Minerals on and beneath the seabed may represent the next great bounty of the ocean, but retrieving them can be a daunting challenge. Stevie Knight examines two early deep-sea mining projects.

DESPITE BORROWING TECHNOLOGY from landside and offshore operations, the new breed of subsea mining vessels will be “a completely different kind of animal,” says Dilip Sarangdhar of SeaTech Solutions, the design company behind the world’s first Production Support and Storage Vessel which is nearing completion in China’s Fujian Maewei yard.

SeaTech’s PSSV is “part heavy-lift vessel, part bulk carrier” with a nod to a drill ship thanks to a big central derrick says Sarangdhar. But, he adds however you describe it, “everything is larger than life” on this 100,000dwt ship.

The idea itself isn’t new but it’s a tricky calculation: a pilot exploration in the Middle East turned up high-grade minerals back in the ’80s - but prices fell away before the technology was ready. More recently there’s been interest in relatively low-hanging fruit for those with the right licenses. De Beers – in partnership with the Namibian government – has been hoovering diamonds from the sand in 120m of water just off the country’s coast since 2014. A 300-tonne sea floor cutter is similar to its landside ‘continuous mining’ cousin, having a series of several toothed blades on a front mounted roller that munches through a swathe of material as it progresses. An auxiliary or preparatory cutter works the rougher terrain: this is a bit more flexible as it sports a series of cutting heads at the end of a boom-type arm, making a ‘bench’ for the bulk cutter to process. The final crawler, a collection machine, hoovers up the material and pushes it to the suspended subsea slurry lift pump; from there it gets pumped up to the vessel on the surface.

These are by no means small: the cutters weigh 250 tonnes and 310 tonnes apiece. While Sarangdhar says that the transit weight “is no big deal”, he points out when these machines are suspended in the air – at a reach of 15m from the hull – it results in very concentrated loads under the footings of the launch and recovery A-frame, requiring structural reinforcement of the hull.

Size helps, but inside the ship’s 227m length, 40m beam there’s also a 42,000-tonne ballasting system: Sarangdhar explains this will bring the freeboard down as low as possible to the water and all in all, the vessel should heel less than 1 degree during deployment operations.

Getting the mineral slurry up into the ship is another issue: the 10m by 10m moonpool in the centre of the ship is reserved for the umbilicals, riser and pumping system. Taken together these items hang up to 700 tonnes on the derrick’s hook. After this the slurry goes to a dewatering plant (the excess liquid is deposited back on the seafloor) and then it’s moved along into the four holds by conveyor belt and distributed by rotating stackers – filling the ship with between 25,000 and 50,000 tonnes of mineral ore.

However, according to Sarangdhar, “bringing the ore 2,000m from below has proved easier than getting it up from the bottom of the hold”. The reason the ore is so sought after makes it an issue to deal with: it’s heavy, highly abrasive and consolidates when it settles “so what goes in has to be scraped out” he says. More, take one look at the crowded deck and it’s obvious there are no hatch openings for grab access – so unlike a regular ship unloading in a port environment, manual labour can’t safely get inside to assist, so the whole system has to be highly automated.

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Behind it is a need for power: 3.1MW of it all in all. There are six Rolls-Royce engines of 5.04MW, two in each engine room, plus a couple of emergency auxiliaries: it’s worth noting that the seabed equipment tots up over 20MW of draw in all, so the practicalities are down to a very flexible power management system from Siemens. In heavier weather this will shunt the power to the ship’s DP where it’s most needed while in normal conditions the dynamic positioning element should only draw around 7MW, the rest being available for seabed or onboard operations.

DON’T DRILL, SCOOP

Seafloor massive sulphides are not the oceans only treasure: IHC is readying its own design focusing on polymetallic nodules, rich in manganese, nickel, cobalt, copper, and in some cases, rare earth elements.

While the surface vessel’s 240m outline is similar to that of Nautilus’ ship with a roughly comparable capacity, the deposits present a very different set of challenges: as Wiebe Boomsma of IHC explains, instead of “small and deep, the focus is wide and flat”.

Unlike SMS, these nodules don’t require cutting out of the seafloor. Instead, they simply sit in a layer on top of loose sediment, “so we prefer to call the machines ‘harvesters’”, says Laurens de Jonge of IHC. Scooping them up is inherently less destructive, and more “a square metres game”, he explains. “You have to travel at a certain speed, covering as broad a swathe as you can manage.”

Because only the largest nodules need to be broken up to be slurried and pumped to the surface, the machine can be a lot less fearsome than those carving up the Solwara 1 bed, drawing just 1.5MW of power from the surface – although they will have broad booms “reaching between 12m and 20m – quite a size”, adds Boomsma.

Different types of harvester are presently being tested full scale in laboratory conditions, but while there may be a need to adapt to a more difficult terrain, “although there will be large areas of homogeneous seabed, differences in the seafloor conditions might require a change of collector”, explains de Jonge. Therefore a modular system with interchangeable heads is under evaluation.

There are further differences between this environment and that of the oceans’ massive sulphide deposits. “You have to be careful on the seafloor, it can be rather soft in these regions and you can’t land anything too heavy, so the underwater weight has been kept down to 20 tonnes,” explains Boomsma, “unlike the design for SMS, where you want the extra mass to cope with the excavation forces.”

However, the harvesters will still have an air weight of around 120 tonnes during deployment: so far the options are being kept open as to whether to deploy over the side via a heavy lift crane or use folding arms and launch through a capacious central moonpool. The ballasting system, as in the Nautilus vessel, will have to be sizeable: “This isn’t just during the launching of the harvester, it will have to cope with different nodule loading regimes,” he adds.

There is another important characteristic that impacts design: these nodules are generally found in deeper waters, anything between 3,000m to 6,000m down, which puts more pressure on the Vertical Transport System (VTS). As a result this is, needless to say, substantially heavier than that on the Nautilus’ ship, weighing in at around 1,200t when submerged.

Still, it’s not just weight. De Jonge explains the problem: “Unlike an oil and gas field where the riser is pinned to the bottom and sealed, you have to be able to move around, so you might have 6km of free-hanging riser pipe to push the product up through. Getting the nodules up to the surface has been one of the biggest issues.”

The answer has been to position no less than six
booster stations along the length of the riser pipe. Each booster station is equipped with two pumps with a combined power no less than 1.2MW just to get it up to the next section, “so that means we have more than 7MW just for the vertical transport to the surface” he says.

Up onboard the surface vessel, the power generation for this riser, the harvester and the internal cargo handling will probably be covered by eight 1.5MW gensets (which will allow for one engine in refurbishment, one on standby), with a very flexible distribution and management system to handle it all.

The two operations are further differentiated by distance: while the Solwara 1 deposit is within 50km of the coast of New Guinea, “if you are nodule mining in Pacific, you could be 1,600nm offshore” says de Jonge. There’s no provision for helicopter flights as they will be out of reach and though it could charter a dedicated supply vessel it’s a very long journey: “Therefore this ship has to be very self-contained, you need to take everything with you,” he says. It’s not just the need to find a way to rotate the 80 to 100 personnel, (although this is a lot fewer than the 200 people onboard the Nautilus PSSV), it’s also maintenance. For example the umbilical reels – the biggest of which will be 8m in diameter – will also have spares and there will be not one but two harvesters onboard, for redundancy. “The design has to double up on everything, so it’s got to be very smart with space,” he says.

Despite the location, there are some advantages to mining polymetallic nodules. It may be that those niggling offloading issues could be mitigated by the sizes of the chips; as these are larger, it will be easier to separate them from surrounding liquid. Therefore the team is looking at wet transfer: slurrying the cargo once again and pumping it across to the waiting bulk carrier – which itself will have to be adapted with a dewatering plant.

Although getting one of these mining ships out and working is still a few years off, IHC is looking at the next step: a pilot system onboard a contracted ship. However, this takes effort: “It’s difficult to plug it into a chartered vessel,” he explains. “From the pickup to the offloading plant, all the balances have to be in place, all the flows have to be accounted for and every system has to interface with another.”

It can’t be avoided that permits and the environmental issues have made the subject a controversial one. There’s a lot of concern about disturbing unknown, potentially delicate benthic ecosystems: the International Seabed Authority (ISA) admits: “[The] first exploitation project will have large uncertainty regarding the environmental impacts, especially on the broader marine ecosystem.” Further, even the most basic activities stand to create issues: as the IHC team point out, mitigating plume formation from either the harvesting or dewatering outlet is a must.

Therefore the first-stage dewatering that takes place inside the seabed harvester reuses the liquid in its low-pressure lifting jet, keeping the loop as closed as possible: further wastewater that results from onboard processing inside the surface vessel is transferred again to the seabed. Even the 1.5MW electrical system is being designed for environmental impact mitigation: instead of the usual oil-cooled induction motors there are innovative seawater filled, permanent magnet units.

Boomsma adds the entire system will be put through rigorous trials including sound and vibration tests. “All these potential sources of environmental impact will be studied and the system optimized around the results,” he underlines. “We are putting a lot of effort into the environmental capabilities of this ship.”

While exploration rights for polymetallic nodules have been granted, exploitation rights have not. Despite the difficulties in getting everyone to agree Boomsma is optimistic about negotiating a forward pathway and adds: “While mining is always disruptive as you take away a piece of the soil... if you put it in the context of the ecosystem as a whole, we believe you can minimize the impact.”

However, others have pointed out that while the ISA is considering how to move forward on environmental mitigation for mining areas outside exclusive economic zones (EEZ), it is not responsible for those within – and here, different rules apply. The uneasy truth is that despite being covered by the same ocean, a number of EEZs will almost certainly be stretched between divergent agendas: the lure of economic growth on one hand, the caution of environmental conservation on the other.