MODULE 5, LESSON 5

TECHNOLOGIES FOR EXTRACTION FOR POLYMETALLIC SULPHIDES IN THE AREA

LECTURE NOTES

Welcome to all interested people in deep sea mining. We are meeting here today for less technologies for the extraction of polymetallic sulphides in the area. My name is Leo Weixler, I'm president of the deep sea Mining Alliance with members out of the mining industry, and I'm also managing director of a service provider for special deep sea mining purposes.

Today we have the following agenda. I will explain to you a little bit about the typical deep-sea minerals which are existing, then, although we need to look a little bit back in the history, I will talk a little bit about existing technologies for land-based mining.

I will explain in detail the trench cutter technology, then how we can adapt these technologies, the land-based mining and trench cutter technology for the deep-sea application. Environmental impact is very important when we make a decision about future mining technologies, and at the end I come with some conclusions. In this slide you can see the typical seabed minerals which are existing and well known since about 50 years.

On one side we have some massive sulphides which are a three-dimensional deposit, are created like a volcano eruption on the continental crust along the earth. The crust length is about 90,000 kilometers. This is a three-dimensional deposit with a small footprint, and on the other hand we have two-dimensional seabed minerals.

One are the manganese nodules, they are laying like potatoes in sediments, and the other ones are cobalt-rich crusts which are similar to a coating of seamounts. While these three-dimensional deposits have a size of maybe about 20,000 - 30,000 square meters, the manganese nodules and the cobalt-rich crusts have a surface of more than a thousand square kilometers. And that is the major difference we need to consider when we make the decision about the right mining technology.

In this slide I made a first general comparison about this sulphides compared to the manganese nodules. I assumed ore rate for manganese nodules with about 30,000 kilogram per square meter. In this calculation I assume the thickness of 10 meter. The abundance of manganese nodules is much smaller as they are two-dimensional. There are only 12 to 20 kilogram per square meter.

For cobalt-rich crusts the abundance is a little bit bigger, about 70 kilogram per square meter. When we further on assume that for a commercial mining we need about 1 million tonnes of ore per year, then we can calculate very simple, I call it surface factor. And we need for massive sulfide about 33,000 square meter per year.

For manganese nodules we have 62 million square meter and for cobalt-rich crusts we have about 14 million square meter. So the difference is really huge. Compared to massive sulphides we need between 400 and 1800 times more surface to make an economical mining possible. And this is very important for the choosing of the right mining method. When we select the right technology then we need to have a look at land-based deposits.

On this slide you can see a typical massive sulphide mine in Chile. It is a huge area covered by a lot of sediments, by a lot of overburden. It has a size of 10 by 2 kilometer and a depth of now one kilometer. These mines are typically mined with surface miners with a horizontal approach. That means they are mined layer by layer. For this you have a very complex logistic. But at this site with this huge size it's no problem. A lot of people can work on it and they can do the logistics as they did it maybe for several hundred years so far. Transferring such kind of technology to the seabed might become challenging as we have no access for humans in the deep sea.

There was already one approach to transfer the surface miner technology to the deep sea for a deposit in Papua New Guinea for a water depth of 1600 meters. They used three different types of surface miners. The first one was used for paving the ground. The second one was originally cutting the ore. And the third one was collecting the ore and bringing it to the vertical transport system. These three units, huge in size, everyone had a weight of 300 tonnes and a power supply of three megawatts. They need to be operated independently but they need to be operated remotely from a mining vessel. And this might be very challenging to do so in a small mine with a small footprint. Another existing technology for land-based mining and foundation is the trench cutter technology which is used since 60 years in the foundation industry. It was originally created to develop cut-off walls and later on it was also used for some mining and sampling approaches. It is a so-called vertical approach. A cutter unit is suspended by ropes, hanging on a crane and going down with its own weight. And it's cutting the material out and pumping it to the surface. With this approach many companies in the world are operating foundation job sites. More than 500 units are existing so far and in operation and therefore it's a very proven technology.

It is very flexible in depths and we just have to increase the size and the capacity of the winch. There are practical experiences existing for cutting depths of more than 250 meters. 30 years ago there was already a first project with such a cutter technology to do some sampling work offshore in the Atlantic Ocean. It was used for the sampling of alluvial soil for diamond deposits. The cutter was lowered to the seabed, it was leveled and then it cut into this alluvial soil and then the deposit was pumped to the vessel and then screened. And so it's already 30 years of experience which are existing for offshore operation with this technology.

Let's have a little bit closer look to the cutting tool itself. As I mentioned before it is used in 60 years on foundation job sites and mining job sites all around the world. There's vast experience regarding choosing the right mining tools, the right teeth, the right cutting wheel for all different soil and rock conditions.

Very important for this cutter technology is to have the possibility that we are cutting 100% of the surface. 30 years ago there was a development of so-called flipper tools which allows the cutting of 100% of the surface. With a special designed mechanism it is possible to under ream the gear shield and with this technology it is now possible to cut in every soil and rock conditions. Experiences for up to 250 megapascal rock is existing so far. Now we need to transfer this technology to the deep sea. To do this again we look at the technology in general, then we look in existing deep sea technologies. From the oil and gas industry a lot of technology is available to marinize land-based technology for pressure compensation, for energy supply and so on. Though it's very simple to transfer this existing foundation technology with means of marinizing to the deep sea, there's no major risk doing so. The principle doing that is like we did it like it was done in the Atlantic Ocean; the equipment is lowered to the seabed, now we have a depth of 2000 to 3000 meters. Then it is leveled so that it can go vertically, a skirt is preventing any plumes while we are starting the cutting process and then the cutter is going into the ore, cutting the material and it is pumping it out with the seawater. It brings it to a basket which is positioned at the top of the cutter unit. Here it is dewatered and the cutting, the fines, they are put in the basket and the processed water is used in a closed process.

We think with this technology we have the most environmental friendly way. We are cutting the ore while it is protected by the surrounding ore. We are transporting it in a closed circuit to the basket where it is separated by means of cyclones. We are using this processed water again for transporting the next portion of ore. And when the basket is filled, we are bringing just the basket to the surface and then we are emptying the basket and we can start the next step for the mining. The technology shown so far was used already for sampling but not for mining. As I mentioned before, for mining purposes we need about one million tonnes of ore per year and therefore we need to scale this technology. This can be done in two different ways, either by increasing the size of the cutter or by using more units in general. These units are operated in a similar way so there are no different works to do, though they can be multiplied very simply.

Regarding the vertical transport system, it is also very easy to increase the size of the basket or using more of the baskets like a paternoster system. What is also very important when we are operating this mine is having in mind the different deposits in general. As I mentioned before, along the continental crust many of these deposits are existing. They are different in depth, they are different in topology and they are different in size. Therefore, for every deposit we need to have a special mining sequence. This has to be done very carefully and then every deposit can be mined very precisely, as we have the vertical approach, we can work very close to sensitive areas but we do not disturb the sensitive areas.

Sustainability I have already explained a little bit. We see it in the slide a little bit more in detail.
We have this in-situ separation which prevents the processed water from the surface water, which is also very important for mining purposes. We have the closed pumping circuit that prevents any plume from occurrence. We have the electrified component which reduces the risk of oil pollution in the seawater.

I mentioned before we have this selective mining process which can work very close without risk close to sensitive areas. Let's come now to the conclusions. At the first view it seems very complex to use the vertical approach for deep sea mining.

A key decision when we decide the right mining method is to look really what is already existing and to avoid any technological risk. The surface miners I showed before are for sure existing technology, a lot of experience on land-based mining, but the logistic on the seabed is quite complex and with remote controls very challenging so far. The vertical approach is all in one unit, it can pave the ground, it can cut the ore, it can transport the ore, though it's just a very simple operation, by using two or more of them you do not increase the risk, you just have a bigger amount of equipment operating in the same way. So we think this vertical approach can be both economical and environmental friendly.

Thank you for listening.