DEEP SEA MINING:
AN OPPORTUNITY FOR THE ITALIAN OFFSHORE INDUSTRY?

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ABSTRACT

Mining in the deep sea is the next frontier for the offshore industry, which will be challenged to move farther from shore to reach resource deposits at water depths often exceeding those of oil and gas operations. The three types of resources that can be found on or just below the seabed at depths between 800 and 6,000m, are considered by several countries as an alternative source of critical minerals that could reduce the reliance on a single producer and thus unfavourable dynamics in raw material supply.
A comparison of value chains of both deep sea mining and oil & gas revealed a substantial overlap in the exploration and production phases. This suggests that there exist possible business opportunities for Italian companies working in the oil & gas supply chain to provide their products and services also in this new industry. Furthermore, the Italian maritime research community has in the past years gained valuable experience and could therefore actively contribute to further development of very important aspects of the nascent industry, such as resource assessment, environmental monitoring and mining risk assessment. On the other hand, research equipment and vessels could be usefully employed throughout the entire mining campaign to not only monitor, but also support resource exploitation.
A combination of advanced research capabilities in the maritime field and a strong, well established oil & gas supply chain could form a basis for providing technological solutions also in deep sea mining. To this end, it is proposed that a cluster of select companies and research institutes is formed around Key Public Institutions such as MISE and Assomineraria with the objective of creating an Italian mining contractor.

INTRODUCTION

Many of the basic and most of the high-tech industries that drive technological development are heavily dependent on the supply of various raw materials. Among the most critical are different types of minerals used in construction, metal production and particularly in sectors of advanced technology such as telecommunications, consumer electronics, computers, and modern vehicles. Uninterrupted supply of mineral resources is therefore becoming increasingly important for the industrial development of a country. However, due to the specific characteristics of the market, which render it sensitive to the continuously changing economical and geopolitical landscape, it is often difficult to control the supply as the demand for new products grows not just in the West, but also in developing countries. China, for example, controls more than 90% of rare-earth elements (REE) [1] that are used to make components of practically all modern mobile devices. As it develops economically, the demand for mobile devices inside China is expected to grow considerably, which will result in reduced quantities of REE available to external markets. In order to manage the risk of supply disruptions and decrease the dependence on a single mineral producer like China, several countries have started looking at the seabed as an alternative source of minerals. Japan, South Korea, Germany and the United States, which are known for their high-tech industries, but have limited mineral resources on land, have been investing heavily in

research of seabed resources as well as the development of the technology for their extraction. Less developed countries such as India, Brazil and even China with its considerable land reserves, have also set up deep sea mining programmes sponsored by their governments. In fact, of the top ten metal consuming countries, Italy is the only one that has not yet invested in a programme for commercial extraction of mineral resources from the seabed.
This paper investigates how the extensive knowledge and experience of the Italian Oil & Gas sector could be applied in the development of an Italian deep sea mining programme. It gives an introduction to the resources as well as their geographical distribution and describes briefly the exploration phase, which, similarly to Oil & Gas, is a crucial part of the value chain.
A typical deep sea mining value chain is compared to that of Oil & Gas in the second part of the paper. Similarities between the two are investigated before opportunities for the involvement of Italian institutions and companies in deep sea mining are discussed at the end.

DEEP SEA MINING RESOURCES AND THEIR DISTRIBUTION

The term Deep Sea Mining (DSM) refers to the whole process of exploration, exploitation and related environmental assessments of non-biotic natural resources (raw material resources) located on and below the seabed in deep waters [2]. The term deep water refers generally to seafloor located beyond the continental shelf break, therefore implying the continental slopes, rises and abyssal plains of oceanic basins. The continental shelf break in low latitude continental margins is located between 100 and 200 m water depth. In high latitudes glacially-influenced continental margins, the continental shelf break is located in a higher water depth reaching 400 end even 500 m as a consequence of the erosion exerted on the seafloor by paleo-ice streams. Care must be taken with the use of the term "continental shelf". In the above definition of deep waters, the use of the term is in its geological meaning of the broad, relatively shallow submarine terrace of continental crust forming the edge of a continental landmass (Fig. 1).

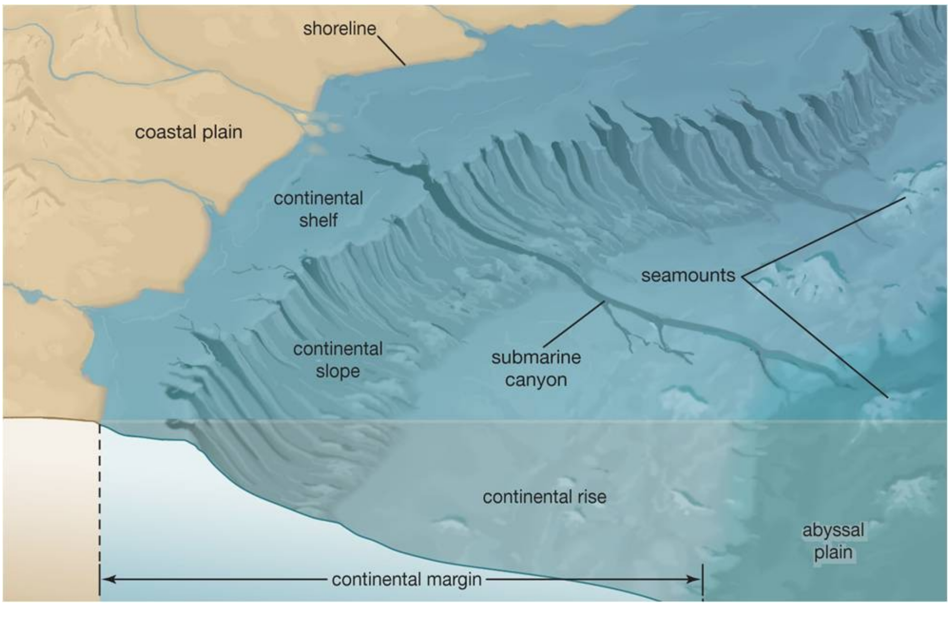

Fig 1: Topographic description of low-latitude continental margins defining the shallow, low-gradient continental shelf and the deep water continental slopes, rise and abyssal plains. The latter are the parts of the oceanic floor that are interesting for deep sea mining activities. (from [3]).

Conversely, according to maritime jurisdiction (United Nations Convention on the Law of the Sea - Part VI, Article76) "the continental shelf of a coastal state comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the

continental margin does not extend up to that distance. Therefore, disregarding extensions and exceptions, deep sea resources can be located within the Exclusive Economic Zone (if the continental shelf break is closer than 200 km to land) that are governed by nation states, or in areas beyond National Jurisdiction (ABNJ) under the supervision of the International Seabed Authority (ISA), a United Nations agency.
Deep sea mineral resources generally exclude hydrocarbons (oil and gas) that are now often exploited in deep waters. However, natural gas hydrates (usually methane hydrates) that are a solid mixture of gas and water found within marine sediments in deep waters (the stability field of gas hydrates requires high pressure and relatively low temperatures) are sometimes included as an unconventional hydrocarbon resource.
Among mineral resources, the following are the three types generally distinguished in terms of genesis, distribution and economic potential [2, 4]:

Poly-metallic (manganese) nodules
Manganese nodules are 2-15 cm in diameter and are made of ferromanganese oxides, containing other valuable metals like nickel, copper, manganese, molybdenum, lithium, rare-earth elements and possibly cobalt. They are found on relatively flat, abyssal seafloor (4,000 to 6,000 m water depth) in sedimentary environments characterized by extremely low sedimentation rate, which means that they grow very slowly. Normally, nodules lie on the seafloor only partly buried, and are not found deeper in the sediment.

Poly-metallic sulphides (or seafloor massive sulphides - SMS)
SMS are deposits of heavy metal sulphides derived from mineral precipitation from hot hydrothermal vents at depths between 1,500 and 3,000 m. They are made of sulphide minerals containing various metals, such as copper, lead, zinc, gold and silver. Their origin is linked to the mid-ocean ridge hydrothermal systems and to volcanic hot spots, but can be found also in convergent tectonic settings such as back-ark basins. The deposits can reach several metres of thickness.

Cobalt-rich ferromanganese crusts
These are encrustations of the rocky seafloor, a few millimetres to centimetres in thickness, on the slopes or tops of submerged volcanoes and seamounts at depths of about 800 to 2,400 m. They are composed of ferromanganese oxides and contain cobalt, nickel, manganese, tellurium, rare-earth elements, niobium and possibly platinum.

Fig 2: Three types of mineral resources of the deep sea. From left to right: A poly-metallic nodule, an example of manganese crust and a chimney with hydrothermal sulphides (from [2]).

Deep sea minerals, including gas hydrates, are characterized by a sparse areal distribution on or below the seabed. As fluid mineral resources, conventional hydrocarbons (i.e. oil and gas) are found concentrated in reservoirs following a process of natural migration from a source rock in the sediments and rock pore spaces. Contrarily, deep sea minerals are found in the same place where they were generated and there is no migration implied in their areal distribution.
Manganese nodules are highly concentrated on the seabed, but they constitute a layer of sediments enriched with nodules with a thickness of only a few centimetres. They are found especially in a huge area of the Pacific Ocean from Mexico to Hawaii, offshore Peru and in the abysses of the Atlantic and Indian Oceans (Fig. 3).

Massive sulphides form relatively thick deposits at the flanks of volcanic edifices. The concentration is very high as they form the bulk of the rock, but they occupy seabed with harsh topography, often associated with active venting and thus high temperature fluids. They are common along the East Pacific Rise, the Central Atlantic Ridge, and the North Fiji Basin in the South Pacific (Fig. 3).
Ferromanganese crusts are also very concentrated deposits that can be spread over large areas of harsh volcanic seafloor with very limited thickness. They are found in the south-west part of the Pacific Ocean where they occupy the majority of the hundreds of volcanic seamounts (Fig. 3).

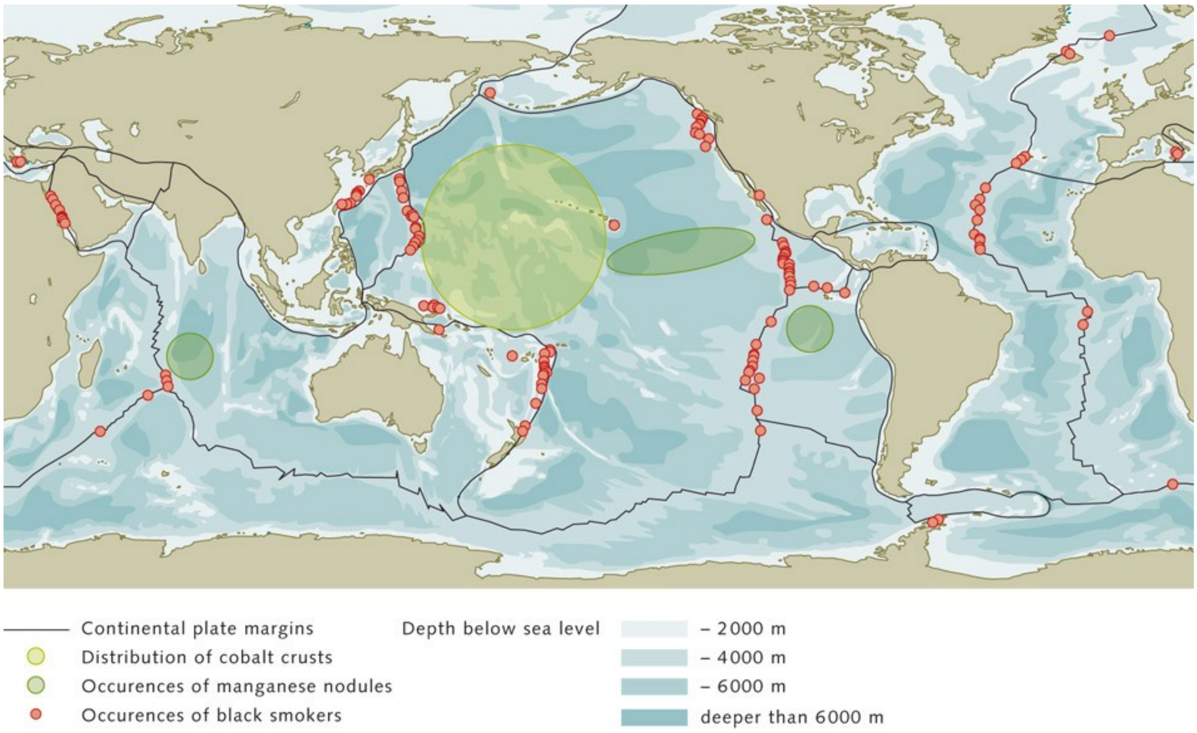

Fig 3: Geographical distribution of deep sea mineral resources (from [5]).

EXPLORATION FOR DEEP SEA MINING

Seabed exploration for mining of mineral resources faces a persisting knowledge gap of the deep marine environment, including the geosphere (seabed and below), the biosphere of the seabed and shallow sub-seafloor, as well as deep ocean water circulation. The vast areas of the mid-ocean ridge systems that host massive sulphide deposits have been explored only in small hot spots where research activities evolved with the development in the technology in seabed mapping, observing, and drilling. Similarly, the deep sea abyssal plains where poly-metallic nodules accumulate have received relatively little attention in scientific research. This is because the vast amount of offshore research and economic activity is concentrated along continental margins, in shallow water depth, close to land, and where hydrocarbon reservoirs are located.

Exploring the deep sea for mineral resources, therefore implies addressing a frontier of knowledge.

The basic approach has to be through the topographic characterization of the seafloor through multibeam surveys, spanning from regional surveys from ship hull-mounted sonars to high resolution surveys with near seafloor sonars mounted on AUVs or ROVs. Seabed mapping implies further seabed back-scatter characterization through deep towed side scan sonars, and direct observation via deep-tow cameras, or ROVs.

The geological environment that hosts the resources must be addressed with geophysical methods. However, deep penetration is normally not required. The abyssal plain environment typical for nodules is likely to be characterized by low rates of sediment deposition on flat or nearly flat surfaces, in a low-energy environment. Nodules are found only in the uppermost centimetres of muddy sediments. However, the presence of volcanic seamounts in abyssal plain settings may complicate the geological scenarios, adding a component of deeply sourced drivers of geological process like lava emissions, hydrothermal fluid circulation systems, volcanic edifice collapse, volcanic eruptions.

More complex is the geological environment in which massive sulphides deposits accumulate. It is intrinsically related to hydrothermal circulation systems in active volcanism areas. Furthermore, research has demonstrated that these deposits may attain several tens of metres in thickness as opposed to the thin distribution of nodules and crusts. The seismic characterization of the sub-seabed in such environments is hindered by rough topography, lack of coherent seismic response, and presence of fluids. In addition to the seabed characterization outlined above, coring and drilling for samples represent a fundamental operation in the exploration phase in this case. Such operations are particularly challenging due to the inhomogeneity of the deposit, alternating soft and hard sediment and rock, as several expeditions of the International Ocean Discovery program (IODP) have demonstrated [6].

Besides the technological challenge of setting up industrial operations in the deep sea, the monitoring of the impact of operations on the deep sea ecosystem represents a critical aspect that must not be overlooked. Given the lack of knowledge about the ecosystem functioning in the deep sea, it is mandatory to establish baseline information about the environment against which the impact of an operation can be determined. Part of the baseline information is inherent in the data acquisition for resource characterisation, but environmental monitoring with acquisition of time series over the prospect areas cannot be avoided. This implies the deployment of moored observatories, benthic cameras, data transmission systems that allow for the determination of the ecosystem functioning over a time span that is expected to be long, given the low-energy sustaining the ecosystems at depth.

The management of any mining operation has to fulfil the following objectives [7]:

- To maintain overall biodiversity and ecosystem health and function (as mandated by international law); and

- To reduce, mitigate, and, where possible, prevent the impacts of mining and pollution that can affect wider habitats and ecosystems.

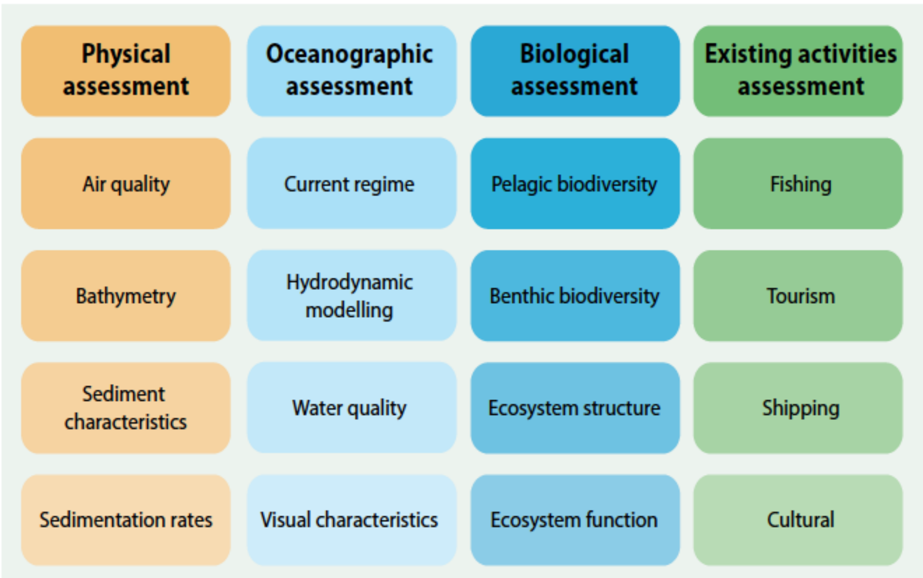

Fig 4: List of potential studies that may be required to define the environment prior to development of a deep sea mining campaign. (from [7]).

FROM OFFSHORE OIL & GAS TO DEEP SEA MINING

Deep sea mining activities will take place at sea and will therefore require solutions that have been developed for offshore oil and gas operations (e.g. support vessels, systems for vertical lifting of material, deployment of the equipment on the seabed and monitoring of subsea operations, etc.). Consequently, it can be expected that the migration of technological as well as operational know-how from oil & gas to deep sea mining will increase in the future. At the same time, some new solutions will have to be developed to make mining in the deep sea commercially viable.

Similarities and differences between deep sea mining and offshore oil and gas are studied by comparing value chains of both industries at macro- and meso-levels, following the example outlined in Ref. [8] for deep sea mining.

In general, both value chains follow the structure that is typical of any resource value chain: it starts with the discovery of resource deposits, their exploration, material extraction and processing, before the final product is distributed and sold. For the purpose of the study, deep sea mining as well as oil and gas value chains are divided into six macro areas, the last of which (i.e. distribution and sales) is not considered in this paper. At the meso-level the value chains are represented by the main activities listed below each macro area.

It should be noted here that while mining activities of different types of deep sea resources vary in some areas of the value chain, at the macro-level the description does not change. In the exploration phase, for example, core drilling is not required for manganese nodules as they normally lie on the surface of the seabed or are only partially buried. Core drilling is used to determine the composition and the thickness of massive sulphides and ferromanganese crusts. However, it is also not necessary to employ a drilling vessel because the sample drilled is relatively small in size. In deep sea mining sampling can usually be performed with seabed drilling rigs. In fact an oil and gas drilling vessel, used to drill deep exploratory wells (see Exploration in Fig. 6), is more similar in design to a mining vessel used in the production phase (see Production in Fig. 5).

There are, however, similarities between exploration phases in deep sea mining and oil & gas in geophysical evaluation of the resources, the equipment for which is relatively well developed and tested (Fig. 7).

Material properties of the resources dictate also the kind of modelling and assessment that is required. In this case, the approach used in land mining to determine the mineral reserves of the explored area will be employed also in deep sea mining and it is believed that reporting will adopt principles from the standard mining codes in use today (JORC, NI43-101).

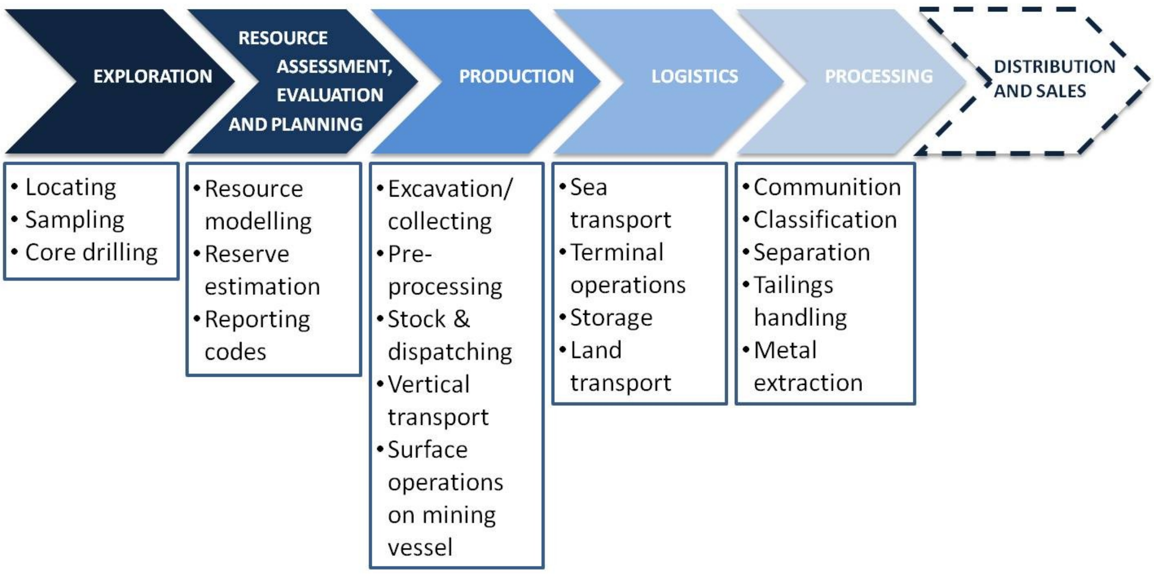

Fig 5: The deep sea mining value chain.

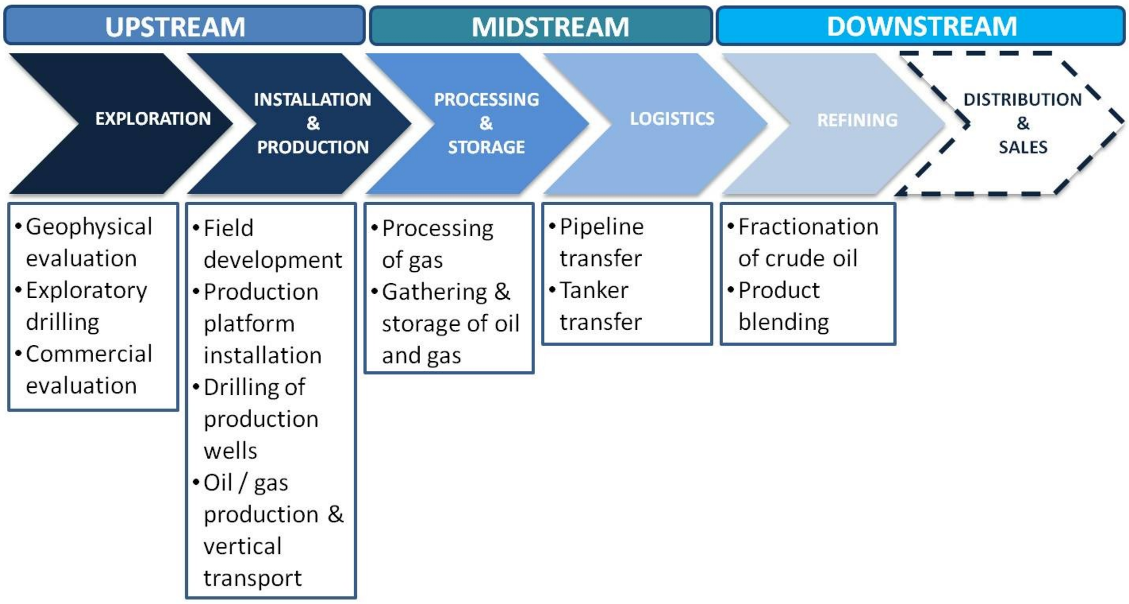

Fig 6: The offshore oil and gas value chain.

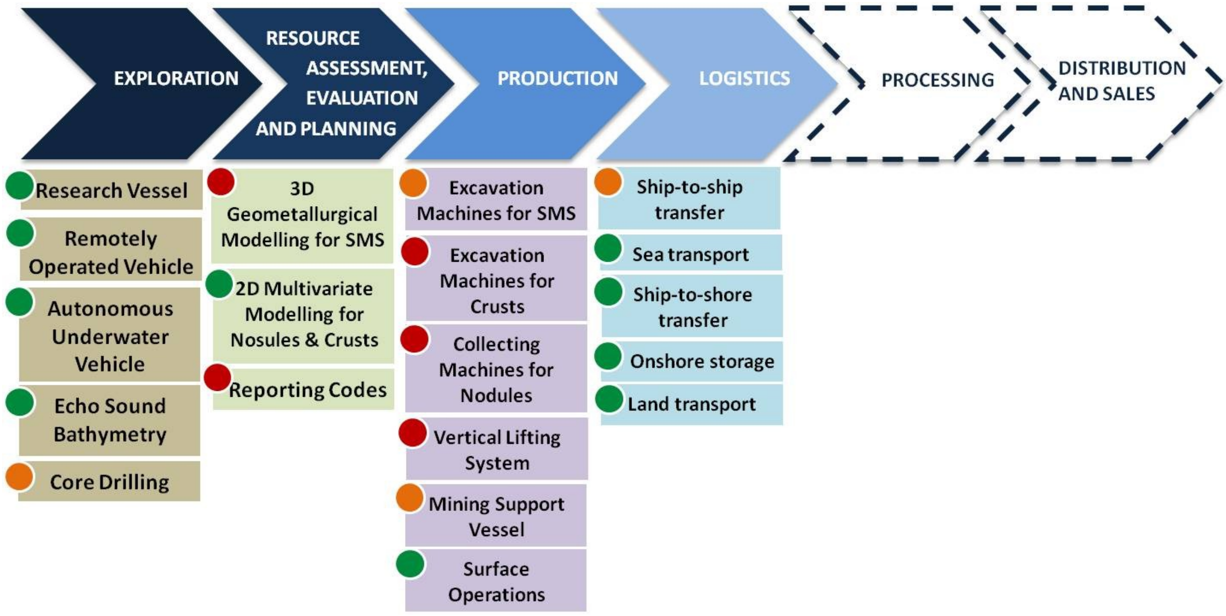

Fig 7: Technology readiness level for deep sea mining – high , medium , low .

As mentioned above, the technology utilised in the production phase of deep sea mining will resemble that of exploratory drilling in oil & gas where solid material (i.e. cuttings) similar to crushed nodules or sulphides is brought to the surface in a continuous manner and is stored on the drilling vessel. Moreover, the mining vessel will need to stay at the place of operation for an extended period of time, similarly to a drillship, which will require the support of additional vessels, for example the kind used in oil & gas for crew management and other regular activities. However, unlike in oil & gas, there will be no need for floating processing and storage units (FPSOs) as the ore will be processed at dedicated on-shore facilities. All material will be transferred from the mining vessel directly to a bulk carrier at the place of operation and transported to ports capable of handling large volumes of bulk material.

ITALY AND DEEP SEA MINING

The Italian offshore areas, like the entire Mediterranean Sea, are not considered a hot spot for deep sea mining (see Fig. 3). The geological environment is not appropriate for the formation of poly-metallic nodules. However, the occurrence of submarine volcanic provinces allows for the accumulation of poly-metallic sulphide deposits. The only known area of the Mediterranean Sea where this has been proven and studied is the Southern Tyrrhenian Sea [9].

Tyrrhenian Sea is a young back-arc basin, formed less that 5 million years ago following the NW subduction of the Ionian lithosphere below the Calabrian Arc. The basin floor of the Southern Tyrrhenian Sea is formed by oceanic crust and active magmatic processes that have produced large volcanic edifices (Vavilov, Marsili, Palinuro, Lametini, Sisifo, besides the Aeolian Islands) (Fig. 8). The high heat flow in the region (as high as 500 mW m^{-2}) and the fractured nature of the volcanic rock induces seawater convection down to the magmatic chambers that produces a vigorous hydrothermal circulation with mineral exchange between supercritical seawater and rocks at depth, and sulphide precipitation from the hot water venting at the seafloor. The water depth of the deep basins exceeds 3500 m.

The presence of massive sulphide ores in the area has been known since the early 1990s [10]. Extensive research has been performed in recent years to characterise the sulphide deposits surrounding the Palinuro Seamount [11, 12, 13, 14]. Seabed investigations were carried out through a dense grid of multibeam bathymetry, seafloor reflectivity, magnetic and gravity lines, and high-resolution single (CHIRP) and multichannel seismic profiles. In addition, lander drilling provided a few metres of rock recovery of core from a sediment-filled depression located at water depths of between 630 and 650 m. Results have revealed unique characteristics of the Palinuro sulphide deposits, rich in barite pyrite and other sulphides, deeply related to in situ microbial activity, not recognized in other modern environments [13]. The estimated size of the permissive area is about 35,000 km^2 [15].

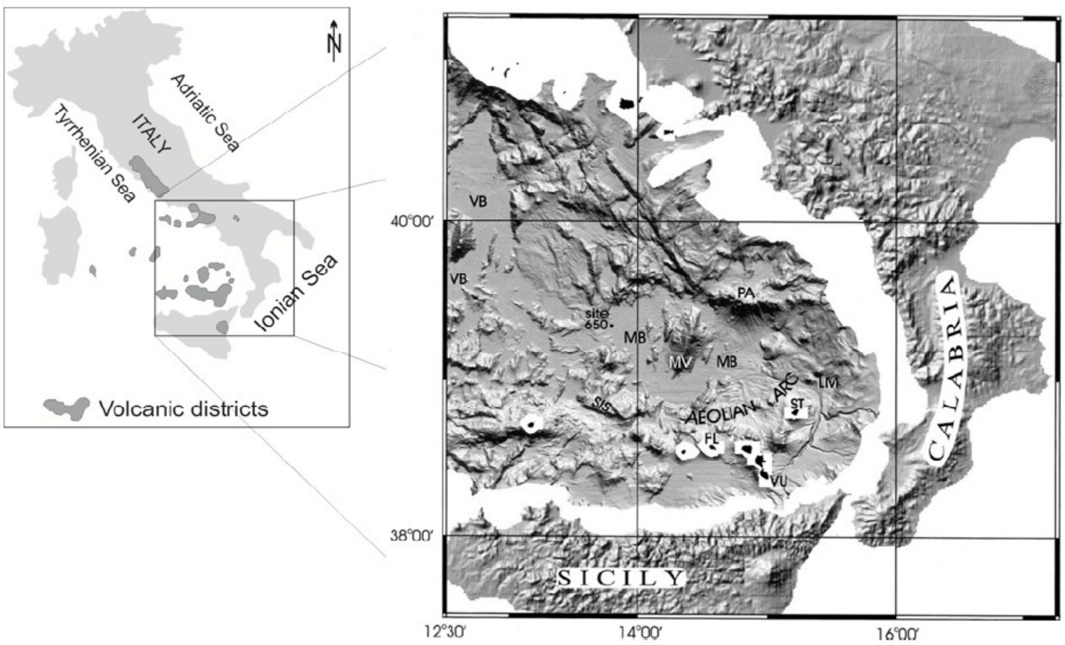

Fig 8: Submarine Volcanic province of the Southern Tyrrhenian Sea. MV: Marsili Volcano; MB Marsili Basin; ST: volcanoes of Stromboli; VU: volcanoes of Vulcano; FL: Filicudi Island; SIS: Sisifo submarine Volcanoes; LM: Lametini Seamounts; PA: Palinuro Seamount; VB: Vavilov Basin. (from [16]).

Given the high environmental sensitivity of the Mediterranean Sea, and the lack of knowledge about the deep sea ecosystems, the assessment of the economic potential of the deep Tyrrhenian Sea sulphide deposits cannot avoid an in-depth evaluation of the impact of mining activity on these ecosystems. Similar environmental assessments have recently been successfully carried out in the Pacific Ocean within the Joint Programming Initiative Healthy and Productive Oceans and Sea (JPI Oceans) on deep sea manganese nodule fields, demonstrating that poly-metallic nodule fields are hotspots of abundance and diversity for a highly vulnerable abyssal fauna [17].

The logistically favourable location of the Tyrrhenian Sea, compared to the Pacific, Atlantic, and Indian Ocean locations, allows for the establishment of a series of studies not only for the assessment of the mineral resources, but also for the environmental impact of various mining approaches. Furthermore, the proximity of suitable locations in the Tyrrhenian Sea to ports and industrial centres in Italy would be provide the opportunity to test subsea and mining equipment in the relevant environment during the development phase, an important advantage for mining contractors especially in the early stages when no standard equipment is available.

Likewise, the extensive experience of various Italian companies working in the offshore sector could be applied not just in assisting the activities of equipment testing, but also in actual mining operations. The ways in which Italian institutions could participate in deep sea mining with a varying degree of involvement and risk are presented in Tab. 1.

Participation at the lowest levels as a supplier to equipment manufacturers or as a service provider directly to the mining contractor brings with it not only the lowest risk in terms of investment, but also lesser benefits due to competition and in particular limited exposure to the new market. At this level only standard equipment or services are offered as there is practically no commitment on the side of the supplier.

Partnering with an equipment manufacturer or a mining contractor eliminates the problem of competition, but in most cases requires a form of investment, which consequently increases the risk the company or research institution is exposed too during the duration of the partnership. For individual companies or institutions with a deep sea mining strategy this may be a viable option in the absence of a national deep sea mining programme.

Tab. 1: Possible involvement of Italian companies and institutions in deep sea mining.

Type of involvement	Level of participation	Level of risk
Supplier to equipment manufacturer(s)	Minimum	Low
Service provider to a mining contractor	Minimum	Low
Partner of an equipment manufacturer	Medium	Medium - High
Partner of a mining contractor	Medium - High	Medium - High
Partner in a DSM cluster	High	Low - Medium

The highest level of participation requires the formation of a cluster dedicated to the development of deep sea mining on a national level. Although considerable investment in terms of know-how, technology and man-hours could be required from participants, their overall risk would be substantially reduced as a result of state sponsorship. Furthermore, close collaboration between participants with different specialities and capabilities could foster innovation also in areas other than deep sea mining, thus improving their commercial strengths in their primary sectors. Parallels can be drawn here with various examples of energy companies, including oil & gas, that are partly or entirely controlled by the state due to the importance of the energy sector for the development of a country and which have created businesses outside their primary sector.

Considering that collaboration within a cluster would greatly reduce the participants' risk of entering into a sector at an early stage of development, while providing greater benefits in terms of business growth compared to other types of involvement, it is proposed that Italy follow other technologically advanced countries such as Germany, France and Japan in creating a cluster of selected companies and research institutions to work towards establishing a deep sea mining industry in Italy. For this, the participants in the cluster should be chosen such that they cover at least the most critical areas of the value chain (Fig. 5) and could be grouped in four principal parts of the cluster, as shown in the schematic in Fig. 9. The role of each part is described below in more detail.

Fig 9: A schematic representation of the proposed Italian deep sea mining cluster.

Key Public Institutions

A cluster of companies and institutions dedicated to the development of the deep sea mining sector in Italy would need to be centred around public institutions such as government ministries, in particular the Ministry of Economic Development (Ministero dello Sviluppo Economico – MISE), and the Italian Petroleum & Mining Industry Association (Assomineraria). These institutions would provide direction for the development of the cluster, act as representatives at various international organisations and agencies (e.g. ISA, EU), provide support for research related to deep sea mining, and act as a sponsor of the Italian mining contractor for exploration as well as exploitation of deep sea resources in international waters.

Ideally, deep sea mining would be included in the government's economical growth strategy as an alternative source of minerals, which could see benefits in improved supply dynamics, technological advancement of the country and also increased employment in the offshore sector.

Strategic Partner (DSM Contractor)

A strategic partner in the form of an Italian deep sea mining contractor would be in charge of operational requirements of a deep sea mining project. It would provide management of technical development, marine research activities, and of course the entire process of mining. Depending on the structure of the cluster, it could also cover the processing part of the value chain with the sale of minerals to end users. In this case, its role would be similar to that of an oil company.

Although a large (land) mining company would be an ideal partner because of its experience in mineral trading, examples of existing private deep sea mining contractors show that with the business models that are being developed, whereby unprocessed ore is considered the final product of a deep sea mining company, the Italian contractor could cover fewer areas of the value chain presented in the previous section. Consequently, a strategic partner could be a financially stable and technologically strong company interested in expanding into a new market.

Marine Geology and Environment Research

Oil & gas development in the Italian offshore areas has helped private and public institutions in Italy gain relevant capabilities in assessing and monitoring the marine environment. Moreover, by participating in different research programmes related to deep sea mining, for example the Deep-Sea and Sub-Seafloor Frontier project [18], the Italian maritime research community has gained valuable experience in areas directly related to deep sea mining and could therefore actively contribute to further development of some of the very important aspects of the nascent industry, such as resource assessment at the exploratory stage, environmental monitoring before and during mining operations, in addition to the assessment of mining risk. The latter is a crucial activity mining contractors working either in national or international waters must carry out before mining machines can be deployed on the seabed and excavation or collection of ore can begin.

Technology Partners

Italian companies are already present in deep sea mining as suppliers of equipment, most notably Bedeschi S.p.A, which has been awarded the order for the cargo handling system of the first mining vessel being built by Nautilus Minerals [19]. Several other Italian companies working in the maritime sector are also recognised as technology leaders, not least Fincantieri as a designer and builder of highly complex vessels for the offshore industry.

The role of technology partners would be twofold:

1. Develop the necessary technology for exploitation of deep sea resources,
2. Provide support to the mining contractor in developing the procedures for resource exploitation (e.g. efficient technology deployment, investigations of effective machine utilisation, etc.).

In addition, companies specialising in equipment for exploration and sampling would cooperate with institutions working in the area of marine geology and environment research, a collaboration that would benefit both sides by enabling the development of new technologies that could be used in other markets.

CONCLUSIONS

Traditionally, the offshore industry grew as a result of the expansion of oil & gas sector into deeper waters. But with the emergence of deep sea mining, new opportunities for business growth have become available to technology and service providers with capabilities to deploy advanced systems deep on the ocean floor and extract vital resources that contain various critical minerals.

New approaches to management and novel technological solutions will need to be introduced to achieve efficient production in the harsh marine environment. However, many existing technologies already in use in the offshore oil and gas industry can be applied directly to deep sea mining. In particular, technologies used in the exploration of hydrocarbons can be utilised both in the exploration as well as in the exploitation phases of seabed mining.

Geophysical methods for geological characterisation of the seabed and research vessels with subsea exploration equipment can be applied for the purpose of resource mapping as well as environmental investigations. Limited knowledge that exists about the deep sea ecosystem in areas of interest for mineral exploitation will require extensive studies in order to establish a baseline against which the impact of seabed mining on the surrounding environment can be determined. The experience gained by collaborating on projects related to oil & gas and also deep sea mining have given the Italian marine research community strong competences in this area.

Similarly, the expertise of the Italian technological sector in the development, construction and operation of offshore vessels and oil & gas equipment could be leveraged to advance the technological level of deep sea mining. Although some systems used in oil and gas can be utilised also to bring deep sea mining resources to the surface, modifications will need to be made to equipment parts in order to allow the transfer and storage of solid ore. The most appropriate equipment for seabed mineral exploitation are systems for exploratory drilling (vessel, vertical lift system, subsea pumping systems, etc.), which are already capable of handling crushed solid material. In fact, by comparing both sectors, it becomes apparent that deep sea mining relates best to oil and gas in the exploration area of the latter's value chain whereas other areas such as transport and processing, which are not part of the offshore industry, understandably do not match.

As a new market that is becoming strategically important to many countries, deep sea mining will without doubt become interesting also for Italian companies working in the offshore industry. In this respect, a proposal is made for the creation of an a cluster of companies, research entities and public institutions to promote the development of deep sea mining technology in Italy with the aim of eventually setting up a national mining contractor. The cluster would be centred around certain key public institutions such as the Ministry of Economic Development (MISE) and the Italian Petroleum & Mining Industry Association (Assomineraria) who would act as sponsors of the industry by putting in place a policy framework that would enable them to engage with relevant international organisations. Collaboration within the cluster would provide the participants with the expected benefits while lowering their exposure to risk. Furthermore, it would enable Italy to better position itself in the market, especially considering that it has sulphide deposits in national waters (Tyrrhenian Sea) in relative proximity to ports and technological centres, which could become an important advantage at the early stages of system development.

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