Gold in the Sea

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Prospecting for gold has turned to the sea. A recent marine venture along the Atlantic seacoast of Nova Scotia has brought to light significant quantities of sea bottom alluvial gold. Several deposits have been discovered by a unique drilling method at sea, and plans are underway to further exploit them by a suction dredge sample mining operation.

It has long been known that the sea covers substantial mineral deposits. Of particular speculative interest are those minerals termed “heavy minerals,” which are often found in concentrated form, caused by the wash action of water.

Mining and mineral exploration interests are increasingly active in investigating the ocean depths as a possible source of mineral wealth. The existence of offshore mineral deposits and their potential wealth is becoming more evident as better investigative techniques are put into use and heretofore unknown deposits are revealed.
The reflection of bottom strata likely to contain gold in a seismic tracing like the one shown above may lead to a successful strike. On the bridge of an exploration ship (right) a man raplty watches the tracing unfold.

(All illustrations provided by the author.)

A look at the prospect of ocean mining is a look at a certain future event for the mining industry.

As known land sources of minerals become more scarce, new sources will need to be found. The sea, still largely unexplored, offers vast potential for mineral removal. Offshore mineral exploration activities are surging ahead to meet the needs and demands of an affluent society that is willing to pay the increasing costs of metals.

Ocean prospecting and mining activities have now reached a point where a few breakthroughs may bring new, untold mineral wealth to within man's reach.

During the summer of 1968, Ocean Science and Engineering, Incorporated, Washington, D.C., under contract to Matachewan Canadian Gold, Ltd. of Montreal, Quebec, carried out an offshore mineral exploration program covering most of the southeast coast of Nova Scotia, Canada. The primary objective was to locate and
Canada's gold coast centers about the Ovens Peninsula of Nova Scotia. On the map above, black dots indicate strikes of gold. Region I is the richest deposit and Region II is the one discovered first. Values go up to $4 per cubic yard.

drill sample marine gold placer deposits, although the possibility of finding other valuable mineral deposits was not excluded.

Onshore Mines Suggest Marine Riches

Onshore and marine geologic indicators, coupled with subbottom seismic reflection techniques, were used to locate suitable drill sites. An 86-foot steel ship, the M/V Polarfish, was used as the support vessel for the site location and for subsequent drilling operation. A total of 268 miles of seismic acoustic profiling and 187 drill holes in alluvium were accomplished. Two weeks were devoted to a study of the marine geologic environment, two months were spent at sea drilling and obtaining seismic subbottom information, and an additional two weeks were spent diving and surveying mineral deposits that were located.

Initial studies of the geology of onshore gold ore deposits of Nova Scotia indicated the likelihood of similar deposits existing in offshore areas. Geologic trends, together with past sea current and beach wave action phenomena, made some prospective offshore sites even more attractive than many of the past high gold-yielding onshore sites. A study of offshore sediment movement and resultant fea-
A prospector's platform, the M/V Polarfish was used as a support vessel for site location and drilling operations. In one season she logged 268 miles of seismic acoustic profiling and 187 drill holes.

...tires aided in properly interpreting the geologic significance of sea bottom configurations.

Beginner's Luck

Gold in the sea is found under geological conditions similar to those existing where it is found on land. A good portion of the peripheral area adjacent to land and now beneath the sea was subjected to weather and stream erosive forces as we know them today. In addition, fluctuating sea levels brought these areas under the influence of beach wave action and sea currents. Areas for exploration were selected first by determining whether the geologic factors were conducive to the formation of gold lode deposits, both onshore and offshore. Once such areas were selected, then a detailed study of the past and present features of the sea bottom was undertaken to locate suitable drill targets such as buried stream channels, scour basins, ancient beach lines, and any other features that indicate water has been at work segregating and concentrating heavy minerals.

Emphasis was placed on searching for heavy mineral concentrations, but exploration was not restricted to that end. A broad view was adopted toward locating any products that might prove...
to be profitable. A few examples of products other than heavy minerals that might be discovered are phosphate deposits for fertilizers, clay deposits for ceramics, sand and gravel deposits for construction, and shrimp and clam beds for human consumption.

A brief look at geologic processes indicated that vast areas of valuable mineral deposits must exist in the sea as they do on land. First, the sea area exceeds that of the land area, which implies that, other things being equal, total mineral quantity should be greater. Second, there are huge quantities of minerals in solution in sea water for which we lack commercial extraction processes. (Some natural extraction of minerals takes place continually by precipitation.) Third, the sea is more favorable than land for the deposition and concentration of mineral deposits because of its movements. Fourth, the land surface is being reduced by erosion, and new minerals are constantly being added to the sea by river and wave action.

Search Beneath the Bottom

The exploration program began with a study of the marine geology, relating it to onshore areas, particularly those having a history of gold production. Small sea bottom features could be studied by contouring marine charts. Specific drill targets were selected in nine priority target areas of about 30 square miles each, extending along 190 miles of the Nova Scotian coastline.

For the exploration cruise, personnel and equipment were gathered from many sources, mostly the United States. The majority of the drill sampling and processing equipment was built at dockside where it could be accommodated to ship design. The seismic reflection equipment was shipped from the United States and fitted onboard. Some minor ship modifications were required to properly handle the drill and seismic tow equipment. Complete mobilization of ship, equipment, and personnel required fourteen days during which time some onshore geologic reconnaissance work was also performed.

A Flexible Drill

A unique drilling method was selected as being most suitable for a rapid reconnaissance survey such as this one. It consisted of a combination high-pressure water jet stream pipe for cutting into alluvium and a 3-inch diameter air lift pipe for vacuuming the hole cuttings and conveying them to the ship through hoses. The jet and airlift pipes are connected to the ship only by a cable for control and support and hoses for the jet water and return sediment vacuum line. Such an arrangement allows an anchored ship to move about the drill hole in rough seas without damage to equipment or danger to shipboard personnel.

Hole cuttings returned to the ship were broken up, mixed with water, and passed over riffles in a 4-foot wide sluice box, which extracted the gold and other heavy minerals. In order to get a gold quantity evaluation, all sluice box tailings were stored and measured in tanks after processing.

A high-frequency 3.5 kHz seismic reflection pinger system was mounted in a streamlined towed “fish” and gave a direct visual printout on a shipboard
Hole drilling in 10 fathoms, crew members (right) read the progress of the drill by holding control cable. The large hose delivers water and sediment aboard. When solids become jammed within it, they must be pounded loose (below).
Seabed mud is sluiced down in this view looking aft on Polarfish. Gold and other heavy metals will be extracted by this process. The tailings, or remaining muds, are passed into measuring boxes, foreground, for gold quantity evaluation.

recorder. It provided good resolution and penetration of subbottom geologic materials for drill target selection.

Each area investigated provided a new set of geologic riddles to be solved before meaningful hole drilling could be planned. Some drill targets were preselected, while others had to be reasoned out at sea. Extensive seismic traverses were required in areas where prime targets could not be easily discerned. A locality whose geology sug-
gested gold potential could be tested by drilling one or more holes in it.

After a brief seismic reconnaissance cruise period, a preselected target in 7 fathoms of water was drilled. This first cruise drill hole yielded traces of gold, enough to warrant other drill hole investigations in the nearby vicinity. The targets selected were in ancient buried stream channels that were once above sea level. Each successive drill hole yielded progressively greater amounts of gold, a good showing for a first attempt. A potentially economic deposit had been found. Subsequent drilling outlined the deposit limits and, coupled with seismic records, allowed its total volume to be estimated. No holes drilled in the vicinity of the deposit were barren of gold. Values ranged from a few cents per cubic yard in fringe areas to over four dollars per cubic yard near the nucleus of the deposit.

The Largest Deposit

After drilling fifty holes in this first-discovered deposit, the exploration ship was moved to another target area with plans to return if cruise time permitted. The ship was brought to this area at a later date and a second nearby gold deposit located. Measured gold-bearing alluvium in these deposits totaled 6 million cubic yards.

Each of the exploration areas was investigated in turn according to priority. Another preselected target area some 140 miles northeast of the first gold-yielding area ranked high on the exploration priority list. One zone in the area offered a classic drill target for investigation. (The zone lay at the intersection of a major strike-slip fault and the crest of an anticline 3 miles offshore.) Nearby onshore areas having a past gold-producing history showed gold lode deposits occurring regularly in just such situations. A study of the bathymetry of this zone, coupled with seismic records, revealed a large dome-shaped bottom feature. Indications were that it was a remnant of a once fair-sized hill or mountain, which meant that it had been eroded away by weathering and possibly glacial action. If such a feature had been weathered and transported away, there was a good chance that the gold, which is difficult to wash away, was left behind in concentrated form.

After drilling several holes in this zone, the presence of coarse gold in the cuttings confirmed that it was a gold producer. Extensive seismic traverses revealed that the deposit was very large in extent and volume, a minimum of 36 million cubic yards, the largest yet discovered. It lay in 14 to 21 fathoms of water and resisted drilling efforts because of the water depth and difficult anchoring conditions. Gold values ranged up to 30 cents per cubic yard. The most significant indication of it being a potential economic deposit is that drill cutting consistently yielded coarse gold particles, which are generally indicative of a nearby source.

Treasure Hides Itself

Coarse-grained gold requires a lot of energy to be transported very far from its source. Gold particles are freed from their host rocks by chemical and mechanical weathering. Gold, because of its high density and tendency to "hide" beneath and behind
large rock particles, lags behind other materials being washed away. Coarse-grained gold is transported with coarse sands and gravels and generally is re-deposited with them. It is these coarse sands and gravels that are most sought after when looking for gold.

Following the Colors

Fine-grained gold may be minute specks or very thin flattened pieces that can be carried long distances in a stream that will not move coarse gold. Such fine gold, called “colors,” is readily visible in processed samples but may amount to as little as 2,000 particles to the cent in value. Once fine gold is released to the sea, it may spread over a wide area. Generally, there is a net movement of the bulk of these fines in one direction. It is up to the marine geologist and oceanogra-

PANNING FOR GOLD is an old method, but it still works. Lighter sediment is washed away by the stream, leaving the coarser sands, gravels, and grains of precious metal at the bottom of the pan.
pher to use these fine "colors" as indicators of the direction to their source and the lagging coarse gold particles which may be concentrated in an exploitable deposit.

Prospecting Land and Sea

Marine prospecting for gold, then, is somewhat similar to prospecting on land in that the prospector first picks a likely area and after finding a sign of gold, endeavors to trace it back to its source by reasoning out the path along which it traveled. A study of the structural geology and the geology of ore deposits of an area is essential in any prospecting effort, land or sea.

During the two-month cruise period, three significant gold deposits were located, which have a combined total volume of 42 million cubic yards of gold-bearing alluvium. A few areas yielded a "show" of fine gold, but none was worthy of further investigation.

Poor weather and corresponding high seas at times threatened operations, but because of the versatile drilling method an impressive number of holes were drilled. Drill hole footage amounted to 1,447 feet for 187 holes and 226 long tons of drill hole cuttings were pumped to the ship and processed for heavy mineral extraction.

The Waiting Wealth

At this writing, Matachewan Canadian Gold, Ltd. is in the process of building a special design suction dredge to further exploit these deposits to determine future mining requirements.

The dredge is being built near two of the deposits at Lunenburg Bay, Nova Scotia. When completed, it will be put to work sample mining by trenching across the gold deposits down to bedrock. The dredge will suck up sea bottom gold-bearing alluvium from 60 feet beneath the water surface, bring it on board, extract the gold, and return the cleaned tailings to the sea.

Initial dredging and processing capacity will be about 150 cubic yards of alluvium per hour with design reservations for future increased capacity.

This summer, two of the known gold deposits will be evaluated and mineral reserves blocked out. Further survey work and prospecting will be carried out in various nearby areas in conjunction with the dredging operations.

Accepted methods of mining mineral deposits are based on the accumulated information of past efforts, most of which dealt with onshore deposits. Offshore mining brings into focus a new set of environmental factors, many of which are alien to the mining industry as it exists today. It remains for technical people to solve the environmental factors that present problems and to derive methods by which many of these problems can not only be simply overcome, but turned to their advantage.

The potential of minerals in the sea is real and only awaits discovery and sufficient advances in mining techniques and mineral shortages to make it a commercial reality.