

# SPOTLIGHT

Subsea oil and gas and seabed mining are a perfect fit.

Loke Marine Minerals' Walter Sognnes

## SEABED MINING

# Subsea veterans set sight.

Team behind Loke Marine Minerals say oil and gas technology is well-suited to nascent seafloor mining business

**OLE KETIL HELGESEN**  
Stavanger

**L**IKE many recent retirees, Tore Halvorsen was looking forward to a less stressful life after years in the subsea oil and gas business.

He certainly did not see himself taking on challenging new tasks.

That changed in 2020, when he was contacted about an interesting new venture by Revus Energy and Spike Exploration co-founder Walter Sognnes and Hans Olav Hide, co-founder and chief executive of Multi Phase Meters and former HitecVision partner.

Sognnes told Halvorsen: "We are establishing a company within seabed mineral mining, and we need the best subsea technology expert there is. Everyone points towards you."

Halvorsen did not have to think hard about it. "This is definitely something I want to take part in," he said.

The company, Loke Marine Minerals, now counts both TechnipFMC — where Halvorsen had served as executive vice president of subsea oil and gas — and the Wilhelmsen Group as part owners.

"Subsea oil and gas and seabed mining are a perfect fit," Sognnes tells Upstream. Highlighting the technology transfer opportunities between the petroleum industry and seabed mining, Halvorsen says: "The development of deep-sea subsea oil and gas production technology for 3000 metres depth took 30 years.

"It is unthinkable not to use this huge knowledge base in a new deep-sea industry."

The transfer opportunities from oil and gas extend to both technology and the subsea industry's safety and environmental record, he adds.

"The subsea industry has developed advanced methodology for development of new technologies for deep water, high pressure and long distances, and methodology for interruption-free, long-term operations and



redundancy," Halvorsen says. Loke plans to use a number of technologies originally developed for the oil and gas industry.

"We are exploring the prospect of using a drillship, which has the size needed," Halvorsen says, ticking off other inherent advantages drillships offer for seabed mining.

"They have Class 2 dynamic positioning, same level power generation needed for deepsea mining, a derrick with riser-handling system, ROVs (remotely operated vehicles), cranes and mud-handling systems."

Some modifications will be necessary, he says. "It will need a

launch-and-recovery system for tools on the seabed, water-handling for large amounts of water, storage for minerals and export systems to bulk carriers."

Halvorsen says the company has its eyes on a currently idle drillship that could become available. Loke plans to use conventional steel risers and subsea pumps that are capable of handling mineral cuttings, technologies borrowed from the oil and gas industry.

"What's new is water depths up to 6000 metres and high-power transfer of up to 8 megawatts," he says.

Loke's patent pending tech-

nology for subsea mining tools fits well with technology partner TechnipFMC's product portfolio.

ROV technology, subsea control and monitoring systems, robotics, umbilicals and risers are all examples of oil and gas technologies that will be required for the subsea mining industry.

### Sediment plumes

Researchers and environmental groups have raised concerns about plumes generated by seabed mining activities that can harm life on the seafloor.

Halvorsen says: "We have raised the bar on environment-

ally friendly seabed mining and are developing new cutting-edge technology to minimise the environmental footprint on the seabed, for example sediment plumes."

Sognnes believes the first commercial extraction of seabed minerals will take place in the Pacific Ocean, despite Norway's efforts to be the first country with regulations and licensing in place.

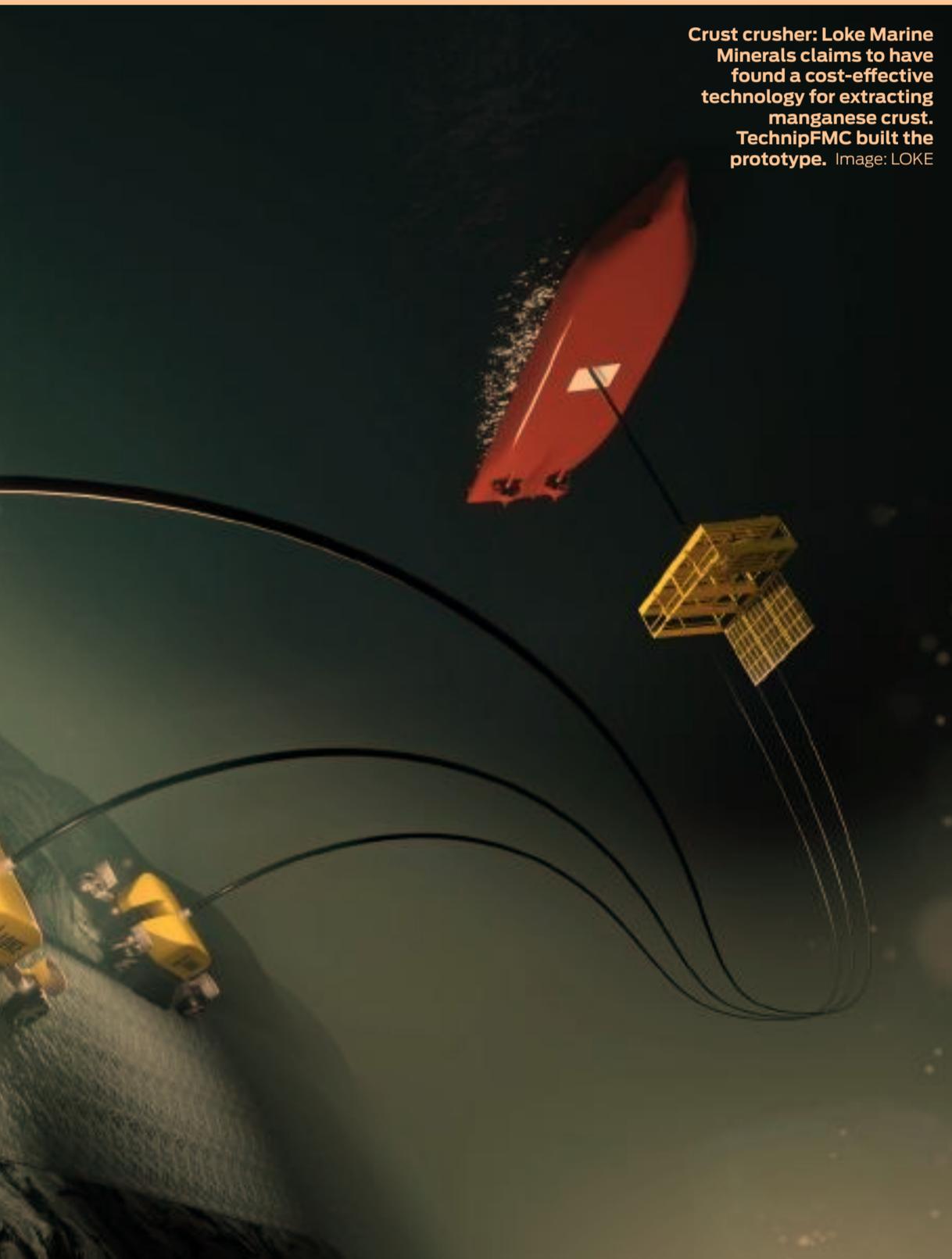
The main reason for this, he explains, is that the Pacific holds a massive amount of manganese nodules, solid balls highly enriched with critical minerals needed for the green energy

**\$10 billion**

The estimated value of a sulphide cluster containing 30 tonnes of ore (with 1.5 tonnes of copper), according to Loke Marine Minerals' Walter Sognnes.



# s on new deep-sea riches



**Crust crusher:** Loke Marine Minerals claims to have found a cost-effective technology for extracting manganese crust. TechnipFMC built the prototype. Image: LOKE



**Pioneers:** Tore Halvorsen (left) and Walter Sognnes

Photo: LOKE



**From the deep:** a manganese crust sample from the Norwegian continental shelf

Photo: NPD

CONCENTRATION OF KEY MATERIALS	
<b>Manganese Nodules Range*</b>	
Manganese	15 to 30
Nickel	0.5 to 1.3
Copper	0.5 to 1.1
Cobalt	0.1 to 1.0
<b>Manganese Crust Range*</b>	
Manganese	10 to 20
Cobalt	0.3 to 2
Nickel	0.2 to 0.5
Copper	0 to 1
REE	0.1 to 0.3
<b>SMS** Range*</b>	
Copper	2 to 10
Zinc	3 to 15
Cobalt	0 to 1

\* Range as a percentage  
 \*\* Seafloor Massive Sulphides  
 Source: JAMES HEIN/BRAMLEY MURTON



**Deep sea:** a sulphide sample from a depth of 3000 metres

Photo: NPD

transition. "We believe these are easiest to extract as they are unattached to the seafloor, and they have low grade variability, which makes them easy to process," Sognnes says.

Loke says there is no toxic waste associated with the processing of manganese nodules and has developed a machine for harvesting them that does not involve hydraulic suction close to the seabed, ensuring minimum sediment disturbance.

The device is capable of free swimming, enabling rapid relocation.

The vertical transport system includes a subsea pump station

suspended at the end of a rigid riser and flexible jumpers between the pump station and nodule collectors.

"All the heavy equipment is located in a riser-suspended station, and the capacity is 8000 to 10,000 tonnes of nodules per day," Halvorsen says.

Sognnes points out that the seabed off Norway is too young to have developed manganese nodules, but has deposits of other minerals that support Loke's interest in Norway's upcoming licensing round.

Norway has deposits known as seafloor massive sulphides that form on spreading ridges through

circulation of hot hydrothermal fluids enriched with metals. Manganese crusts — thin surface layers up to 25 centimetres thick — are found on the tops and sides of subsea mountains known as seamounts, he says.

Halvorsen says the company believes it has found a way to extract manganese crusts.

**Seamount surfaces**

"We are developing a unique ROV-based production system using smaller autonomous vehicles for cutting and collection of crust," Halvorsen says.

"The vehicles can operate equally well on horizontal as well

as steep seamount surfaces and apply a new method for excavation of crusts."

He demonstrates with a video of a unit with four wheels and a mechanical tool for crushing and excavating the crust.

With the patent "still in progress", Sognnes says, further details are not yet available on the device.

Loke is also developing a tool for AUV-based mapping of crust thickness using acoustic measurements with ultra-high frequency.

Sognnes says a seafloor massive sulphide cluster may contain an estimated 30 tonnes of ore (con-

taining 1.5 tonnes of copper), which corresponds to a gross value of \$10 billion — roughly equal to the value of an oilfield of 160 million barrels of oil.

A geophysicist with 30 years of experience in the oil industry, he is convinced that seabed mining will be a lucrative business.

"Our goal is to become the operator with the highest ESG [environmental, social and governance] rating in the mining industry," he says. "The focus on technology right now is primarily to enable this ambitious goal."

**Weighing the options for seabed mining: Pages 18&19**

## SEABED MINING

# Weighing the options for

Norwegian government studies gauge the extent of the country's offshore mineral resource

**OLE KETIL HELGESEN**

Stavanger

**J**AN Steinlokk holds a sample of sulphides the way someone might handle a rock from the surface of Mars.

"These samples have been collected at 3000 meters depth, a place where no one has ever been," says Steinlokk, a geologist with the Norwegian Petroleum Directorate (NPD).

The sulphide samples, often referred to as "black smokers", are formed when seawater comes into contact with magma below the earth's crust, heats up and is flushed back to the seabed carrying dissolved metals and sulphur.

Steinlokk's colleague Nils Rune Sansta, coordinator for seabed minerals at NPD, says the Norwegian continental shelf holds sulphides and manganese crusts containing metals and minerals that are crucial ingredients in batteries, computers and mobile phones, and in the technologies needed for the energy transition, such as wind turbines.

"These are elements, and there simply is not enough of them available for the green shift," he says.

"For some of them, recycling doesn't help until there are a sufficient amount of them available, which makes extraction necessary.

"Extraction from the seabed makes this an interesting option, and the resources on the Norwegian continental shelf should be mapped," Sansta adds.

#### Mapping the resource

Steinlokk will not be drawn on the economic potential of mineral extraction off Norway in depths of 3000 metres.

"We don't know," he says. "Our purpose is to map the resources on the Norwegian continental shelf and coordinate the ongoing impact assessment."

But he acknowledges an avid interest from companies.

"We have had dozens of companies wanting to look at and study our samples," he says. "They are allowed to look at and hold them, but they are not allowed to take samples at this stage."

Norway has mapped deposits along the Mid-Atlantic Ridge between Jan Mayen and Bear Island, where the sulphides are found, and also along the Voring Spur and south of Jan Mayen, where manganese crusts have been discovered. Manganese crusts in the Norwegian Sea fall



**Minerals and metals are important as the world moves towards a low-carbon age. We want to explore the opportunities this represents.**

Amund Vik, State Secretary at the Norwegian Ministry of Petroleum & Energy

and 2020 at the Mohs Ridge between Jan Mayen and Bear Island, where the sulphides are found, and also along the Voring Spur and south of Jan Mayen, where manganese crusts have been discovered. Manganese crusts in the Norwegian Sea fall

into two groups, one containing roughly twice the amount of rare earth minerals as samples from the Pacific and other Atlantic sources, and the other having less.

The expeditions have also discovered high concentrations of

lithium and the rare earth metal scandium, used in electronics and alloys, in manganese crusts, which build up on bedrock.

The government plans public consultations on its environmental impact assessment and on a proposal for opening areas

for exploration and production by the end of 2022, followed by debate and a vote in parliament in the second quarter of 2023.

According to Sandsta, this could place Norway among the first countries to mine for seabed minerals.

Amund Vik, recently appointed State Secretary at Norway's Ministry of Petroleum & Energy, says there is no doubt that deep sea mineral mining could become an important marine industry for Norway, with opportunities for value creation and employment.

"Minerals and metals are

# seabed mining



Treasure trove: NPD seabed minerals coordinator Nils Rune Sansta (left) and geologist Jan Steinlokk. Photo: NPD

important as the world moves towards a low-carbon age. We want to explore the opportunities this represents," Vik says.

He acknowledges concerns raised by environmental groups and others about the practice but stresses that Norway has a long tradition of responsible management of natural resources.

Legislation applying to mineral activities on the Norwegian continental shelf, the Seabed Minerals Act, came into force on 1 July 2019.

In April, six environmental organisations, including the

World Wildlife Fund and Greenpeace, called on Norway to stop plans to open ocean areas for deep-sea mining, according to Reuters.

Environmental concerns may have caused some companies to keep a low profile so far.

## Expansion

Norwegian energy giant Equinor told Upstream in 2019 that it may expand into seabed mineral mining after developing a new seismic technology to search for valuable minerals offshore.

The company chairs the

industry and research association Norwegian Forum for Marine Minerals, and a spokesperson says Equinor has not made any decision as to whether it will engage in the extraction of seabed minerals in the future.

"Equinor established a research project in 2015 to consider if it is possible to extract seabed minerals in a safe and sustainable way... a relatively small project," the spokesperson says.

"We are awaiting the results of the government studies that are ongoing."

## Battle brewing for Norway's resources

OLE KETIL HELGESEN

**B**ATTLE lines are being drawn in Norway as the government prepares to open offshore acreage to exploration and extraction of seabed minerals.

The debate pits environmentalists against the business of natural resources extraction, a familiar scene for citizens of the oil and gas producing nation. But the issues in this case are less clear-cut.

Green activists are pushing for a rapid transition to renewable and clean energy. But many of the technologies to enable that transition require metals and other resources that must be mined, whether at sea or on land, and their extraction will inevitably have an impact on the environment.

Supporters of a new – and potentially highly profitable – industry to Norway argue that seabed mining will take place in relatively small areas on the continental shelf, and that it will be possible to keep environmental disturbance at an acceptable level.

Environmentalists caution that the government is moving too fast with opening offshore areas to seabed mineral extraction, a position backed by the Norwegian Environment Agency.

The head of the government agency's marine section, Ann Mari Vik Green, told Norwegian broadcaster NRK that little is known about the environment in the proposed licence area, making it nearly impossible to consider the consequences of mineral extraction.

The leader of Greenpeace Norway, Frode Pley, agrees that all industrial activity has a footprint but questions whether it is necessary to disturb the earth's last untouched frontiers in the quest for raw materials.

"Metals used in, for example, batteries for electric cars are derived from mining onshore," he says.

"This is an industry Greenpeace monitors and is concerned about.

"However, with the ongoing and rapid electrification of our societies, we must ensure less dirty and more ethical mining for rare metals like cobalt and lithium.

"Maybe most importantly, we need a circular economy, even for products like batteries."

Greenpeace is calling for a moratorium on seabed mining.

At the very least, says Pley, the government should not allow the practice to go ahead before scientists have had time to properly assess the consequences.

"The Norwegian Institute of Marine Research has stated that there is a big knowledge gap in ocean ecosystems and is concerned about the impacts on biodiversity and commercial fisheries from mining out at sea," he says.

"The oceans already face a multitude of threats – climate change, destructive fishing practices and plastic pollution. It is madness to consider



Views: Greenpeace Norway leader Frode Pley

Photo: NTB/SCANPIX

seabed mining before we even know what we might lose."

Supporters, however, say the country has an opportunity to apply lessons and practices from its long history in offshore oil and gas operations to ensure that seabed mining can be carried out safely and with minimal impact to the environment.

At a conference in Bergen in November, Norway's Petroleum & Energy Minister, Marte Mjos Persen, said the the country's success in developing an offshore oil and gas sector governed by strict environmental regulations makes her optimistic that seabed minerals can be sourced responsibly and thereby contribute to the green-energy shift.

The government is considering putting Norway's Petroleum Safety Authority (PSA), which has played a central role in regulating offshore oil and gas activities, in charge of supervising the country's seabed mining activities.

PSA director Anne Myhrvold believes there are many similarities between petroleum exploration and production and the extraction of seabed minerals.

"It is up to the Ministry of Petroleum & Energy to decide which agency should be the safety authority," she says.

"We have, through public hearings, expressed that we believe we are suited for this role based on our understanding of risk, our competence and our experience with regulations and audits with safety and working environment in industrial activities on the continental shelf."

She believes seabed mining and oil and gas activities have much in common in terms of players, technology and operations, as well as risks.

"Regulations and audit activity should be adjusted to the risk the activity represents, something (with which) we have experience from petroleum activities, in addition to our new responsibility areas within offshore renewable energy production and carbon transportation and storage," Myhrvold explains.

Noting that the proposed seabed mining locations are far from shore and existing infrastructure, she says: "The PSA has knowledge and experience related to the regulation of health, environment and safety within petroleum activities in these areas – areas far north and in deep waters."