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STUDENTS' NOTES

UNDERGROUND METALLIFEROUS MINING

TOPIC-DEEP SEA MINING

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Deep sea mining is a mineral retrieval process that takes place on the ocean floor.

In include extraction of polymetallic nodules or active and extinct hydrothermal vents at about 1,400 - 3,700 meters below the ocean's surface.

The vents create sulfide deposits, which contain precious metals such as silver, gold, copper, manganese, cobalt, and zinc .

The deposits are mined using either hydraulic pumps or bucket systems that take ore to the surface to be processed.

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Problems

- These impacts were categorized as follows:
- direct physical disturbances,
- sediment plumes,
- acoustic impacts,
- waste water disposal,
- machinery leaks or malfunctions.

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Problems

- Disturbances to the benthic layer, increased toxicity of the water column.
- Sediment plumes from tailings.
- Removing parts of the sea floor disturbs the habitat of benthic organisms, possible.
- direct impact of mining the area, leakage, spills and corrosion would alter the mining area's chemical makeup
- Plumes are caused when the tailings from mining (usually fine particles) are dumped back into the ocean, creating a cloud of particles floating in the water.
- floating particles increase the turbidity, or cloudiness, of the water, clogging filter-feeding apparatuses used by benthic organisms.

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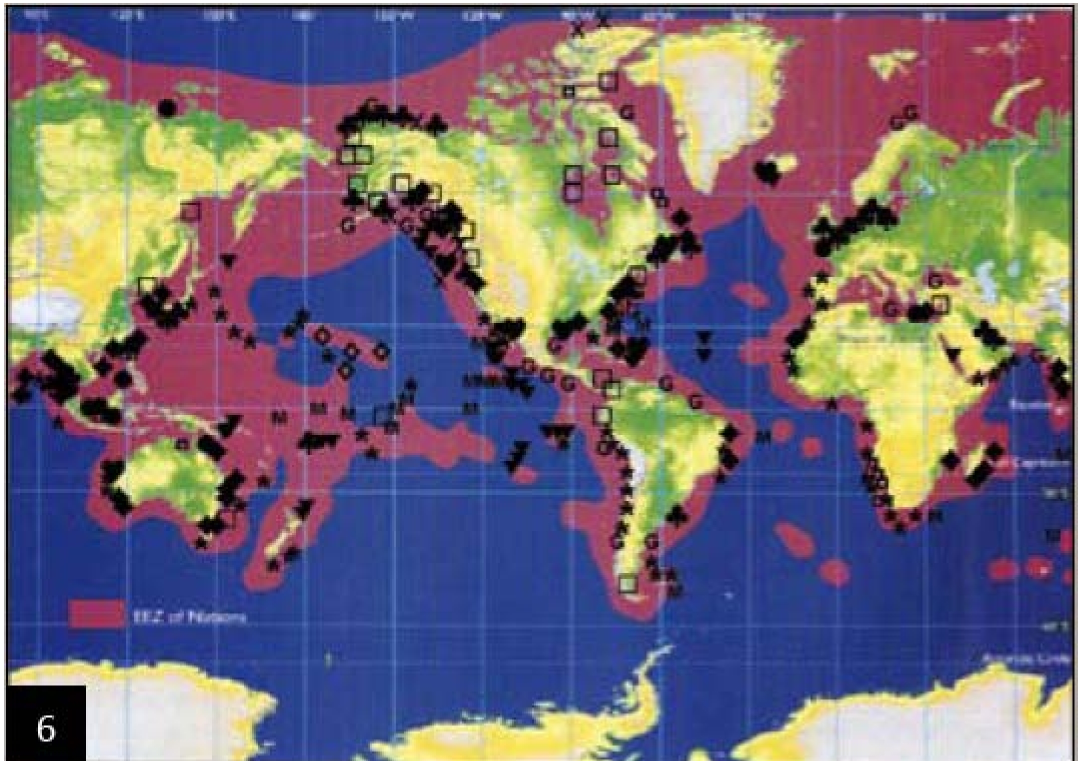

Legend:

□	Au, AG, Pt; X Cr;	*	Phosphorites;
+	Barite;	◘	Diamonds;
♦	Ti,Zr,ReO;	▼	Polymetallic Sulphates;
●	Sn;	◊	Cb crusts;
♣	Aggregates;	M	Manganese Nodules;
♥	CaCo3;	G	Gashydrates

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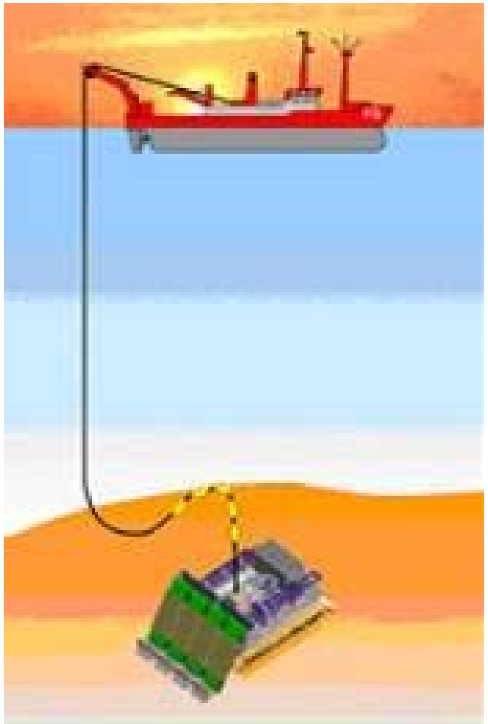
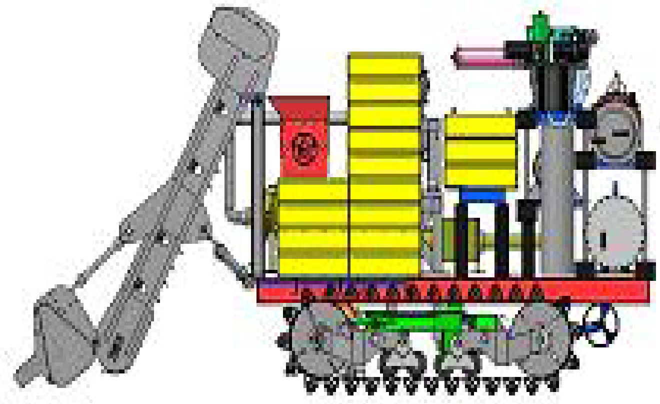
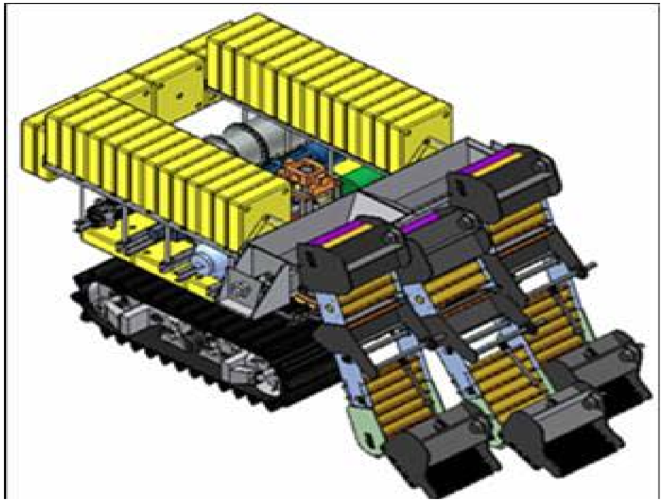
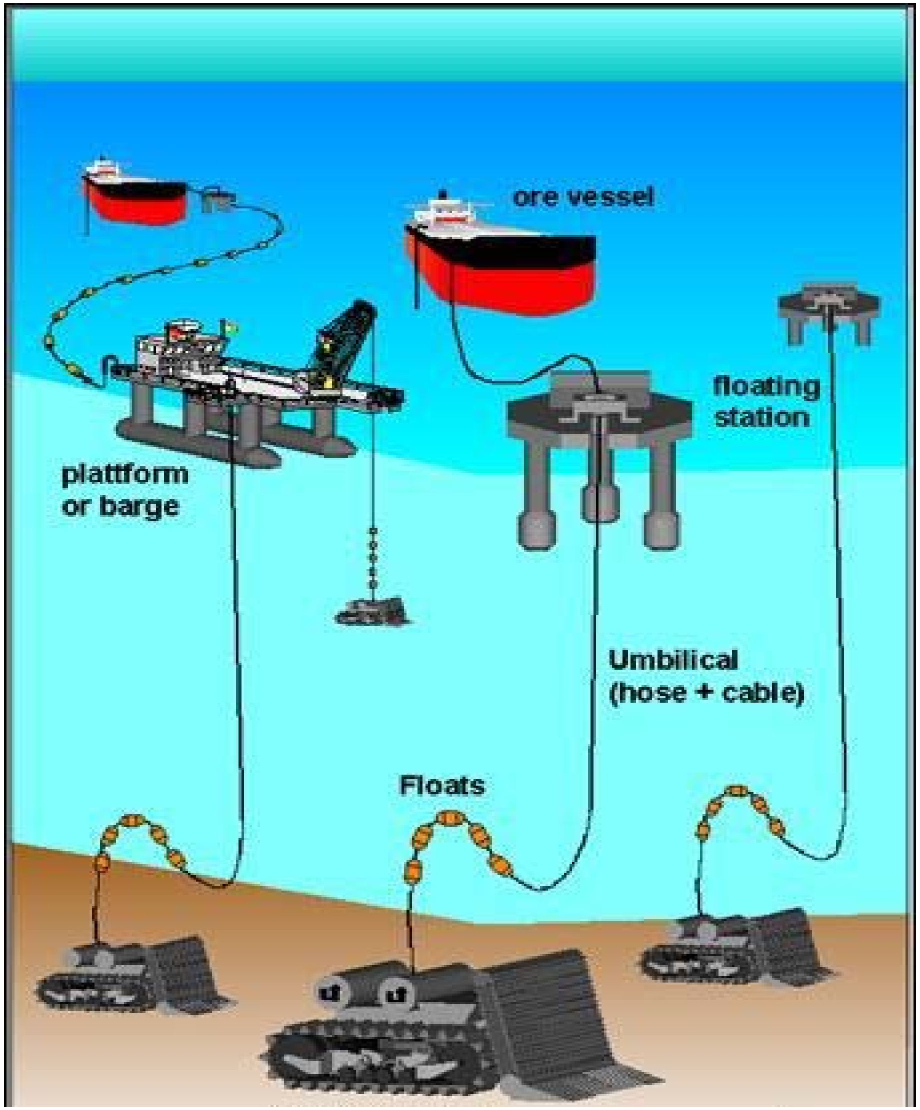


Schematic of Deep-sea Mining System





Crusher System


ore vessel
floating
station
plattform
or barge
Umbilical
(hose + cable)
Floats

Problem is DSM

DSM technology may not need to be large, but it will be required to operate in an extreme environment.

Temperature at hydrothermal vents can be up to 400°C and as low as 2°C short distances away.

The acidity around vents field is a pH of 3-5.

The topography around mining site is very rugged.

Beyond basic functionality, technology will be required to operate safely and efficiently while minimizing environmental impacts.

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Exploration

Locating

Exploratory technology for deep-sea mining is currently in use and is similar to petroleum exploratory technology.

Active vents can be located from the plume, which can be detected up to 10 km away, and tracked it to its source.

Active vent plumes can be located by detecting compounds or elements such as methane and manganese, which occur in the water around the source vent.

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Sampling

Sampling for ore grade and deposit tonnage.

It can be achieved by a submarine, remotely operated vehicle, drilling, or dredging.

Submarines and ROVs are typically equipped with multi-function manipulator arms. ROVs can also be equipped with a drill pack capable of retrieving a 75mm diameter core 15m in length.

Submarines require pilots and are more expensive to operate than ROVs. Submarine depth ratings range between 400-6500m.

ROVs used are depth rated to 3500m and can dive for a week or more

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Drilling

If the initial samples indicate a high-grade ore, and the video and sonar surveys show a SMS deposit of commercially exploitable size, then coring is required.

Grid drilling is used to determine the average ore grade throughout the body of the deposit and to determine its volume.

Drilling can be achieved by drill ship or by a remotely operated coring machine.

The need for a cheaper solution has led to remotely operated coring machines which can be lowered to the drill site thus avoiding the need for long drill strings.

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Extraction

After the size and ore grade of the deposit have been assessed, trial mining may begin.

The ore body is comprised of a combination of loose material such as fallen chimneys, and solid fused minerals such as re-crystallized sulfides and deposition layers.

Second, the seafloor terrain may be rugged due to tectonic

An SMS extraction device can be divided by three components:

1) drive body,
2) ore crusher,
3) ore lifter.

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1. Remotely Operated Vehicles: "Drive body"

The prime workhorse for DSM operations is the ROV. Used originally in transoceanic communications cable laying applications, it has found a new application in DSM.

Minerals, by digging a trench in the ocean floor using ROVs

The flexible nature of the ROV's use of attachments, make it ideal for working in an uncertain environment.

ROVs fitted with drum cutters originally used in terrestrial coal extraction.

The ROV crawls over the seafloor on tracks "after one track length (the 'miner') has made a flat 'road' to operate on"

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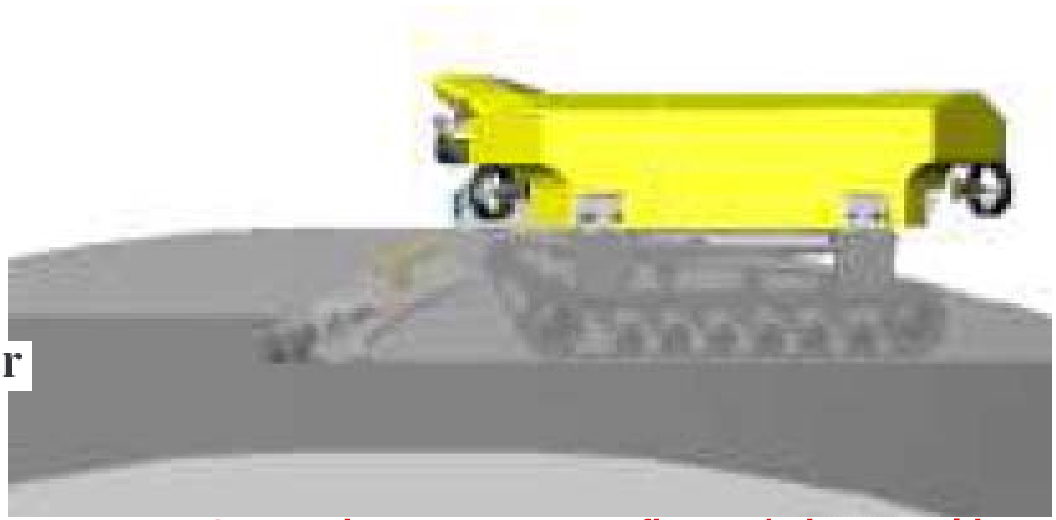
If the seafloor is rugged it may be difficult to set down and apply the proposed big ROVs to cut the first layer.

Therefore, a special ROV which bulldozes the rugged surface and prepares for setting up the proposed big ROV may be needed

Remotely Operated Vehicle



ROV with drum cutter

These ROVs will be powered electrically from an anchored platform, each mining 200 tons per hour.

ROVs operate on an electric-to-hydraulic conversion system.

Typically electric-hydraulic conversion is not very efficient, but modern ROVs compensate for this by "the ability to locate very powerful but compact hydraulic motors right where the power is needed.

Comparatively the power to weight ratio of hydraulic motors is more than twice that of electric"

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Cutters: "Ore crusher"

- Currently, there are two designs for breaking up the sulfides:
  1) A cutter drum used for coal mining applications, and
  2) three-head rotational cutters used for ocean diamond mining.

Cutting teeth on the drum cutter are designed to minimize the production of ultra fine particle and optimized to produce particles averaging 50 mm in size and as large as 70 mm.

Natural particle sizes of the minerals in the ore depend on the formation processes and can range from 10 to 600 microns, though larger sizes can form when "early-formed minerals are continuously re-crystallized by hydrothermal reworking"

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ALPINE
BOLTER MINER

Risers: "Ore lifter"

The SMS ore will then be lifted to the platform and prepared for transportation to a processing plant.

Currently, two methods are proposed.

One is a riser pipe using cold deep-sea water as a transport fluid. The ore is then "dewatered" and the fines recovered by cyclones. Lift water is then returned to a (currently undetermined) location in the water column. A depth of 500 m was suggested

A different method, originally designed for crustal mining, is a "wire-line-bucket method", which uses big buckets connected in series by a wire. This more conventional method is appropriate when the scale is less than a few millions ton per year

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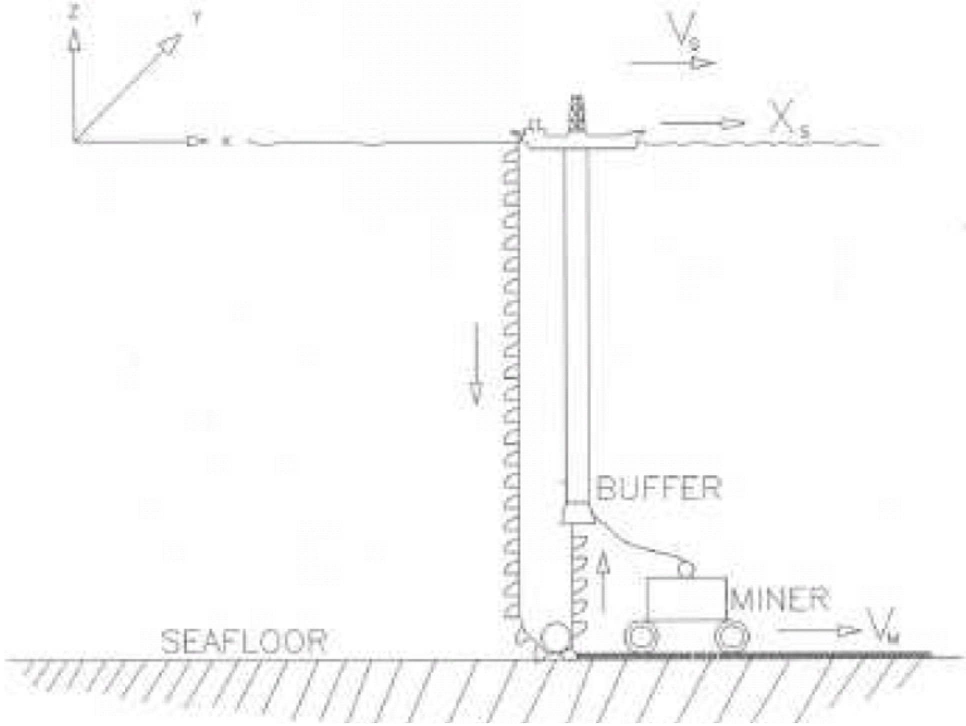
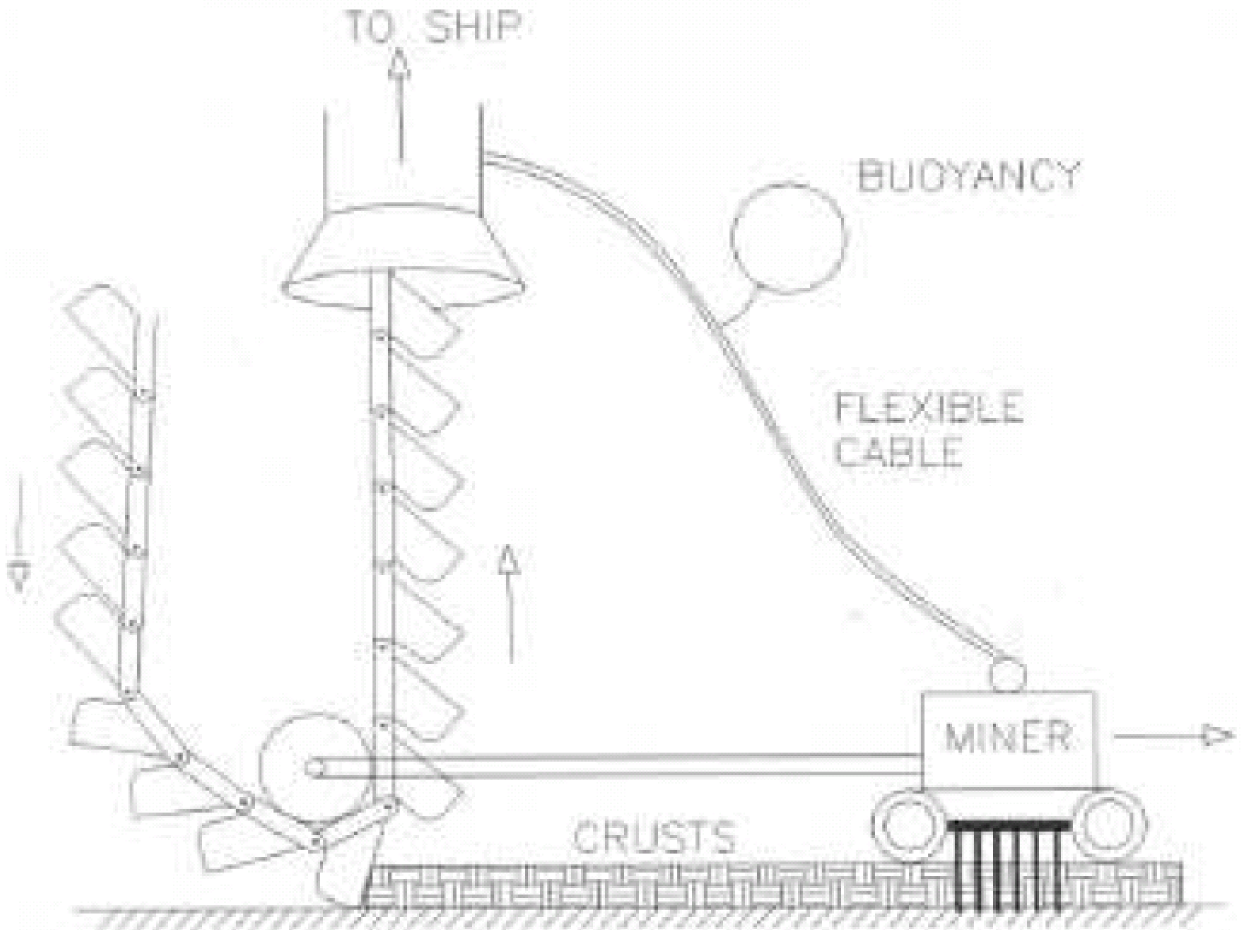


continuous line bucket (CLB) system through pipe;



combined CLB and hydraulic system

Transportation

The ore body will be transported to shore by ships, which means platform-to-shore transport.

Cargo ships generally run off of diesel engines that operate in multi-egawatt range, consuming hundreds of gallons of diesel fuel per hour

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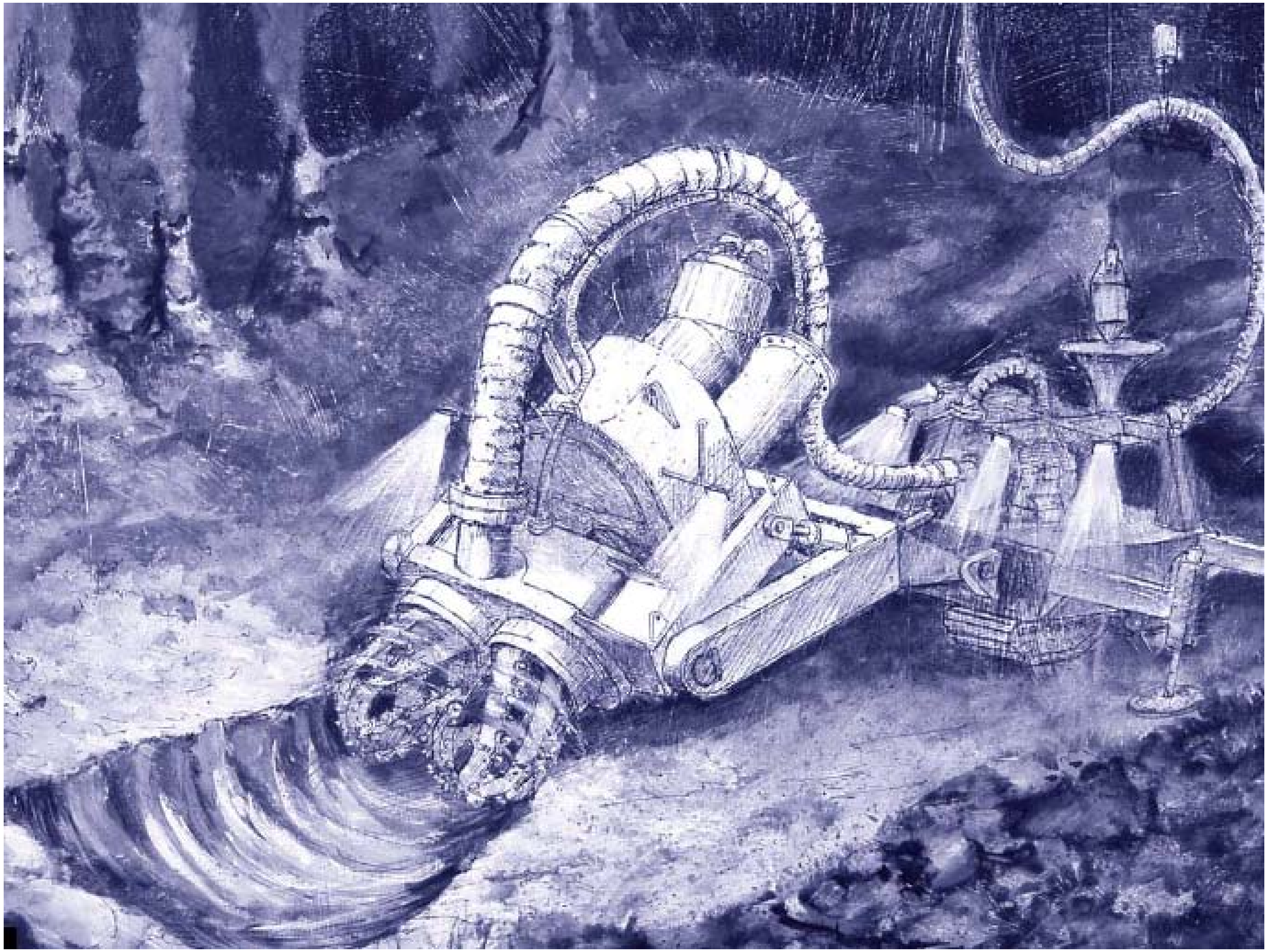


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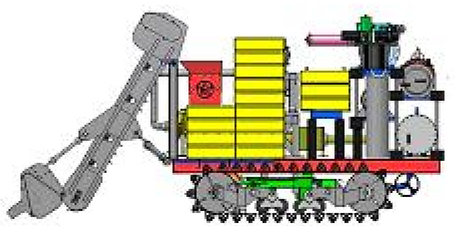
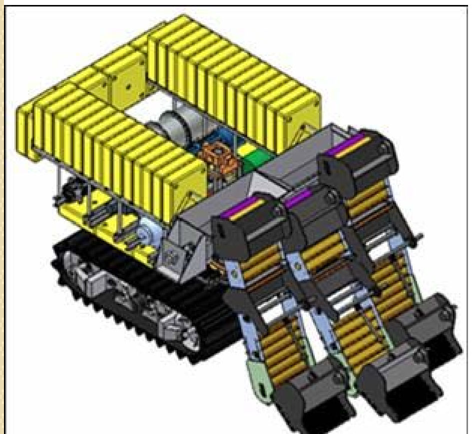
Development of Collector and Crusher system for manganese nodule mining





NIOT had already developed an underwater mining machine for sand mining and successfully tested at a depth of 450m off the coast of Goa. In the second phase a crawler based mining machine with nodule collector, crusher and pumping system is being developed. The system in integrated form consists of nodule pickup and collecting device, sun sea crushing and pumping system with all the instrumentation and drive systems.

The flexible riser concept is being used in this system. The entire structure is indigenously designed and fabricated at NIOT. The system is designed for mining rate of 8 tons/hour of wet nodules with nodule abundance of 5 to 10 kg/m^2 in sea floor. The crushed nodules are pumped to the surface by a solid handling pump capable of delivering 45 m^3 of slurry per hour

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Development of In-situ soil tester

n-situ soil strength values are very useful inputs for design of underwater crawler for mining nodules from soft sea floor. NIOT-Institute Konstruktion (IKS), University of Siegen, Germany team, jointly developed a soil tester capable of measuring soil properties in-situ which was tested successfully in 33m water depth.

The tests were done in Ocean Research Vessel (ORV) Sagar Kanya. The soil tester measures the bearing strength of the soil using a cone tester and the shear strength by using a vane tester. An In-situ soil tester rated for 6000m water depth was developed jointly with Sevmorgeo, Russia. A new winch with drum and pedestal was realized to handle 7000m length umbilical cable.

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