Manganese Resources

THE OCCURRENCE AND DISTRIBUTION OF FERROMANGANESE NODULES

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ABSTRACT

Distribution of manganese nodules in the world ocean is extremely important to the people of Hawaii. This is because Hawaii is the land closest to the largest accumulation of these manganese nodules. This industry may be very important to those of us in the Puna district because a processing plant could be built.

INTRODUCTION

One hundred years ago, the widespread occurrence of ferromanganese nodules and crusts on the ocean floor was discovered during the deep-sea expedition of the H.M.S. Challenger.

These nodules precipitated out of the water over great numbers of years. As the need to find new sources of minerals increases, the distribution and accessability of this resource becomes more and more important.

Ferromanganese nodules have seed grains that serve as a nuclei. In order for ferromanganese accretion to take place, it is imperative that a solid base, regardless of its size and composition, is available for initiation of the process.

There are two different types of nodules that have their own kind of nucleus. One type is the small nodules which are 1-4 cm. in diameter. These nodules have a smooth outer surface and well defined nuclei of yellow grains of palagonite. These small nodules result from the interaction between unstable basalt and seawater.

The second type has an irregular outer surface and a disc to sub-spherical shape. The nucleus is a large fragment of a former concretion. The fragments represent a period of degradation from an earlier period of nodule growth. Features of the nuclei of the earlier period of nuclei development have been erased by total replacement. This is why it is necessary to use the smaller nodules with their well-preserved nuclei as a means of understanding the controls of distribution.

There are two dominant types of ferromanganese deposits each reflecting conditions at the site of deposition. Encrusting material develops on exposed submarine elevations where current activity prevents normal sediment accumulation. This current provides a continuous supply of metals which

accrete to exposed surfaces and form ferromanganese crusts.

The second type is nodular and forms at great depths where sediment accumulation is negligible. In these deep abyssal areas, ferromanganese precipitates about nuclei (volcanic, biologic, glacial, nodule fragment, etc.) and in time the addition of concentric layers results in the formation of nodules.

The distribution of ferromanganese deposits in the North Atlantic is restricted. They have found only scattered occurrences.

Ferromanganese deposits of the South Atlantic and western Indian Oceans are restricted to areas of either non-deposition or negligible sediment accumulation. Ferromanganese is more widespread in the South Atlantic than in the North Atlantic.

The North Pacific Ocean is the largest sedimentary basin in the world. It receives very little land-derived sediments. Their distribution is a function of low rate deposition of red clay (less than 1-3 mm/1000 yr.), and ooze (3.5 mm/1000 yr.). The North Pacific has the highest density of nodular deposits in the world ocean.

The South Pacific is similar to the North Pacific. However, fewer samples of ferromanganese have been recovered and less is known about the sediments of the region.

1. D. R. Horn, B. M. Horn and M. N. Delach

Factors Which Control The Distribution Of Ferromanganese Nodules

2. David R. Horn

Ferromanganese Deposits On The Ocean Floor

MANGANESE NODULES AND THEIR POTENTIAL IN HAWAII

by Randall Bachman, Waiakea High School

Physical Characteristics

Manganese and iron peroxides are distributed on the ocean floor as grains, nodules, slabs and coating on rocks. Small manganese dioxide grains about 0.5 mm. in diameter are almost the same as red clay and organic ooze found in the pelagic areas of world oceans. Frequently rock outcrops are coated with a layer of manganese and iron oxides sometimes 10-15 cm. in thickness. Big rocks, boulders or rock slabs that were carried out by icebergs or seaweed are commonly coated with manganese oxides.

Manganese nodules have been found in a variety of physical forms. Agglomerating colloidal particles tend to form a spherically-shaped concretion. The nodules have been described as appearing like potatoes, marbles and tablets.

Manganese nodules from the sea floor are generally earthy black in color; however, the color may vary from black to tan. Nodules with a high iron content are generally reddish brown while nodules with a high manganese content are blue black in color. The hardness of the nodule is variable ranging from one to about four on the Mohs scale. In size the manganese nodules range between 0.5-25 cm. in diameter. The biggest nodule ever found and kept was dredged from the

Blake plateau off the east coast of the United States--it weighed 55 kgs.

Formation of Manganese Nodules

There are several ways in which manganese is added to the sea. They are: streams; submarine volcanic eruptions; springs; and the decomposition of sea floor igneous outcrops and debris. It is agreed by oceanographers that the dissolution of igneous rocks both on land and on the sea floor, is the major source of the manganese and iron in the ocean. Another theory is that carbonate and sulphate bearing waters act on the sea floor rocks to release manganese, mainly as the bicarbonate. Since there is dissolved oxygen in the sea, the bicarbonate may be transformed to a colloidal manganese peroxide which collects on any convenient hard surface to which it attaches. This theory was a common geochemical cycle of manganese on the continents.

Mining of Manganese Nodules

There are many different methods of mining sea floor surface sediments. There are unmanned crawler-type units which submerge, fill with manganese nodules and surface; there are manned crawler type bathyscaphs which serve as the motor power to pull scraper units along the bottom; and a large submarine with manned spherical control chambers and flooded storage chambers into which the nodules are gathered.

For the immediate future the only two methods of bringing the nodules to the surface are the deep sea drag dredge and the deep sea hydraulic dredge. Probably the best method of mining sea floor nodules is some form of deep sea drag dredge. The type of equipment involved is simple, inexpensive and has been used for about a hundred years to recover sediments at depths of over 30,000 feet deep.

Manganese Nodules a Mineral Resource

Since manganese nodules are full of minerals it would be a good mineral resource, but it is yet to be seen. Undoubtedly, it would be very profitable to mine certain of these deposits, even at present day cost. Laboratory experiments indicate that there should be no major problems in adapting existing industrial equipment and processes to the mining and processing of the manganese nodules. Studies have shown in the past two years that the nodules should be composed of manganese, nickel, cobalt and copper. Other materials such as molybdenum, lead, zinc, zirconium, several of the rare earth elements and possibly iron, aluminum, titanium, magnesium, and vanedium could be recovered as by-products.

Manganese Mining and Processing

Hawaii may soon be benefiting economically from the mining of the vast quantities of metal-enriched manganese nodules which have a large amount of all kinds of metals and

which are found at the bottom of the Pacific Ocean floor. Now in Hawaii people have been working on developing and testing technology and different types of machines to collect the metal-enriched manganese nodules at the ocean floor. There will be more employment available in Hawaii because of providing goods and services to ships and crew that will be mining the nodules near Hawaii. However, the greatest economic benefit would derive from a large processing plant in Hawaii.

Hawaii's locational advantages for attracting such a plant possibly on the Big Island include:

1. Proximity to the richest concentration of manganese nodules.
2. Abundant water supply.
3. Port facilities.
4. Energy supplies from oil shipped from Alaska, bagasse, and eventually geothermal power.
5. Central location between American and Asian markets.

Hawaii Up to Now

Hawaii at present has played only an indirect, limited role in the potential development of a marine mining industry. Honolulu and other parts in the Hawaiian islands have furnished ships for exploration.

Nodule Waste Transportation in Hilo in the Future

Manganese nodules will be mined and then will be transported in barges to Hilo harbor and then pumped in slurry form through a pipeline from the port facilities to the processing plant. Processing wastes will be pumped through a pipeline to the port facilities and onto barges preparing to return to the mine site. These activities are not likely to have a significant impact on the environment except in the case of accidents. Pumping of process wastes, or improper storage of them on land, could have significant impact. At the port at Hilo, special facilities would be required to receive nodule shipments. A special unloading pier will have to be built with three ponds: one to take the nodules, one to take the trace nodules; and one for water which will also be needed. Then the nodules will be transported eight to nine kilometers to the Puna District near Keaau. It is assumed that the reduction ammonia leach process will be used to extract nickel, copper and cobalt from the nodules. Most of the chemicals needed for processing nodules will be imported from the mainland. The wastes from the processing will perhaps go back to the port and back on the ship and be taken back to the mining sight. Metals recovered by the processing will be shipped to the mainland or other metal fabricating plants.

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MINING THE OCEAN FLOOR

by Cindy Aoki, Waiakea High School

Manganese nodules are black, pea to potato sized and shaped. They are authigenic deposits composed chiefly of metal oxides. Manganese nodules are formed when manganese and iron oxides from land form an accumulation on other deep sea sediments and continue to grow as coat after coat is added. These nodules are found in abundance on the ocean floor. Hawaii is near a belt of high grade manganese nodule deposits that is located just off the coast of Central America at a point southwest of Hawaii. Because these nodules contain quantities of iron, nickel, copper and colbalt, there are several proposals for obtaining them and using them for mineral resources. Present indications show that the first commercial recovery of nodules for extraction of nickel, copper, colbalt and possibly manganese will begin in the mid 80's.

Different consortia favor different processing techniques, which prove that more than one technique is economically feasible.

One of the nodule collection devices to be used in Hawaii is that of the Deep Sea Miner II. This consortium is led by Deep Sea Ventures. The Deep Sea Miner II is a 20,000 ton, 560 ft. converted ore carrier. Its 70 ft. high, 52 ft. diameter geodesic dome provides a weather cover for a 55 ft. high gimbal mounted derrick which can support up to one million pounds of dredge pipe. A dredge head is lowered over the side of the ship and keel-hauled under a 27 ft. wide by 34 ft. long moon pool. The pipes are pulled up through the moon pool, a large rectangular vertical hole through the center of the ship.

The SEDCO 445 of the INCO consortium has air lift pumps which inject air into a 9.625 in. diameter pipe string at depths from 5,000 - 8,000 ft. Submersible hydraulic pumps are installed in the pipe string at a depth of about 3,000 ft. A nodule collector head 40 ft. wide can collect up to 250 tons of nodules per hour, during full scale operations.

These are just a few of the techniques used. There are many others who have also been collecting and testing.

A manganese nodule processing plant in Hawaii would have various effects. An economic impact is expected on the state and county. Although millions of dollars would be needed to build and maintain such a plant, it would also create many new jobs. New laborers will be needed for construction of the plant and machinery. After the plant is established, workers will be needed to man the processing plant, the nodule ships, and for ocean, land and air transportation. This creation of new jobs would cause a personal income increase. A nodule processing facility can also be expected to generate sizeable federal, state and county tax revenues.

The mining of manganese nodules will have a definite effect on the environment. Sea floor mining operations will disturb the bottom sediments and other various sea organisms, therefore throwing the balance of nature off. Processing wastes will be returned to the mine sites. This dumping of wastes or the improper storage of them on land could have a significant impact on our environment.

The amount of manganese found on land is limited, because of this it is an important potential economic resource. Manganese nodules will be processed for their nickel, copper and colbalt content and possibly for manganese, molbdenum and other metals as well. The United States is almost completely dependent on foreign supply of nickel, colbalt and manganese. Nodule mining and processing could reduce this dependency considerably.

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POSSIBLE METHODS AND PROBLEMS OF MANGANESE NODULE MINING

by Kevin Jackson, Waiakea High School

INTRODUCTION

Today the United States imports vast amounts of resources from overseas to meet the demands of it's growing industry. Some of these resources we depend upon to run our factories, provide electricity for our homes, and make steel and other metals which are vital to our ecomomy. With improved mining technology some of these vital minerals can be gathered in vast quanities, reducing or even stopping our dependence on foreign countries. Manganese nodules are part of the answer because they are abundant and contain vast amounts of minerals.

HYDRAULIC DREDGE SYSTEM

Manganese nodule mining requires specialized equipment because it usually takes place in waters which are between 15,000 to 18,000 feet deep. Currently there are two methods under investigation which are capable of mining nodules at such extreme depths. Of the two possible systems the hydraulic dredge system is favored because it has a greater commerical potential.

Basically the hydraulic dredge is like a huge vacuum cleaner which picks up nodules by suction. It looks rather like a large sled which is connected to the mining ship by 18,000 feet of pipeline. When in operation the dredge is slowly towed behind the mining ship by its 18,000 feet of pipe. As the dredge is towed, a powerful pump sucks up the nodules and transports them through the pipeline to the mining ship above. To prevent clogging of the dredge, it has a screening device which will shuttle aside nodules too large for the pipeline.

Through clever engineering several potential mechanical problems were solved.

The first problem is how to get the nodules from the dredge and through the pipeline, to the mining ship, which could be floating as much as 18,000 feet above the dredge. There were two possible solutions to solve this problem.

One solution employed the use of submersible pumps to draw water and nodules up through the pipeline. The second solution used compressed air injected to several points along the pipeline which rises and expands to provide a lifting force.

Another problem was concerned with the stress and strain on the pipeline. To solve this problem, special joints were used to create a string of pipeline strong enough to withstand the stress of its own weight and the stress of the dredge being towed along the bottom.

Finally a specialized hydraulic mast and transfer system was invented, which was capable of handling the 18,000 feet of pipe line, it also pivots freely to keep the mast at a vertical position regardless of the ship's pitching during rough seas.

To aide in the location of manganese nodules, each dredge will be equiped with T.V. cameras and flood lights to allow the controlers to scan the ocean floor.

Bucket scoop system

The other system is the bucket scoop system which is not as favored as the hydraulic system but still has commercial potential.

When mining with the bucket scoop system, the buckets on a long loop of cable strung between 2 ships will scrape the bottom, emptying the contents on one of the ships, then rotate to the other ship where they return to the bottom in a continuous rotating cycle.

The main advantage of the bucket bridge system over the dredge ststen, is that it can scrape nodules up along a wide path.

Potential of manganese mining

The potential of manganese mining has a very promising future with 15 to 20 mining sites in operation by the year 2010. The Department of interior estimates that there are 180-460 commercially viable first generation mine sites which are available. What makes manganese nodules a reality in the near future is the United States shortage of certain minerals which are abundant in the nodules, such as nickle, colbalt, manganese, and copper. Right now the U.S. imports 71 percint of it's nickle, 98 percent of it's cobalt and manganese, and 15 percent of it's copper.

The proposed processing plant on Hawaii will be a large operation capable of handling 3 million tons of manganese nodules per year. The mining of the manganese nodules will take place about 1,000 miles south of Hawaii, in a nodule field which has manganese nodules high in mineral content. After the nodules are mined they will be transported to the port of Hilo using a tug and barge system. When they arrive at Hilo, the nodules will be pumped in slurry form, through a pipeline to a processing plant about 8 to 10 miles south from Hilo in the Puna district.

The processing plant will probably recover nickle, copper, and cobalt; then despose of the waste by pumping it through a pipeline back to Hilo, where it will be loaded on barges, and dumped some time during the barge's return to the mine site.

Possible Environmental Problems Of Nodule Mining

With these good aspects of nodule mining there are also some bad ones, such as environmental problems that could arise from mining oprations. At present marine biolgists don't know very much about ocean bottom organisms which could be hurt by the mining dredges tearing up the sea bottom. To prevent these possible enveronmental problems the National Oceanic Atmospheric Administration have scientists studying the bottom organisms to determine how much and what kind of damage nodule mining will do.

One Potential environmental problem which could arise from nodule mining is the seafloor may be scraped as deep as 2 inches, violently displacing organisms accustomed to a life of little change. Another problem which might arise is the stirring up of sediments, which could bury bottom organisms upon resettling. In recent months scientists have identifed over 20 nodule dwelling organisms which live in the pore spaces of the nodules. If mining becomes a large scale operation all the organisms living on the nodules picked up by the dredge will be destroyed.

Possible Environmental Problems of Waste Disposal

The dumping of waste and ocean bottom sediments as a result of manganese nodule mining operations could be harmful to the marine enveronment. Waste dumped from the surface into the photic region will block out some sun light, which will interfere with photosynthesis. Perhaps this will be offset by the introduction of nutrients from the deep, increasing productivity.

The most serious environmental problem that could arise from dumping might be the eutrophication of the upper waters of the ocean, as has occurred in Lake Erie and countless other bodies of water.

SUMMARY

In the near future manganese nodule mining will become a large industry which will supply the world with much needed minerals. There is a possibility that other forms of ocean mining will come into reality such as extracting minerals from sea water and the development of aquaculture. However, with all the industrial potential that the ocean can provide, we must not overlook the environmental problems which could arise. The sea can be a great benefactor to mankind if used wisely, but if mistreated it will provide us with very little.

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