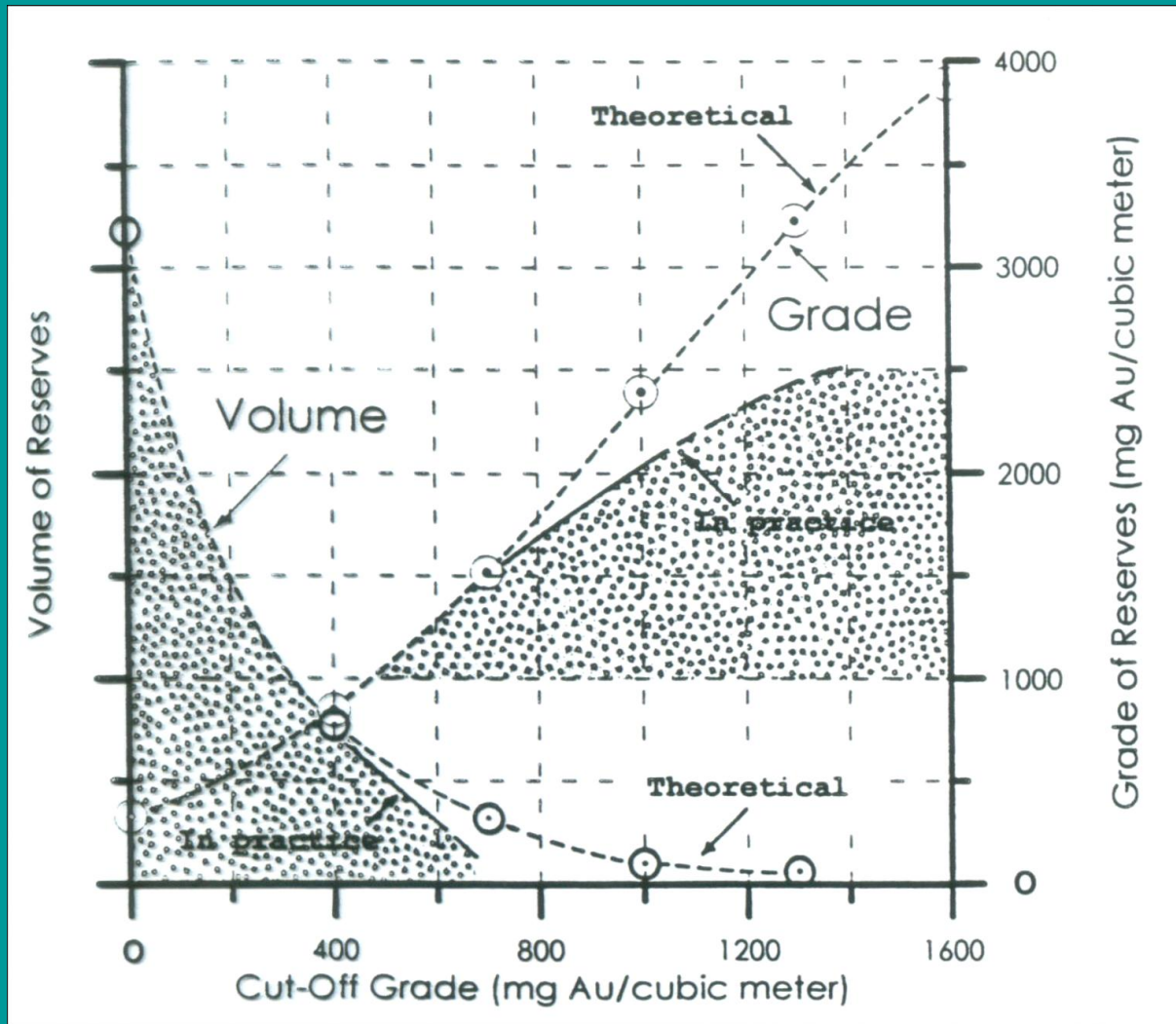
Inspection and condition monitoring



Mineral Processing Technology

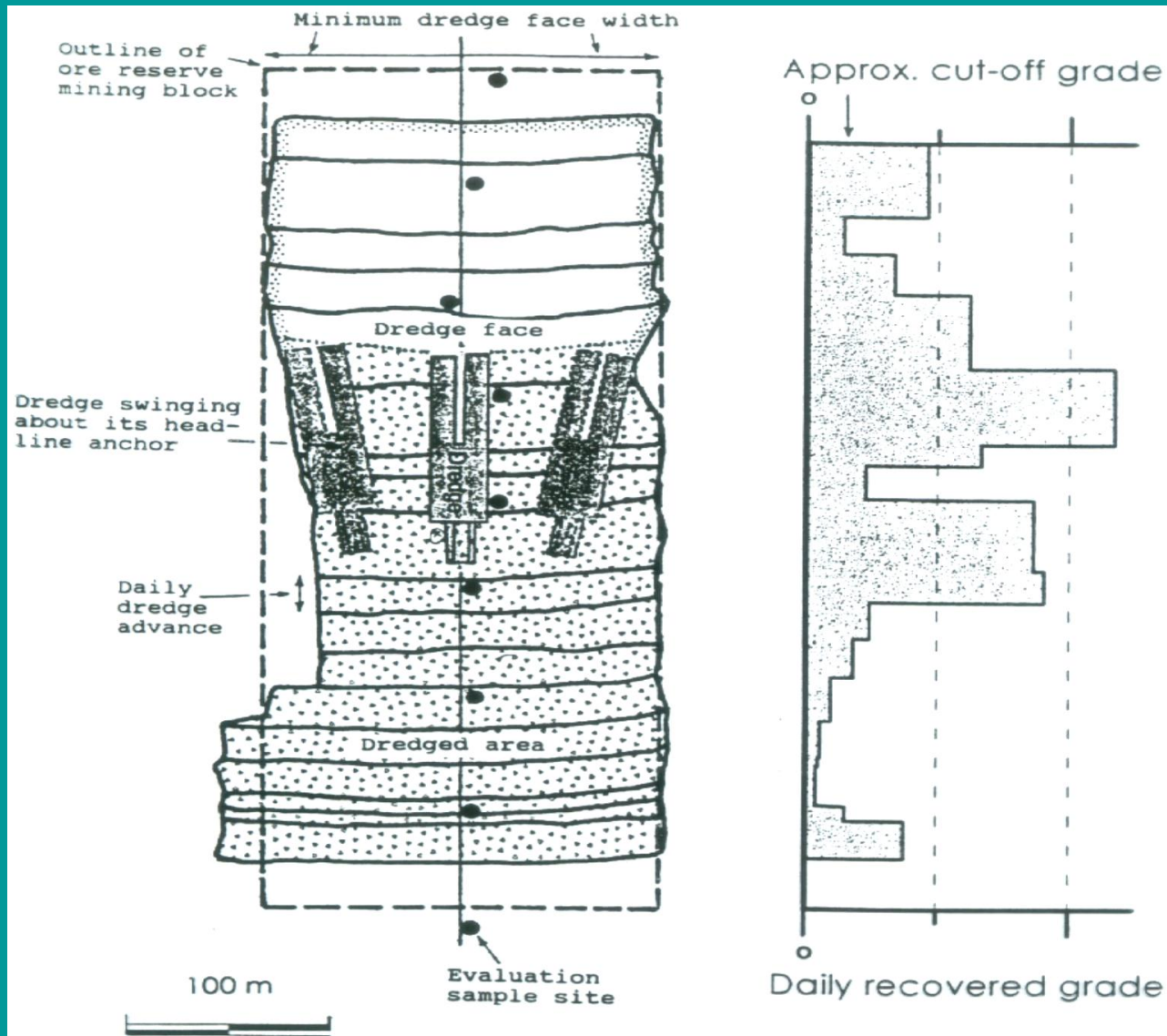
Source: IHC Deep Sea Dredging & Mining

Grade-Volume Curve for Surficial Sediments of Nome, Alaska Marine Placers

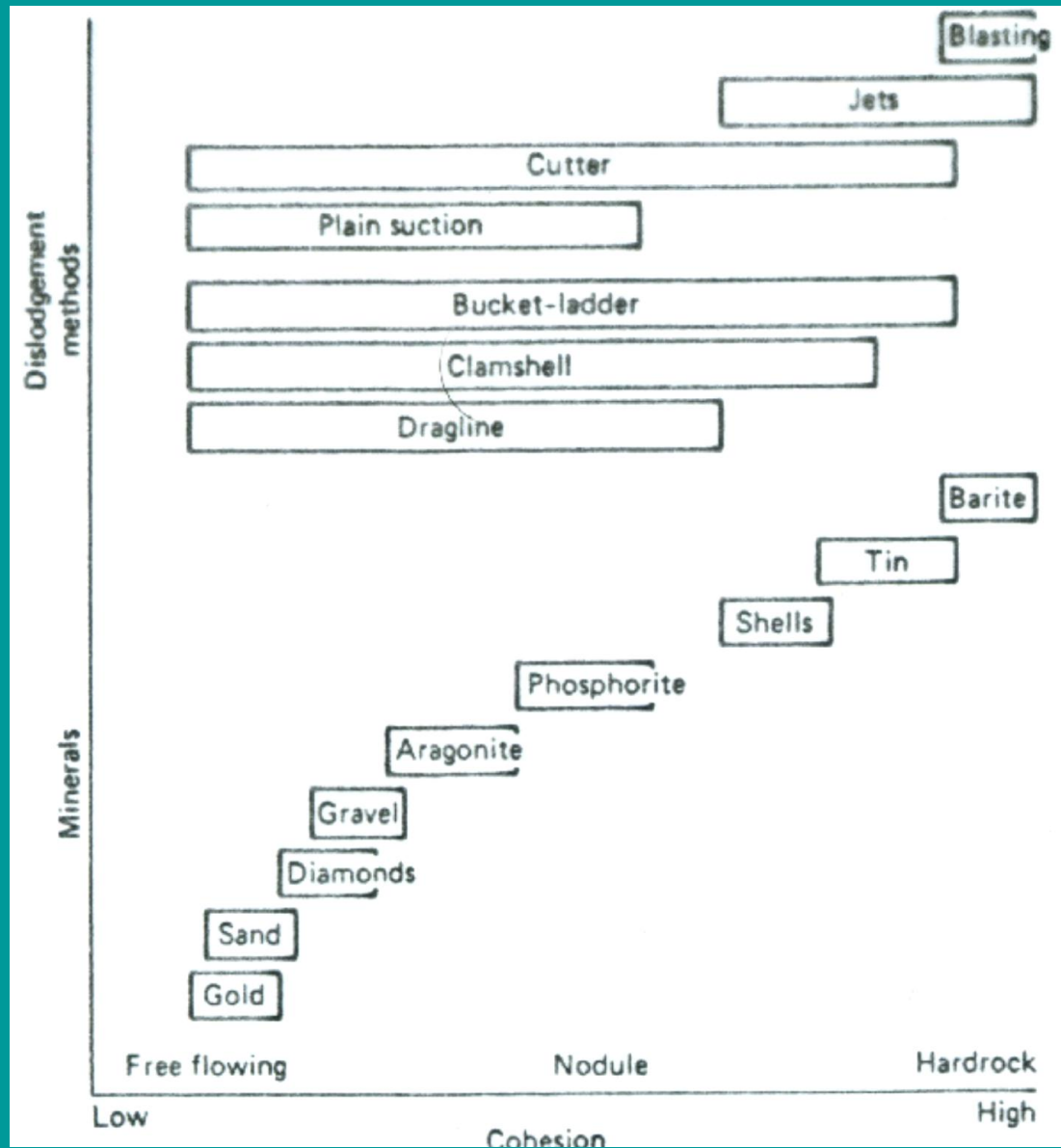


High Volume = Low Grade; High Grade = Low Volume!

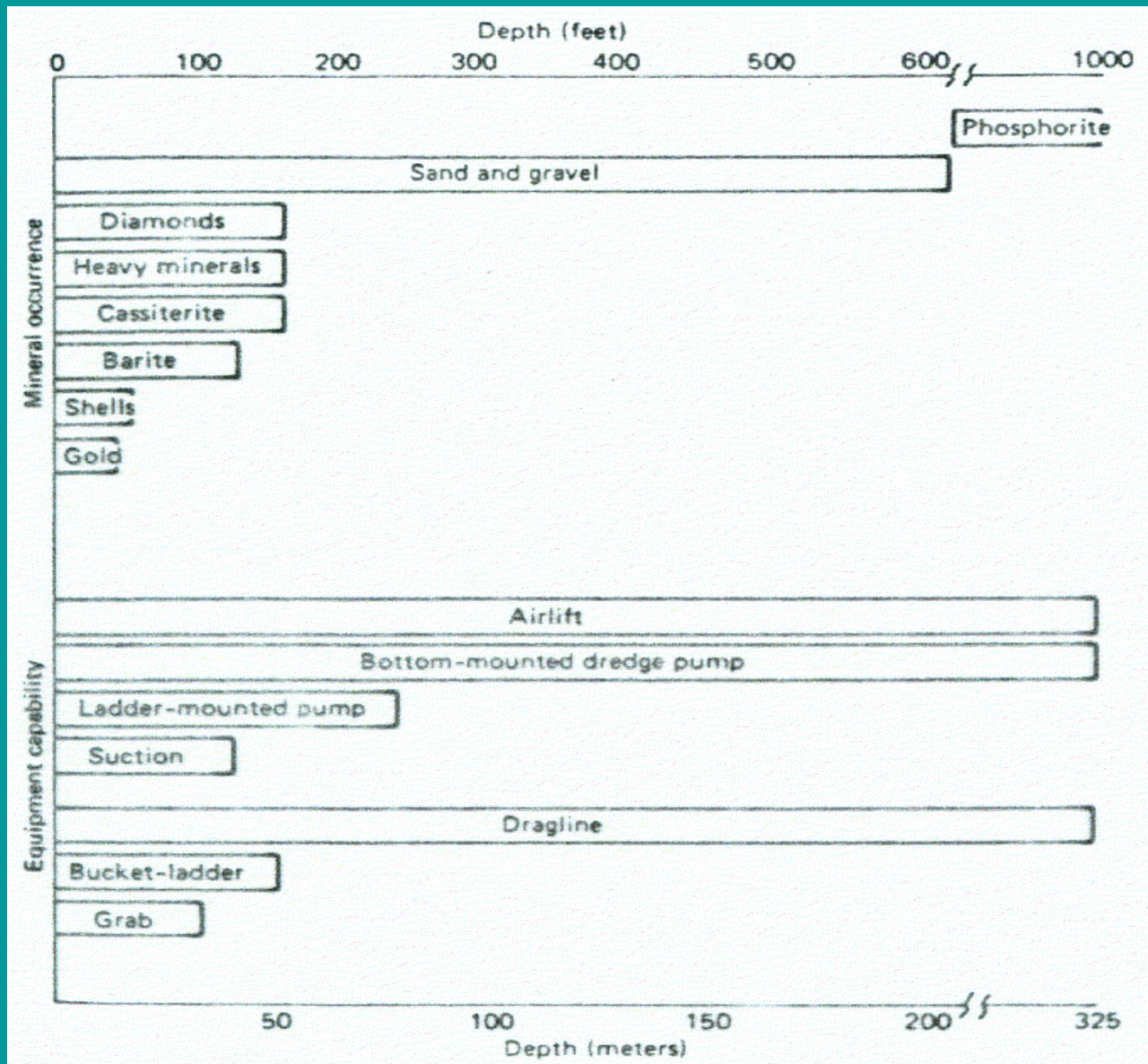
Progressive Dredging of a Reserve Block off Nome, Alaska



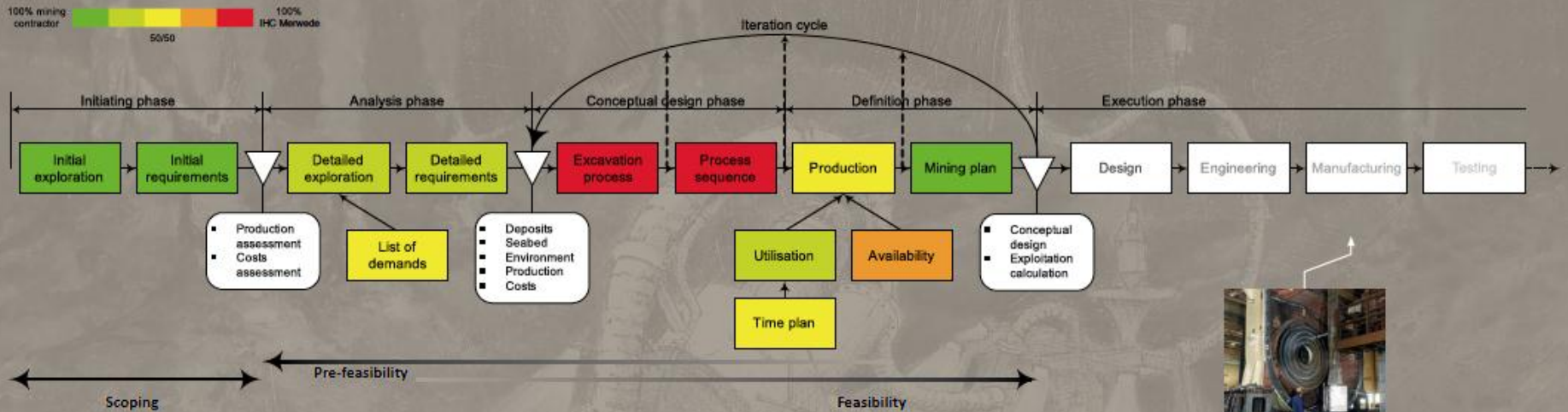
Dislodgement Needs for Mining Marine Minerals



Depth of Marine Minerals & Equipment Capability



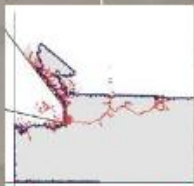
Project Development: From customers expectations to realization.



Initial exploration



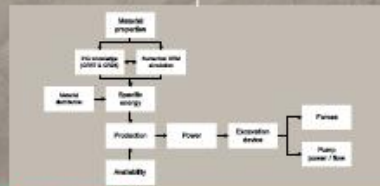
Nexans crawler



Cutting (atmospheric conditions)



Cutterhead



Engineering procedure



Tripod



Shipyard Kinderdijk

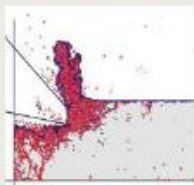


Test set up centrifugal pump



- Evaluate initial results of exploration of deep sea Greenfield mine sites
- Determine the feasibility and profitability of mining these sites
- Decide to take further steps for detailed analysis

- Detailed exploration, focusing on**
- deposits (geological aspects)
 - seabed (geotechnical aspects)
 - the environment
- Results**
- Detailed information on the content of deposits
 - Input for the selection of the excavation process slurry transportation system integral mining installation

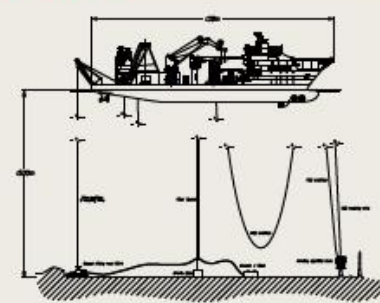


Cutting (hyperbaric conditions)

- Excavation process under hyperbaric conditions**
- Effect on rock cutting – cutting forces and installed power
 - Ductile plowing versus brittle chipping



Cutterhead (double)



With its know-how of excavation processes in dredging and wet mining equipment, IHC is capable of defining a dedicated solution for an end-to-end deep sea mining installation.

- Iterative process to determine optimal design specifications
- As the integrator, IHC can manage all the interfaces of a mining system to supply a mining system with top performance

- The key to developing a successful mining tool:
- Close cooperation between the mining company and the manufacturer
 - Clear instructions for the exploration company
 - Translation of the specific conditions of the deep sea into effective excavation and vertical transport systems

Crucial challenges

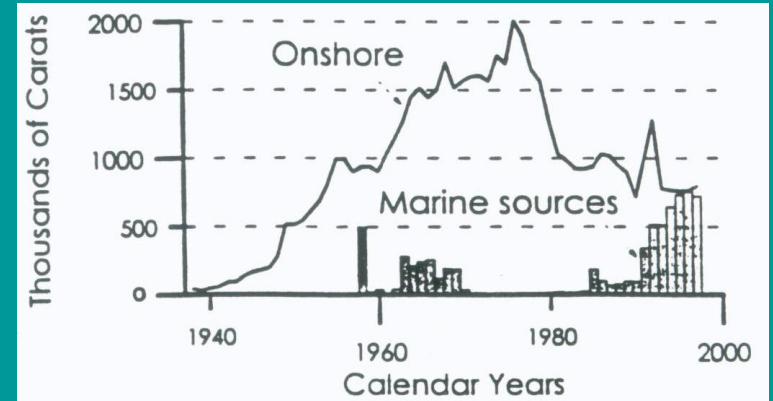
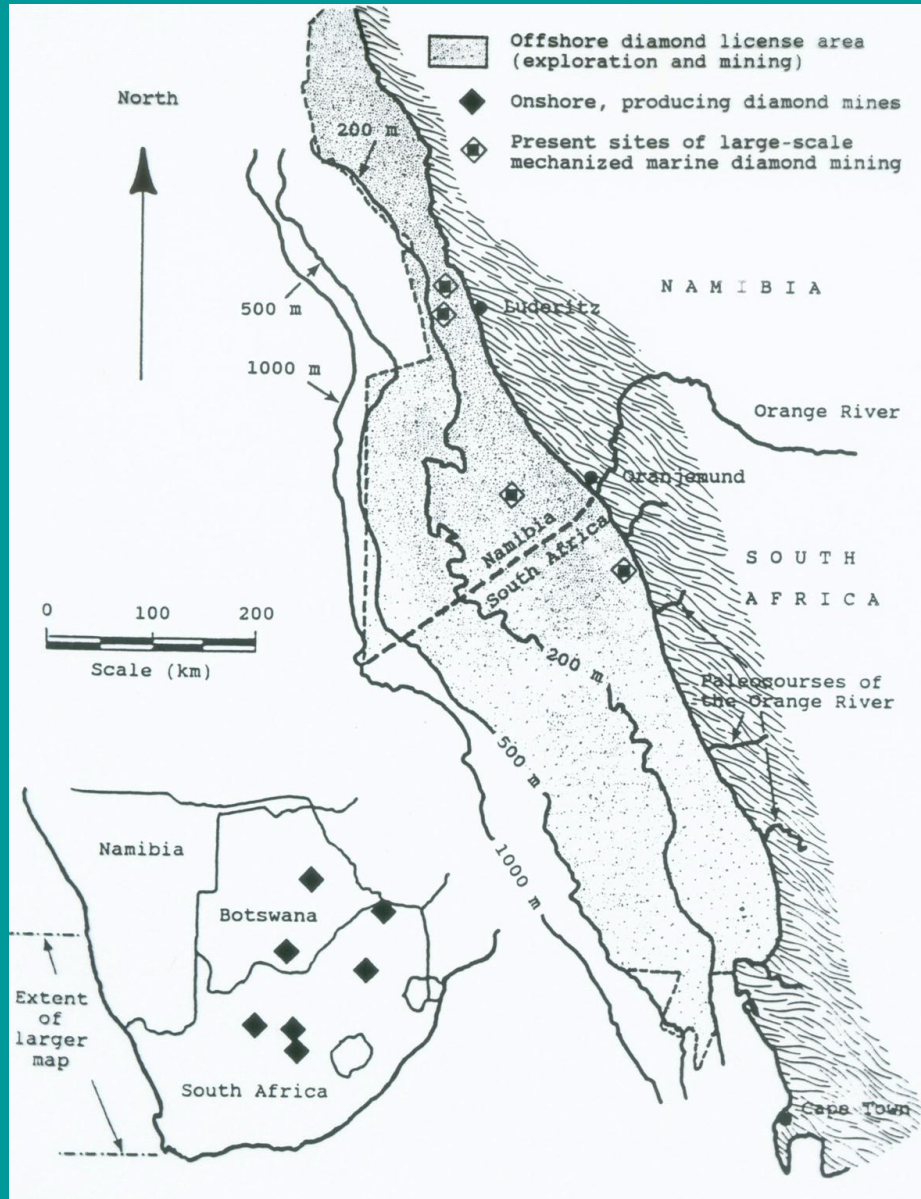
Adaptability to seafloor conditions (profile, rock characteristics versus excavation process, distribution of the minerals, water depth, environment & sustainability, etc.).

Utilisation and high system availability (weather conditions, maintenance, mining preparation, versatility, reliable production rates, etc.)

Handling of materials on board the vessel and further transportation to land-based installations (hydraulic transport, process monitoring, ore conservation, etc.)

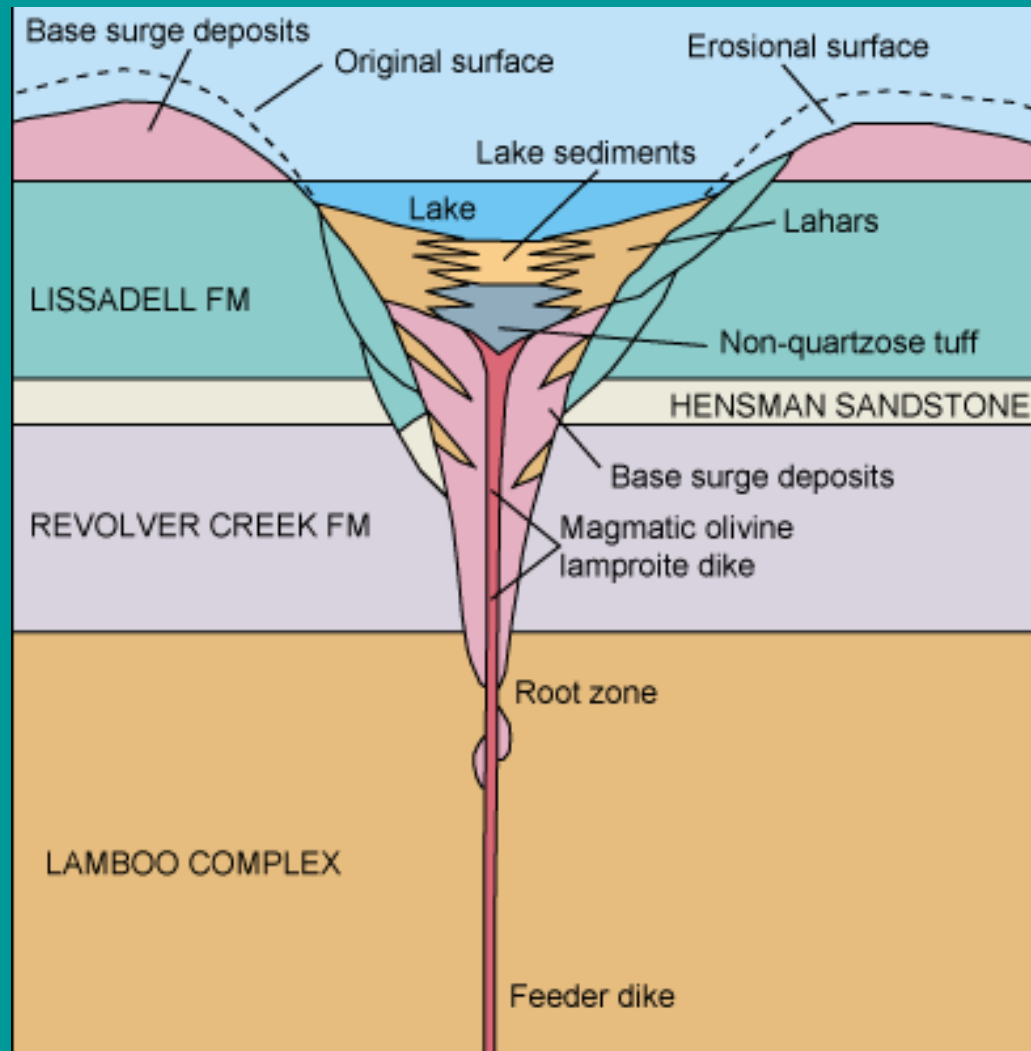
- Research and development**
- Long distance vertical transport under harsh deep sea conditions
 - Air-lift
 - Deep sea centrifugal pumps
 - Deep sea excavation
 - Torque variation subject to pick point position
 - Numerical analysis of cutting forces subjected to penetration levels and hydrostatic pressure
 - Optimal cutter geometry for deep sea mining applications (reduction external forces / moments)
 - Hyperbaric effects
 - Deep Sea System
 - Pump shaft sealing at great depth under high internal pressure
 - Crawler design related to deep sea conditions (submerged pump motor combination, umbilical, etc)

Marine Diamond Exploration & Mining Areas of Southern Africa



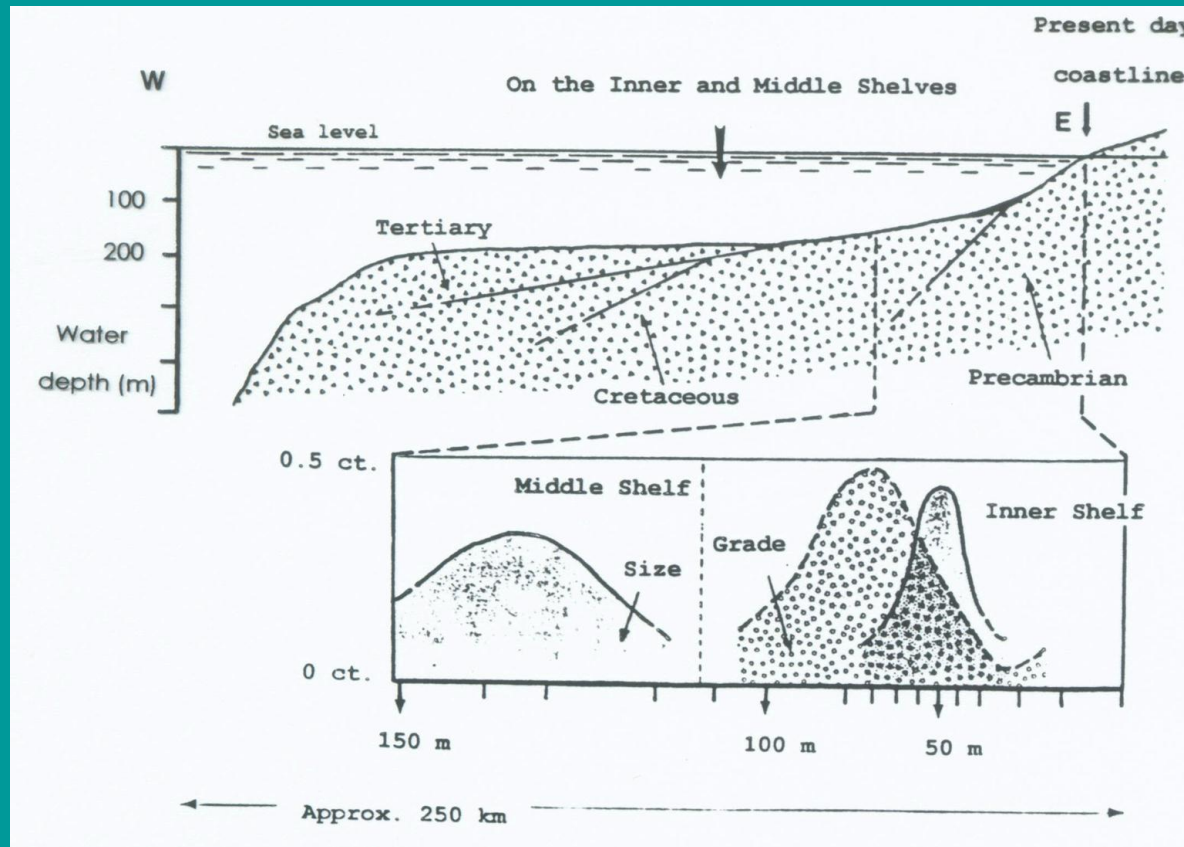
Historical annual diamond mining from Namibian sources

Diamond-bearing Igneous Pipes

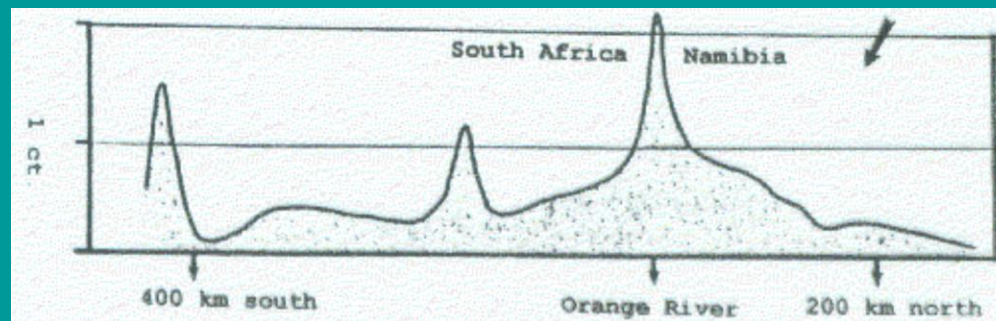


Interpretive section of a pipe in Australia

Inner & Middle Shelves of Namibia & South Africa: Diamond Sizes (Carots)



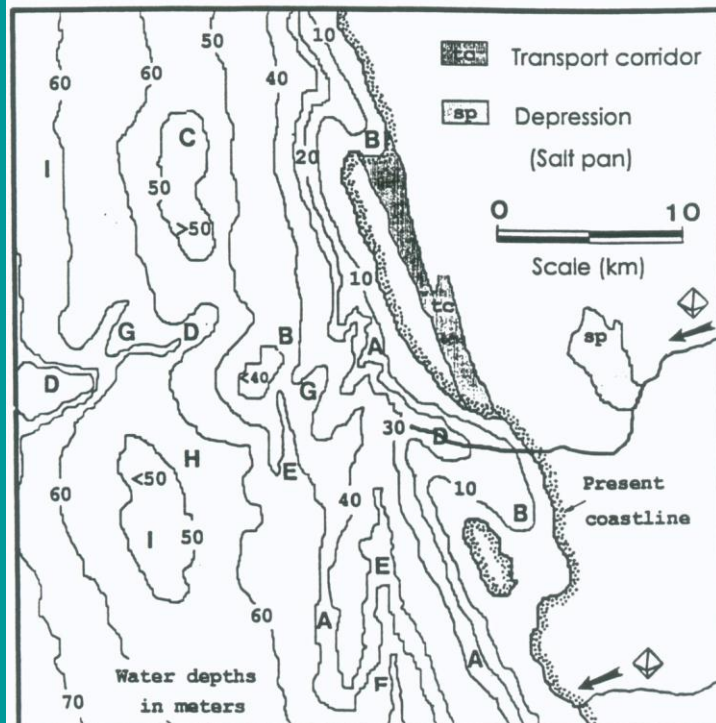
Along the coastline



Target Paleo-Features

TARGET PALEO FEATURES

- A....Coastline
- B....Embayment
- C....Depression
- D....River
- E....Corridor
- F....Valley
- G....Major gullies
- H....Area of energy change
- I....Sheet gravels

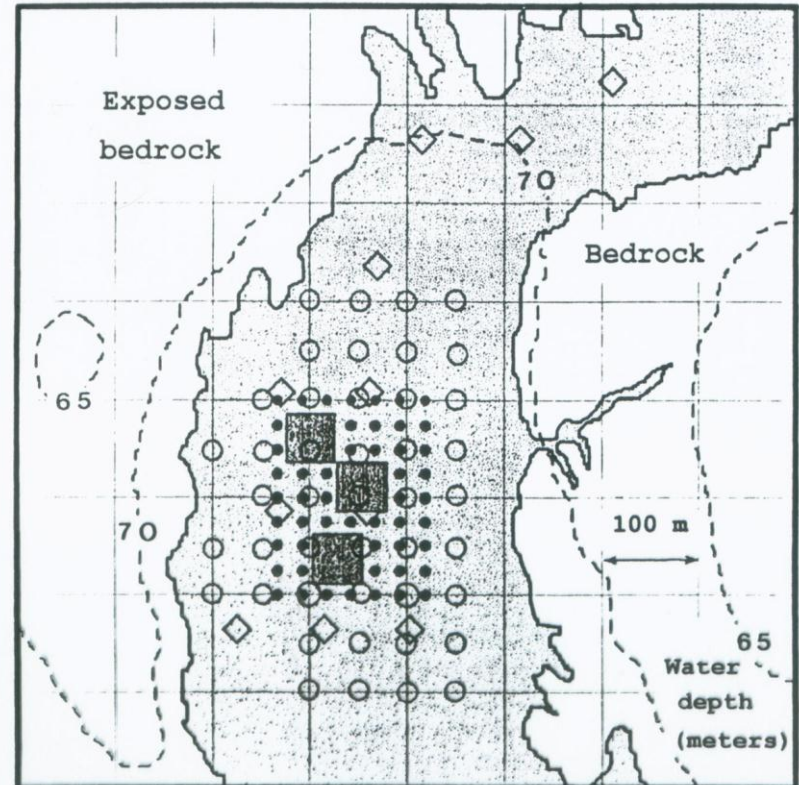


Typical diamond accumulation features on inner shelf.

- ◇... Reconnaissance samples
- ... Confirmation samples

- ... Evaluation samples

- ▣... Bulk samples



Progressive sampling of a "diamondiferous" feature.

Drill System

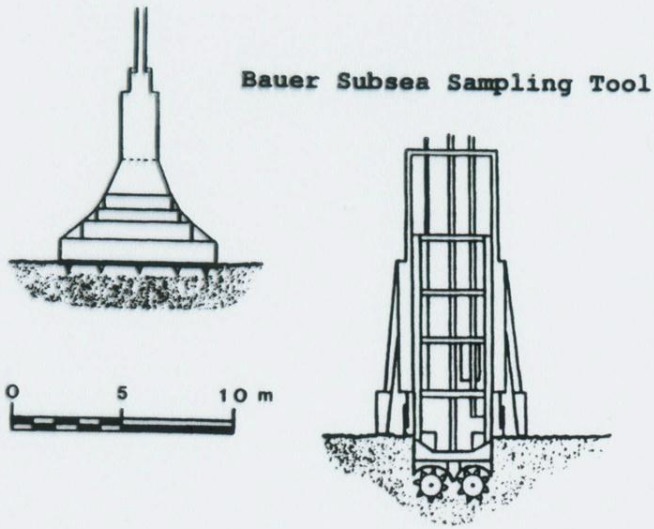
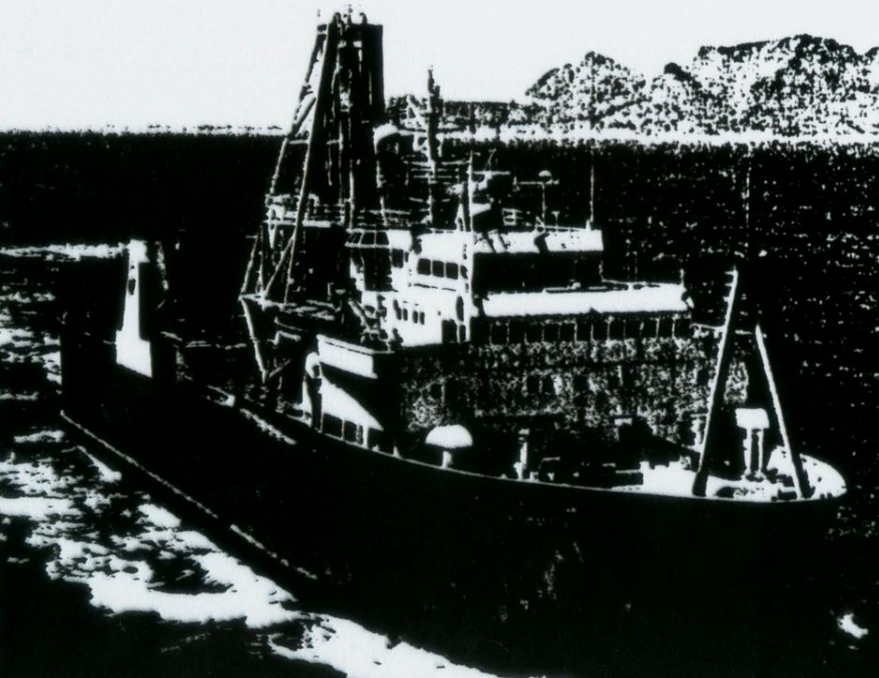
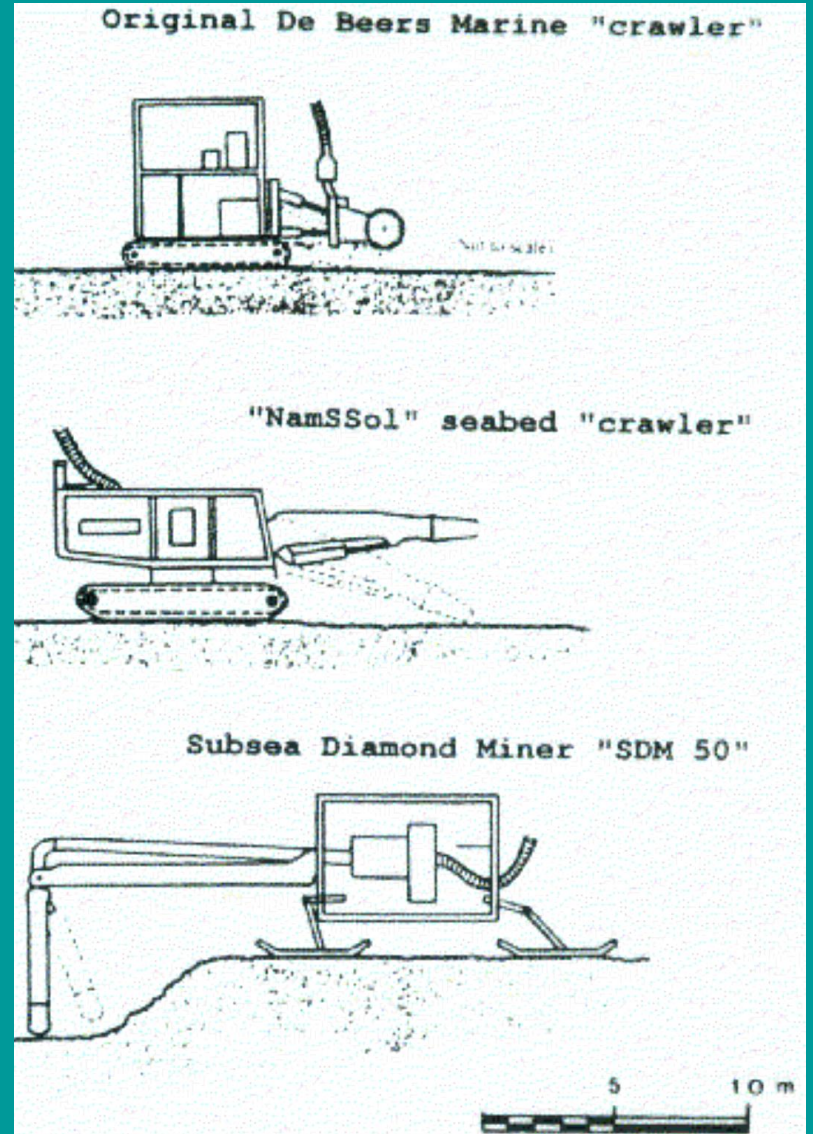


FIGURE 5.9 Large drilling systems modified for marine use.



DeBeers' High-Tech Seabed Mining Machines Now in Use



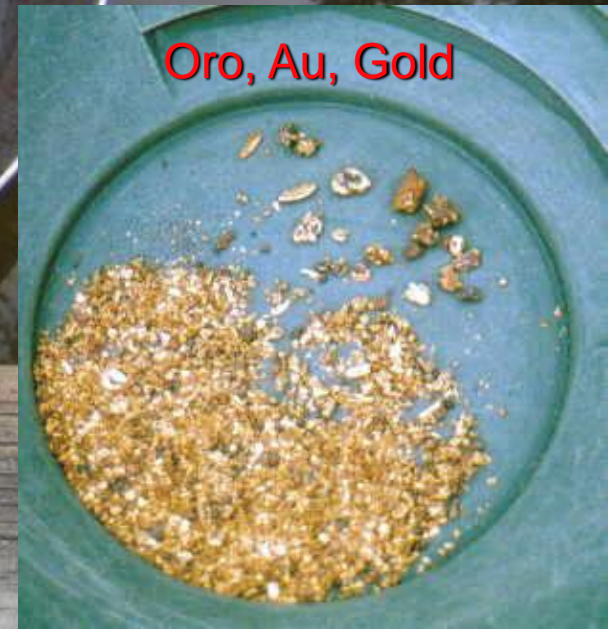
It's Where You Find It.



Sluice, Alaska



Gold Pan



Oro, Au, Gold