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Deep Sea Mining. Environmental Impacts on the Sea Floor

Deep sea minerals have been seen as a potential new source for in demand metals and rare earth elements. Offshore sector firms are eyeing the potential for a new revenue stream. Elaine Maslin reports.

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Featured image: Nautilus' sea floor production tools, made by Soil Machine Dynamics (Source: SMD)

Many are looking to a new resource, deep sea minerals, thanks to growth in demand from emerging economies and the development of new technologies that require increased supply of metals such as copper.

While interest in mining metals from the deeps has been ongoing since the 1960s, activity has remained low, due to low metal prices and the challenges of operating in deep sea environments. This activity is also the focus of strong local and environmental opposition.

Slowly, however, the pieces have been falling into place to permit this activity. In 1982, the United Nations Convention on the Law of the Sea (UNCLOS) established the International Seabed Authority (ISA), based in Jamaica, to organize and regulate mineral-related activities in seabed areas beyond the limits of national jurisdictions.

More recently, the MIDAS project, which sought to assess the environmental hazards of deep sea mining, reported its findings. Many in the offshore sector, with technologies that could be complimentary to this space, are watching, but there are still concerns over its impact.

All that glitters

According to the MIDAS program, there are three types of resource: polymetallic (or manganese) nodules that occur in surficial seafloor sediments in abyssal plain muds, mainly in the Pacific and Indian Oceans; cobalt-rich ferromanganese crusts (CRCs) that occur as a surface encrustation on seamounts and rock outcrops in all oceans, but with the richest deposits found in the western Pacific; and seafloor massive sulfides (SMS) that are formed at seafloor hot springs along ocean plate boundaries.

Polymetallic (manganese) nodules – 2-15cm in diameter– can be found some 4-6km deep, and could provide a source of copper, nickel, cobalt and manganese, as well as rare earth elements. Mining them, and others, requires a combination of remotely-operated or autonomous underwater vehicles, pumps, suction and riser pipes, Italian shipbuilder Fincantieri's Marko Keber told the Offshore Mediterranean Conference (OMC) in Italy, in March.

Polymetallic sulfides, meanwhile, are found in 1500-3000m water depth and are made of sulfide minerals containing various metals, such as copper, lead, zinc, gold and silver. CRCs are found in 800-2400m water depth, and are composed of ferromanganese oxides and contain cobalt, nickel, manganese, tellurium, rare earth elements and possibly platinum, Keber says.

Activity

Since 2000, the ISA has signed 13, 15-year exploration contracts. Six of these contracts expired in 2016 and a seventh will expire in 2017. The areas being explored are in the Clarion Clipperton Fracture Zone, the Indian Ocean, Mid-Atlantic Ridge, South Atlantic Ocean and the Pacific Ocean, according to an ISA report from last year.

There are concerns relating to impact of the mining systems on the sea floor, the creation of sediment plumes as a result of seabed operations, the integrity of the riser pipes and the release of waste materials following pre-processing of the minerals at the sea surface, says MIDAS, which conducted research from the *Pelagia* vessel from 2013-2016.

> "The scale of these impacts needs to be assessed so that the development of regulations to control mining activities can be properly informed."
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> "New environmental issues need to be considered, such as the large surface areas affected by nodule mining, the potential risk of submarine landslides through sediment destabilization in gas hydrate extraction, or the release of toxic elements through oxidation of minerals during seafloor massive sulfides (SMS) mining," MIDAS adds.

Some of MIDAS' work on sediment-laden plumes showed that they could have significant impact on ecosystems tens of kilometers away from the mined sites. MIDAS project scientists said that investment in technology (to limit the generation of plumes during mining) and in legislation (to make sure all contractors adhere to best practice) would be needed, as well as more research. Even with legislation, opposition is likely to remain to this activity.

Exploration plows on

Nevertheless, activity is ongoing. Most recently, ISA and China Minmetals signed a 15-year exploration contract for polymetallic nodules over a surface area of 72,745sq km of the Clarion-Clipperton Fracture Zone in the Pacific Ocean.

China has also been sponsoring another contractor with the ISA for the exploration for polymetallic nodules in the Clarion Clipperton Zone since 2001, and for which a five-year extension was signed this year. China also sponsors the China Ocean Mineral Resources Research and Development Association (COMRA) in contracts for exploration for polymetallic sulfides in the Southwest Indian Ridge and for exploration for CRCs in the West Pacific Ocean.

In January, ISA approved a plan for Poland to explore for polymetallic sulfides in the Mid-Atlantic Ridge between the Hayes, Atlantis and Kane transform fault zones, with 100, 10×10 km exploration blocks.

Nautilus

Nautilus Minerals could be the first company to commercially explore the sea floor. The company plans to search for SMS systems, a potential source of high grade copper, gold, zinc and silver.

Nautilus is developing a production system using existing technologies adapted from the offshore oil and gas, dredging and mining industries.

Its first project, a copper-gold project, Solwara 1, is due to start development offshore Papua New Guinea in Q1 2019, subject to financing.

Canadian-listed Nautilus has been developing the kit it needs for carrying out this work, including three sea floor production tools (SPTs), a riser and lifting system (RALS), a launch and recovery system (LARS), and a production support vessel (PSV).

The SPTs, built in northeast England by Soil Machine Dynamics (SMD), arrived in Papua New Guinea earlier this year and are being put through trials. Work on the production support vessel, including integrating the LARS and ancillary equipment, is ongoing at Fujian Mawei Shipbuilding's Mawei shipyard in China.

The SPTs comprise three different vehicles, one each for three separate sea floor tasks. These are an auxiliary cutter to prepare the sea bed for the second tool, a more powerful bulk cutter. This is then followed by the third vehicle, a collecting machine, which then pumps the seawater slurry through a flexible pipe to the PSV via a riser system. Following initial processing, materials would be transferred to a Handymax vessel for shipment.

The cutting drum of the bulk cutter was designed and built by Sandvik; all the SPTs track sets were designed and built by Caterpillar. Modification to the track set for subsea operation and required cutting duty was completed by SMD in consultation with Caterpillar and Sandvik. The dredge pumps for all three SPTs were supplied by Damen. The hydraulic equipment for all three SPTs is based on existing Bosch Rexroth hydraulic equipment, with adaptations by SMD.

GE Oil & Gas has been involved in the development of the subsea slurry and lift pump. The riser has been designed by Nautilus' RALS main contractor, Technip, and built by subcontractor General Marine Contractors. An agreement for the charter of a PSV to be first deployed at the Solwara 1 Project was awarded to Dubai-based Marine Assets.

Nautilus is also weighing operations offshore Fiji, Tonga, the Solomon Islands, Vanuatu and New Zealand as well as other areas outside the Western Pacific.

Opportunities

Many others are watching. Deep sea mining could offer offshore industry firms a new business, and Italy could be at the forefront of this business, Keber told OMC.

> "The deep sea mining chain is practically the same as you have in other extractive industries. Exploration, seismic, production, logistics, processing, distribution and sales," he says.

Keber notes similar technologies are used in the planning and production phases, and says that the support vessel being developed by Nautilus for SMS recovery is similar to

Fincantieri's Overdrill drillship design.

> "We are mostly interested in surface vessels," he says. "The configuration [of Nautilus' ship design] is similar," he says. "The power requirement is similar. Both are dynamically-positioned. The size is similar. The migration is a reality, it is possible."

SMD has also continued its work in this space, teaming up with South Africa-based Underwater Mining Solutions, which already supplies shallow water mining equipment, to offer full scope subsea mining equipment.

The most developed area of the supply chain is the logistics, i.e. transporting ore from the production vessel to the coast for processing. The least developed part of the chain is the subsea part, Keber says. And, a potential gap exists for the development of a nodule or CRC production vessel, he says.

Norway has also been investigating deepsea mining, with projects including DeSMO and Marmine underway.

DeSMO is a pre-study to identify technology research and development opportunities, while MarMine completed a research mission over the Mohn's Ridge area earlier this year. Work included drilling a core in 2700m water depth with an ROV-based drill rig.

The system was delivered by Seattle-based company Williamson and Associates and is custom made for ROV operations. It was deployed from the *Polar King* research vessel, operated by GC Rieber.

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