



# SOUNDINGS

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The International Marine Minerals Society of SME

## Welcome to the new *Soundings*

This issue of *Soundings* is the first since the International Marine Minerals Society (IMMS) agreed to become a division of the Society for Mining, Metallurgy & Exploration.

IMMS' 160 members share a common interest in marine minerals as a resource for study and sound application to meet world demands for strategic minerals. Founded in 1987, IMMS includes a worldwide membership of individuals from industry, government agencies, and academic institutions.

The primary objectives of IMMS are to promote and improve the understanding of marine mineral deposits within the province of the global ocean; aid in the interchange of information among members through networking and formal symposia; encourage the prudent development of marine mineral resources, including

concern for the environment; and encourage research in all aspects of marine minerals development.

IMMS, on occasion, presents its highest honor, The Moore Medal, to those who have contributed notably to the objectives and initiatives of the Society. This award, named after UMI and IMMS founder, J. Robert Moore, is a reflection of the long and distinguished career he fulfilled in the advancement marine minerals research, development, and management.

*Soundings* will be published three times a year, in February, June and October. Readers are encouraged to send industry, personnel, technological and other news items concerning under water mining that would be of interest to *Soundings* readers. Contact Steve Kral, Editor, [kral@smenet.org](mailto:kral@smenet.org). ■

## Japan finds rare earths in Pacific seabed

A team of Japanese researchers reported that they have discovered large deposits of rare earth minerals, used in many high technologies appliances, in the seabed.

The geologists estimate that there are about 100 Gt (110 billion st) of the rare elements in the mud of the Pacific Ocean floor, the *BBC News* reported.

China is currently estimated to produce about 97 percent of the world's rare earth metals.

Analysts say the Pacific discovery could challenge China's dominance, if recovering the minerals from the seabed proves commercially viable.

The British journal *Nature Geoscience* reported that a team of scientists led by Yasuhiro Kato, an associate professor of earth science at the University of Tokyo, found the minerals in sea mud at 78 locations.

"The deposits have a heavy concentration of rare earths. Just 1 km<sup>2</sup> (0.4 sq miles) of deposits will be able to provide one-fifth of the current global annual consumption," Kato.

The minerals were found at depths of 3,500 to 6,000 m (11,500 to 20,000 ft) below the ocean surface.

One-third of the sites yielded rich contents of rare earths, Kato said.

The deposits are in international waters east and west

of Hawaii, and east of Tahiti in French Polynesia.

Kato estimated that rare earths contained in the deposits amounted to 80 to 100 Gt (88 to 110 billion st).

The U.S. Geological Survey has estimated that global reserves are just 110 Mt (121 million st), found mainly in China, Russia and other former Soviet countries, and the United States.

China's apparent monopoly of rare earth production enabled it to restrain supply last year during a territorial dispute with Japan. Japan has since sought new sources of the rare earth minerals.

The Malaysian government is considering whether to allow the construction of an Australian-financed project to mine rare earths, in the face of local opposition focused on the fear of radioactive waste.

The number of firms seeking licenses to dig through the Pacific Ocean floor is growing rapidly.

The listed mining company Nautilus has the first licence to mine the floor of the Bismarck and Solomon oceans around Papua New Guinea. It will be recovering what is called seafloor massive sulfide, for its copper and gold content.

The prospect of deep sea mining for precious metals and the damage that could do to marine ecosystems is worrying environmentalists. ■

## Nautilus releases Solwara 1 report

Nautilus Minerals released “Definition and Cost Study for the Solwara1 project,” an independent analysis of the project.

The study provides in depth details on resources, production planning and equipment to be used in the proposed operations. The key conclusions for the Solwara 1 offshore production system are:

- Capital costs, including those associated with barging to the Port of Rabaul, estimated to be US\$383 million (including a 17.5-percent contingency).
- Average operating costs to the Port of Rabaul estimated to be US\$70/t (US\$68/st, including a 10-percent contingency) based on a 1.35-Mt/a (1.48-million stpy)

production rate.

- Production rate commencing at 1.2 Mt/a (1.3 million stpy) (dry equivalent) with capacity to ramp up to 1.8 Mt/a (1.9 million stpy).
- Once approved by Nautilus’ board of directors, the build program is 30 months.

Through strategic partnerships and collaboration with industry leaders from around the world, the company is refining existing technologies for the Solwara 1 project. Technologies from surface mining (rock cutting), dredging (slurry pumping/hard rock cutting/gathering) and offshore oil and gas (trenching/remotely operated vehicles/risers) sectors are being combined and adapted for the Solwara 1 production system. ■

## Underwater Mining Institute held in Hilo, HI

IMMS is the primary sponsor of the [Underwater Mining Institute](#) (UMI), an international forum that brings together the marine mining community to exchange ideas and foster partnerships for research, exploration, and mining ventures. IMMS supports graduate student participation in the UMI and conducts its general membership and executive board meetings in conjunction with the UMI.

The 40<sup>th</sup> UMI was held Sept. 14-18 in Hilo, HI. One hundred sixteen professionals from industry, academia and government attended. More than 30 technical presentations were made during the meeting, in addition to six poster sessions. The meeting also included three field trips.

The following three items are abstracts from the UMI meeting:

## Road map to successful commercial deep ocean mining

by John Halkyard, Jon Machin and Eric Jackson

Deep ocean mining is experiencing a rebirth following many years of low levels of activity. Large-scale mining is being projected as just over the horizon. A lot has been made of the advances in deep water oil and gas developments during the last 30 years, and how this technology is directly applicable to ocean mining.

The authors present their views on this from a perspective of a legacy of participating in the development of manganese nodule mining systems in the 1970s, followed by 30 years in the deepwater oil & gas arena.

While it is true that great advances have been made in subsea technology, the differences between mining and oil and gas recovery should not be diminished. Fundamentally, oil and gas are stored in compact reservoirs under pressure. Any intervention leads to a flow of the material up a pipe to the surface.

The seabed hard minerals are stuck in place, either

adhering to sticky pelagic sediment (nodules) or bonded together as hard rock (massive sulfides). The minerals require complex machinery in order to be extracted, sized, concentrated and lifted to the surface.

Once at the surface, the ore must be dewatered, defined and transferred to shore for processing. The overflow from this dewatered product must return to the sea in an environmentally satisfactory manner. These steps involve technology unique to mining that has to be addressed in a methodical fashion before commercial mining systems can be designed.

The presentation discusses the critical technical challenges of deepsea mining and thoughts on different routes to commercialization.

The program will address the critical technical challenges, as perceived by the authors, and steps required to address them. Alternate development programs will be discussed focusing on nodules and sulfide. ■

# Vertical hydraulic transport for deep sea mining applications

by Paul M. Vercrujisse and Stanislav Verichev

Deep sea mining operations by nature are performed (or planned) in challenging environments. Another typifying characteristic of deep sea mining operations is the relatively high investment cost. This combination challenges engineers to design configurations that are able to mine the desired production rate in an efficient way. As design choices made for individual systems impact other parts of the system, it is vital to follow an integral approach to establish the one optimal overall system.

Dredging, and especially dredge mining, shows that the excavation system, the slurry transportation system and the processing plant cannot be considered as individual subsystems. These systems in any “traditional dredge mining” operation interrelate to such an extent that they must be developed toward an integral solution. The nominal production, peak production and variability of these figures must match for all of subsystems in the overall mining system to optimize the mining efficiency. We call this the “game of capacities.”

For a deep sea mining configuration comprising a seafloor mining tool, a hydraulic transport system and a surface support vessel equipped with a (pre) processing plant, the same holds as for a traditional dredge mining operation, namely; we need to consider the game of capacities to optimize the mining efficiency.

However, the game of capacities for a deep sea operation implies extra challenges, for instance;

- The effect of hyperbaric pressures on the excavation process.
- The hydraulic transport of the excavated material over relatively large vertical distances.
- The (pre) processing of the excavated material on board an offshore operating vessel.

It would be interesting to address all of these challenges. This, however, is concluded to be out of the scope of the intended presentation. Instead, the presentation focuses on the results of the authors’ studies regarding the hydraulic transport of material over large vertical distances.

A main goal of these studies is to better understand the phenomena involved in vertical hydraulic transport of solid particles and the developed concentration profile inside the riser. Here, the authors developed a numerical model that determines the volumetric solid concentration profile inside the riser related to a certain inflow situation.

In several cases, the obtained numerical solutions show a considerable increase in mixture density when the solid cuttings are transported through the riser. The volumetric solid concentration in sections of the riser becomes so high that a serious threat to the mining operation is formed. The main reason for this increased solid concentration is the overtaking of particle fractions with varying transport velocities, caused by a difference in particle dimensions.

By considering specific volumetric solid inflow concentrations, it is observed that when a monodisperse suspension (or a mixture with a narrow particle size distribution) propagates through the riser, the variations in mixture density levels out over distance. The initial fluctuations dissipate, influenced by axial dispersion. This means that the highest volumetric solid concentration is, in that case, always observed at the inflow of the riser.

Hazardous situations arise when the particles size distribution consists of a number of fractions with a significant difference in characteristic particle diameter. The different fractions develop varying transport velocities and, as the various fractions start to overtake, the volumetric solid concentration increases. This can cause much higher solid concentrations to arise half-way through the riser than were initially present at the inflow. It is shown by some of the examined situations that the developed volumetric solid concentration inside the riser can increase to twice the inflow concentration, which clearly is undesirable as it makes clogging a serious threat.

The numerical model can be used to determine if a certain solid inflow profile, related to the deposit characteristics and the used mining equipment, causes high solid concentrations to develop. This enables one to “test” a designed transport system before the actual system is operational and, as such, avoid a large investment in an unsuitable installation. If critical volumetric solid concentrations are predicted, adjustment of the equipment might be necessary to prevent breakdown of the system.

At present the authors are performing experiments to validate the model and we are expanding the model to two dimensions, this by including the radial movement and distribution of particles. The intention is to present the results of our numerical model as well as provide insight in the latest developments resulting from the present activities. ■

## Developing deep sea mining systems

by Hans Smit

The face of mining as we know it is changing as mining companies all over the globe realize the reality of accessing the vast mineral wealth contained on, and under, our ocean floors. With some land-based mineral deposits being fully exploited across the world, deep sea mining is set to revolutionize global approaches to the search for precious metals and other sought-after minerals.

Previously, the financial and technological implications of deep sea mining outweighed the benefits of access to the mineral rich deposits identified all around the world. The process of marine diamond mining off the west coast of southern Africa started in the late 1950s — and subsequently continued by De Beers to the present day — has proven to be an excellent proving ground for the development of technology and mining systems that ensure a sustainable and financially viable business.

Although the current challenge of developing and defining technology to mine the deep oceans is the focus of the technological world, there remains an equally and possibly greater challenge that has to be overcome: the “art” of adapting designs and solutions to ensure that the development of components and mining systems achieve a sustained mining rate and the required mining availability. It is a skill that only a handful possess based on hands-on experience.

During the past 20 years, IHC Marine and Mineral Products (MMP) has been part of, and instrumental in, the development of the only large-scale sustainable subsea mine in the world. The company has, through hands-on experience and sometimes failure, learned how to adapt its technology and solutions to ensure that the mining system achieves a sustained continuous mining rate and high availability that makes the operation financially viable. The company knows how much redundancy to implement, what spares need to be kept and has learned how to optimize access to ensure fast and reliable maintenance at sea. All this is aimed at one objective — time on the ocean floor.

Once on the seafloor, MMP understands how to ensure that the mining system remains efficient and effective. Equipments continue to evolve and refined, and the processes are improved upon to obtain better results. This presentation provides an insight into the process followed when developing underwater mining systems, and how this process identifies the ideal combination of equipment, carrier systems and support system to optimally mine the deposit with the minimum of risk. The focus will also be on the various technologies that are available and how these are evaluated, adapted and the risk of use mitigated thereby producing the optimal mining system. ■

## Offshore diamond mining in Namibia

For more than 100 years, diamond mining has been Namibia's most important mining sector. Today, it provides the highest foreign currency income for the country's development. Since the late 1970s, offshore mining of diamonds has gained more importance and now more than 60 percent of Namibia's generally high quality stones come from those offshore deposits, with a steady increase expected for the coming years.

In the December issue of *Mining Engineering* magazine, Helmut Mischo, professor of mining engineering at the Technical University Bergakademie, Freiberg, Germany, provides an overview of Namibia's diamond mining industry, with a particular emphasis on the development and future of its offshore mining activities and technologies.

The Namibian mining sector generates 21 percent of the gross domestic product (GDP) and more than 50 percent of the export income. Half of this amount derives from the diamond mining industry.

The deposits in the Namib Desert are almost depleted. NamDeb, a joint venture of the Namibian government and DeBeers, estimates that, with the end of the diamond mining in the Sperrgebiet area in 2020, more than 98 percent of all diamonds in the Namib Desert will have been recovered. Additional rich diamond deposits have been found since the 1960s in the shallow and shelf areas of the South Atlantic in front of the Namibian coast, and have been mined since the 1970s on industrial scale.

The low grade of the deposits requires a continuous drive for mechanization and automation. This is especially true for the marine mining operations in the tidal zone and shallow water areas as well as in the mid-water- and shelf zones in which the use of highly mechanized technologies are a major factor for feasibility. The technology already available, in combination with new technical developments, will allow for a further increase in the production from the maritime deposits. ■