

# Marine Mineral Resources

## Continental Margin Mineral Resources - Hard Minerals

### Hard Minerals

Ocean mining of mineral resources has enormous economic potential. The hard minerals mined for resources can be classified into five groups:

- construction material, including sand, gravel, and other high bulk materials;
- industrial materials including silica sand, aragonite, phosphates, and sulfur;
- metallic minerals in placer deposits - gold, platinum, tin, titanium, and rare earth metals;
- metaliferous oxides, which contain manganese, copper, nickel, and cobalt; and
- metaliferous sulfides, including copper, lead, zinc, chromium, and gold.

The major problems for any country in mining mineral resources are the costs and environmental concerns. Production cost, including mining and transport, must be low enough to compete with onshore mining processes. Only a few mining industries on land are producing at more than 80 percent of capacity, some not even at 50 percent which reduces demand or profit for alternate sites. In 1983 among eighteen selected minerals now produced or potentially available in the oceans, annual production averaged not quite 75 percent of capacity.

Political issues associated with efforts to establish an ocean-mining regime are another deterrent to proceeding with deep-seabed mining. The less-developed countries are determined to obtain a greater share of the wealth that might be provided by deep-seabed mineral resources. Numerous industrial states are equally determined that the welfare of their populace and national economy will not be jeopardized. With offshore technology increasing using better equipment, and with more understanding of what resources are available, and fifteen years of work on Law of the Sea treaties, marine mining may become competitive with onshore mining.

In the U.S., there is little or no marine mining of sand and gravel, metallic minerals, and phosphorites. The U.S. has used up the majority of its land-based mineral resources. Therefore, the potential for minerals from offshore is great for the United States and even though the market is depressed, the reduction of mineral imports would reduce the national debt.

Diamonds have been mined off the South African coast and barite off the Alaskan coast, tin off the coasts of Thailand and Indonesia, oyster shells off the Gulf Coast of the United States, and sand and gravel off the coast of the United Kingdom.

The chief tool for underwater mineral exploration is the practicing marine geologist using seismic and magnetic profiling, dredging and coring tools, depth sounding, laboratory analyses, and geological and bathymetric mapping. At the present, less than 5% of the coastal seafloor of the world has been scientifically surveyed. In the search of the deep sea for minerals, if all of the dredge samples taken to date were averaged over the deep sea floor, this would give three dredge hauls per million square kilometers --three samples to evaluate the state of Texas.

### Construction and Industrial Materials

The non-fuel mineral production from the world's continental shelves is about \$500 million per year. This is only one percent of the total world mineral production. Sand and gravel mining is about 40% of the marine production by value. Because of the volume ratio to value (one cubic meter of sand is currently \$20) the reserve must be close to the market, but the low cost of barge transport can reduce total transport costs. Dredging of these deposits is attractive because of low capital investment, quick returns, high profits, and operational mobility when the operation is limited to less than 250 feet in waters free from severe weather and wave problems. The depletion of onshore deposits of construction aggregates and environmental restrictions on beach dredging have led many nations to develop offshore mining for aggregates. Figure 9.9a



Japan is the world's largest producer of offshore aggregates. Japan's onshore aggregate industry is experiencing increasingly stringent environmental regulations which makes offshore extraction of sand and gravel appealing. Between 20 and 25 per cent of Japan's supplies of natural aggregate comes from marine sources. Canada's offshore sand and gravel production in late 1984 was limited to the Arctic, where it was being dredged to build artificial islands for oil and gas drilling in the Beaufort Sea. Collectively Canada's coastal provinces have good offshore aggregate potential. Canada's offshore predicted sand and gravel production in the year 2000 might range between 1.8 million and 46 million tons.

On the east coast, Newfoundland-Laborador and Nova Scotia are projected to be the leading sand and gravel producers. Approximately 50 percent of all aggregates produced from the east coast provinces are consumed there. Great Briton has a major offshore aggregate industry. By the mid-1970's, production from offshore accounted for 12 percent of the national total (15.6 million tons). In 1986, 27 percent of the total aggregates used in southeastern England came from offshore showing a continued rise in offshore production.

Because of diminishing onshore reserves, an increasing public concern for the environment and a likely growth in consumption, offshore dredgers will need to produce additional tonnage. The demand for construction sand and gravel in the U.S. is expected to grow at an annual rate of about 2.9 percent between 1982 and the year 2000. by the year 2000 estimated requirements are  $8.1 \times 10^8 \text{m}^3$  for the US - rebuilding major segments of the interstate highway system, deep draft port facilities, airports and beach replenishment. A rough approximate of east coast United States sand resources are  $5 \times 10^{12} \text{m}^3$  of sand.

obviously not all of the  $8.1 \times 10^8 \text{m}^3$  annual need will come from marine resources; but demand may initiate more use of offshore resources.

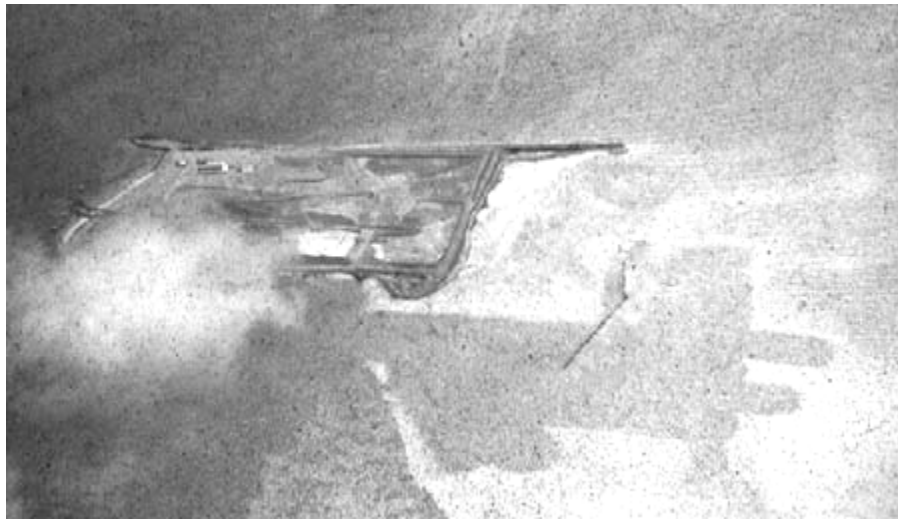
Exploration tools for sand resources are seismic profiling and side scan sonar; followed by vibrocoreing. recovery can be by a variety of dredges.



Sand and gravel mining is done with two systems: clamshell type buckets and sand pumps -- a hydraulic system. the hydraulic hopper dredge seems to be a universal type suited for open marine waters but it causes a higher degree of turbidity and environmental problems with ensuing regulation of operation. Figure 9.9b Besides turbidity, a possible problem with sand extraction is a change in bottom bathymetry, which could cause a change in wave regime, in turn a problem of coastal erosion. In Japan, this is eliminated by restricting extraction to water depths greater than 20 meters.

Industrial sand is another most widely used non-metallic commodity. Pure silica sands are dredged for the glass and chemical industry off Japan, northern New Zealand, and in the Baltic. Of the nearly 25 million tons of industrial sand produced in the U.S. during 1983, glass manufacturers used 36 percent, foundries 26 percent and abrasives producers 8 percent.

Aragonite sand occurs in shallow waters off Andros, Bimini, and Eleuthera in the Bahamas as oolite shoals. Marcona Ocean Industries uses a suction dredge to extract aragonite to a barge which then carries it to a stockpile on a combination of natural cays and interfilled area Figure 9.9c. It is moved from this storage for shipment to US and Caribbean markets. It is used for beach fill, acid neutralizing plants, and in agricultural and industrial chemical processes. Figure 9.9d



Marine shell material has been used as an alternate to sand and gravel and has been used as a source of lime for cement. Because of Iceland's lack of sedimentary rock, the government has developed a state-owned cement-works and an agricultural lime establishment that use seashells as their raw material. Brazil began producing lime from seashells in the 1950's. Several areas in the U.S. produce, or have produced seashells, including California, Texas, Louisiana, Mississippi, Alabama, Florida, Virginia, and Maryland. In the Gulf Coast, local road-builders surface roads with shells, where good construction sand, gravel, and stone are not available locally. Currently, Louisiana has an important shell-dredging industry. The state has no major commercial limestone or other calcium carbonate resources. Shells help fill this gap in Louisiana's resource base, and the industry contributes significant revenues to the state's coffers.



Controversy has centered on the environmental impact of shell dredging. Three complete Environmental Impact Studies (Mobile Bay, Tampa Bay, and San Antonio Bay) show that shell dredging causes only

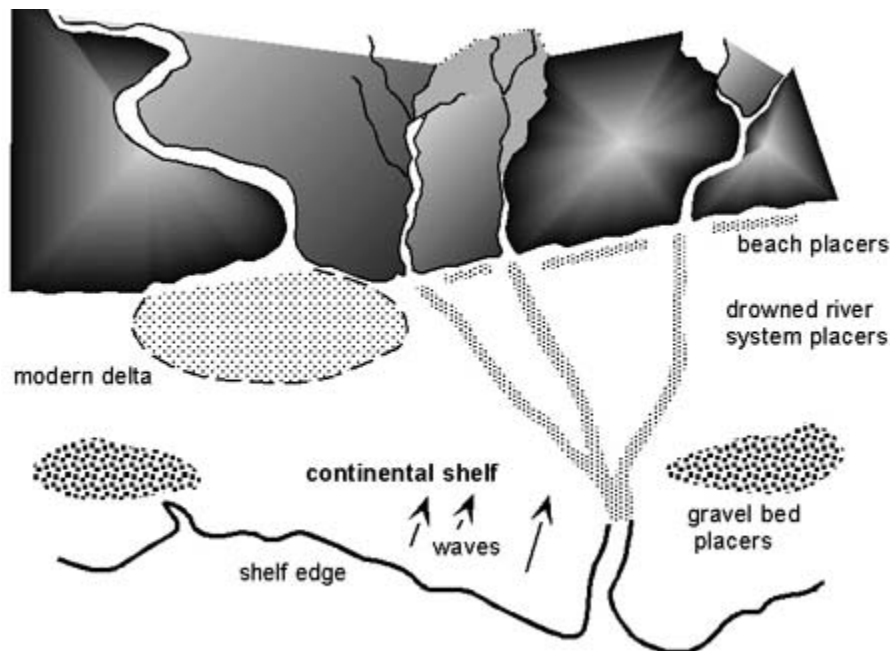
minor damage. Control of allowable dredging sites has prevented kills of live oysters; nearly all sediments settle out within about 120m of the dredge -actually less disturbance than a shrimp trawl. Dredging in Texas and Florida has stopped because of: depleted shell supplies, competition from lower cost crushed limestones and other limestone sources, economic recession and increased costs for environmental protection.

Deterrents to marine mining have been aesthetic and environmental concerns, development of technology, cost-benefit factors, and the lack of clear government regulations. The removal of the sand can cause severe erosion and loss of marine habitat. Research has shown that dredging operations can cause impacts that range from detrimental to beneficial. The impacts are predictable and careful planning can minimize undesirable ecological effects.

Another problem is purely economical, the cost of transportation to the market. The maximum transport distance for aggregate to be competitive with traditional onshore sources is about 150 km. Silica sand and carbonate aggregates have a higher unit value and can be transported farther distances. In the case of aggregates, port facilities and storage space are also important cost factors. Local markets and favorable geology are important for aggregate mining. Placer minerals which are concentrated at the site and which have much higher unit value are less sensitive to transportation.

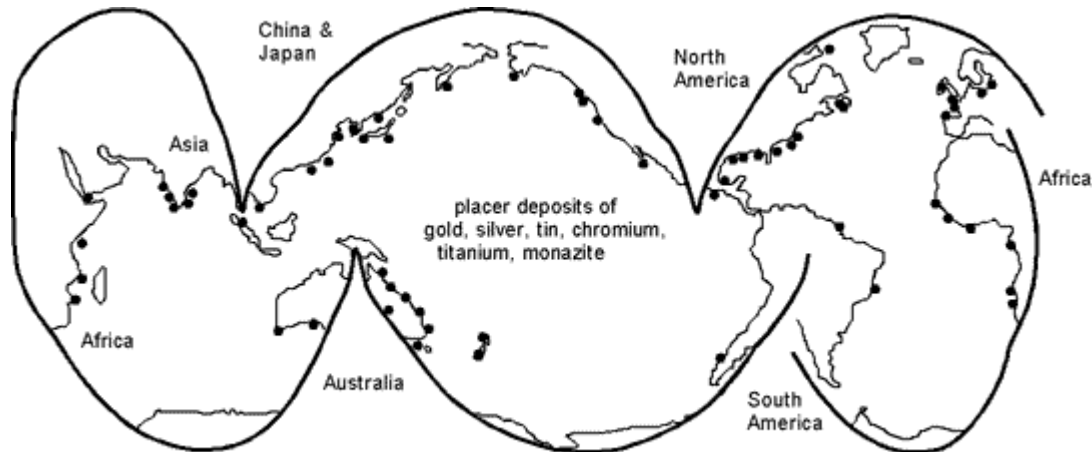
### **Metallic and Gem Minerals in Placer Deposits**

A placer deposit is an accumulation of mineral grains concentrated by sedimentary processes. When pebbles, sands, and silts are sorted by wave action or stream flow, minerals with higher specific gravity and resistance to weathering become concentrated, especially in beaches and drowned river mouths. Marine placer mineral deposits are found on the continental shelf from the beaches to the outer shelf Figure 9.10. These transported deposits may have formed in a marine environment, but have generally been emplaced while the shelf was emergent under a lower sea level. The glacial sea level lows exposed most of the shelf to subaerial processes and stream placer deposits extended across the shelf.



The concentration of minerals depends on the source rock, weathering, transportation and trapping by subaerial processes and subsequent reworking and modification by marine processes. Locating potential marine placer resources is often less difficult than determining their exploitability, because varying littoral drift rates and directions, altering wave-energy distributions, and changing water levels contribute to

regional and local variations in placer distributions. Many mineral-bearing offshore and beach placers (diamond, gold, platinum, tin, chromite, iron sand, zircon, ilmenite, rutile, and monazite) are now mined or have been mined in the past. The major placer materials in the U.S. are tin, titanium, gold, platinum, and chromium Figure 9.11.



Diamonds are the only gemstone presently mined offshore. World production of diamonds has grown to 100 million carats in the nineties but offshore mining produced less than 100 thousand carats in 1995. Diamond mining from the beaches and nearshore in Southwest Africa was done from 10 to 40 meters water depth with suction and airlift dredges, but the loss of three dredges caused a halt in 1971. In 1978, mining began again with SCUBA divers and suction tubes, with recoveries of about 26,000 carats of gem quality stones per year. Dredging for diamonds in Brazilian waters has been reported. Demand for gemstone diamonds is likely to expand as personal incomes increase in the US and other industrialized states.

The noble elements such as gold and platinum yield very high returns and can be mined from beaches and the nearshore off Alaska, British Columbia, Nova Scotia, Philippines, and Russia. More than \$500 billion dollars of gold placers are estimated in Alaska. Presently, no platinum placers are mined in the world's oceans, but at one time, dredgers worked them in waters near the villages of Platinum and Goodnews Bay, Alaska. The western world's estimated demand for platinum is greater than the supply and Alaska still has a good potential for offshore platinum mining. The US consumes about one-third of the world's total annual platinum mine production, and it's probable consumption is projected to increase by 63 percent from 1983 to the year 2000 so there should be an interest in the offshore potential. A continuing vulnerability of the US's platinum supply, and an anticipated growth in demand for the metal, make it important that a greater effort be made to locate and develop domestic sources.

The strategic element titanium, derived mainly from ilmenite and rutile ores, is an important placer mineral. About 5 percent of the world's annual production are consumed in making metal alloys that need special strength and corrosion resistance. Titanium placers occur in West Africa, along the coast of Mauritania, on the continent's opposite coast, near the south-eastern shore of Madagascar. The titanium mining industry, in the past, experienced "boom and bust" periods. Its fortunes are tied to the amount of activity in the military and commercial aircraft industries. With future growth likely in the worldwide aerospace industry, titanium will continue to play an important role in world markets. Total titanium metal consumption is expected to increase annually in the U.S. by 5.5 per cent between 1983 and 2000; the probable annual rate for the rest of the world will be 26.2 percent.

The best known and most important marine metallic placer is tin which is found in the mineral cassiterite. Today tin goes into the fabrication of containers, solders, engine bearings, and air-cleaner and oil-filter cartridges. The world's most important area for offshore tin production is in waters surrounding the Malay Peninsula and those lying between Sumatra and Kalimantan. About 7% of the global production of tin is mined offshore. Malaysia, the world's most important tin producer, had 31 percent of its total tin output come from the offshore in 1984.

The offshore now accounts for 50 percent of Thailand's total annual tin production. The Indonesian Government expected to produce nearly half the country's annual total output of 27,000 tons in 1986 from the offshore. Offshore or beach tin placers also occur in the UK, USSR, US (Alaska) Burma, the Peoples Republic of China, and the Philippines.

The world market for offshore production of tin is estimated to be from \$1-2 million to \$100 million, but the industry has been in a deep depression. The U.S. alone has potential tin placers off the coast of Alaska worth approximately \$39 billion dollars, which is not being mined presently. The surplus problem is made worse because not all tin-producing states are members of the trade cartel and Bolivia and Brazil, the world's fourth and fifth largest market-economy producers continue to produce without quotas. The tin market is in oversupply, and the outlook for offshore tin mining, in the near future is grim. The tin industry should recover, although many of the less efficient producers may have been eliminated.

Because placers are available in marine beaches and nearshore environments, they are more accessible than the deep-sea minerals. Overall, the physical and economic problems confronting placer producers should be less severe than those faced by deep seabed miners, and more importantly, most placers lie within the continental shelf, which is legally controlled by the adjacent nation. Marine placer extraction should form an increasingly significant part of the offshore mining industry.

Different operating conditions, seabed characteristics and economic demands have contributed to the development of a variety of dredges for exploitation of placer deposits. Shallow-water dredges may be broadly classified into hydraulic and mechanical types. Hydraulic units siphon (by pipe) the desired material onboard as an ore and water slurry, whereas mechanical units cut into the ore and lift the fragments onboard by a dragline, a dipper, a clam shell or an endless-chain bucket system. Mechanical dredges can operate in waters of unlimited depth, but ordinary hydraulic dredges are limited to about 60m, with most operating at depths of no more than 30m. Seabed dredging creates sediment plumes that, after settling out, may affect some sessile and mobile benthic biotic communities.

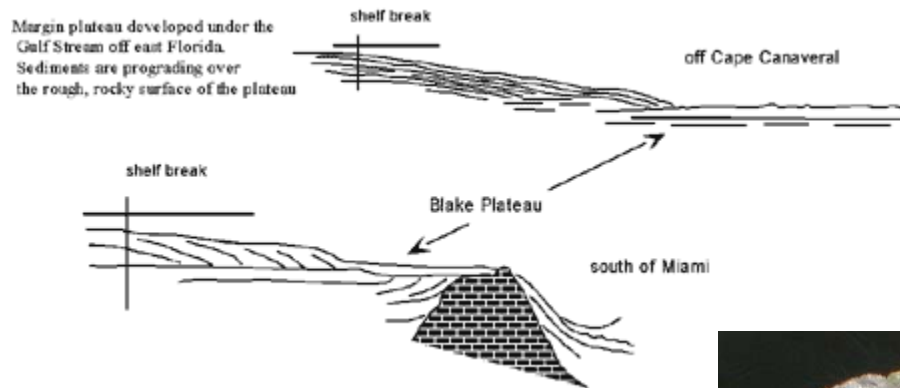
## Phosphorites and Sulfur

About 52 million tons of phosphorite are mined on land in the U.S. annually. The reserves still available are estimated to last 20 more years. Phosphorites are used mainly by the agricultural industry for fertilizer. The present phosphate market is in oversupply, but the long range view indicates an increase in their use, as world population growth will require more phosphates for agriculture and industry. This may lead to offshore production because onshore local environmental regulations are increasingly difficult to meet. Changing land use in onshore sites and depletion of onshore open pit deposits on land will also lead to offshore exploration.

Phosphorite deposits occur on several continental shelves -Atlantic waters of the U.S., Morocco, Gabon, Congo, Namibia, and South Africa and in the Pacific Basin in the US, Mexico, Ecuador, Peru, and New Zealand. They usually are in less than 1000m of water in relatively tropical regions where they are linked to zones of coastal upwelling, divergence and biological productivity. Most deposits are of Miocene age, reflecting good environmental conditions for phosphorite deposition at that time.

Specific areas in the United States include the Blake Plateau Figure 9.12a, offshore areas of California's central and southern coasts. Phosphorites are in a sediment sequence up to 10m thick on the Blake Plateau

off Florida and economic studies of several shelf deposits indicate that if thick deposits exist in relatively shallow water and near markets they would be potentially economic today.



Sulfur is used in manufacturing and agriculture. Native sulfur is associated with salt domes in the offshore of the US Gulf Coast in salt dome cap rock Figure 9.12b. Most is produced onshore, but one offshore mine is in shallow water off central Louisiana. The sulfur is extracted by the Frasch system, which uses the injection of superheated water through boreholes to melt the sulfur which is forced to the surface by compressed air. The operation is minimal because of glutted sulfur markets stemming from by-product sulfur extraction in environmental control systems and petroleum refining which accounted for 55% of total world production. Figure 9.12c



## Environmental Problems Associated with Mining of Hard Minerals

Since we are moving coastal or sea bed materials in a mining operation, all of the environmental problems associated with dredging and filling apply. In the case of construction materials, large amounts of sediment are moved and the local environment may be altered. Mining of sand from beach dunes and

from river mouths will affect beach sources and equilibrium. Indiscriminate removal of sand will result in beach erosion. Problems also exist in offshore bulk material mining. Both the direct removal, and the debris released to the water column can have an effect on local marine life. Large removals can change the bottom configuration enough to change wave and current patterns, possibly to an adverse effect on the coastal beaches.

Although metallic and precious minerals are less bulky themselves, large amounts of material must be removed to recover the minerals. This not only parallels the removal problems of bulk mineral mining, but adds return of the waste material as fill.

## Deep Sea Mining

All of the minerals discussed previously have been recovered by surface mining on the shallow continental shelves or nearshore coasts. The metaliferous oxides and metaliferous sulfides occur in the deep ocean. Metaliferous oxides such as manganese nodules were collected by the HMS Challenger in 1872 and their potential has been dreamed about ever since, but deep ocean mining of these minerals is still in its infancy.

At depths between 4,000m and 6,000m, developing mining and processing technologies needed to recover the desired minerals from the nodules - nickel, copper, cobalt, and manganese - require large investments. One enterprise is now in an advanced stage of preparatory work for extracting hydrothermal metalliferous muds from the deep trenches of the Red Sea. Despite the rather dismal mineral market conditions, we will become more dependent on the oceans as a mineral resource reservoir in the future.

### Metaliferous Oxides

In the early 60's John Mero's thesis demonstrated the economic potential of manganese nodules. This was followed by "nodule fever" with industrial companies investing millions of dollars in the development of mining and processing technology. In the 1960's, the competition for copper, nickel, and cobalt drove prices upward and many nonferrous metals were in short supply. Ferromanganese nodules (manganese nodules) and ferromanganese crusts (crusts) have a wide distribution and have in common a composition dominated by manganese and iron oxides.

Manganese nodules occur in all the oceans. Their accretion rate is very slow, only a few mm in 1 million years. The average nodule has 24% manganese, compared to 35 to 55% manganese in land ore bodies, so they do not offer solid economics as a manganese source, but they also contain iron (14%), copper (1%), nickel (1%), and cobalt (0.25%).

Cobalt enriched crusts on the flanks of seamounts, volcanic islands, and ridges contain as much as 2.5% cobalt and these occur in depths of 1000 to 2500 meters. Figure 9.13a Because the crusts are only about 2 cm thick, the mining technology presents a problem. Both the manganese nodules and crusts may be exploited in the future. Potential mining sites are a 500 mile wide nodule belt running for 2500 miles from west of Mexico to South of Hawaii, belts of North





Pacific nodules that are close to Japanese and American markets, and a large concentration in the North Atlantic that is near American and European markets.

Cobalt is the most important of the elements in nodules and crusts in price and as a strategic metal. It is indispensable for "superalloys" used in jet aircraft engines. Cobalt supplies are limited, and the largest producer is Zaire. Ocean mining would provide a new source. Cobalt-rich manganese crusts occur on the shallower flanks of volcanic islands and seamounts. Thus, these deposits may be easily recovered compared to the deposits found in the deeper areas.

In the last 20 years, many nodule deposits have been located, mapped, and evaluated. Commercial interest have centered on the region of the eastern Pacific between the Clarion and Clipperton fracture zones. In 1984, the US Dept. Commerce issued exploration licenses to four consortia. But now a hiatus in activity that began in the mid 1980's is evident. Progress has slowed until advancement is nearly imperceptible. After the first oil embargo in metal markets were affected. Poorer nations not only ceased purchasing metals, but immediately increased ore production whenever possible. The life-style of affluent nations plunged and the metal market was depressed.

Problems associated with nodule mining include who owns the deposits, how to obtain mining claims, and environmental problems of collection and processing. Provisions written into the Law of the Sea were designed to handle nodule exploration, exploitation, distribution, and the sharing of profits. We still have no deep sea mining, and probably will not for some years, but the early interest led to drawing up the Law of the Sea to answer some of the questions hindering legal mining. Political stability and investment climate will be important driving factors. Many once active nodule mining technology research programs have been on hold since the early 1980s.

Nodule mining is sensitive to metal prices and to the required energy and capital costs involved in mining. Processing is the most costly phase of nodule production, with energy the paramount input. A cost-cutting approach is nodule beneficiation on board shipboard by leaching (hydrometallurgy), roasting/smelting (pyrometallurgy), or combinations of the two. Because the main minerals (copper, nickel, cobalt, and manganese) contained in nodules are some of those most in demand by industry, extraction technology, and economic analyses have focused on them. Looming beyond the engineering difficulties, prospective producers face a currently depressed metal market. Cobalt's onshore "resource life expectancy" has been calculated at 340 years and world capacity to produce cobalt exceeds demand.

At the present, exploration ships are limited in number and no mining ship has been developed. It would be an enormous vessel, capable of operating non-stop for months at a time and scooping up millions of tons of nodules per year Figure 9.13b. Nodules would be transferred to bulk carriers, which would shuttle between mining ships and shore processing plants. The magnitude of costs



and rewards are enormous -- the amount of metals produced from a single major operation could alter world prices. Production might equal 50% of the current consumption of manganese and 100% of the required cobalt.

The value of nodule-bearing areas differ widely; any location will have a value depending on metallic content, density of occurrence, depth of water, characteristics of the bottom, distance from shore. Development of these resources is restricted to developed nations because of the requirements of technology and capital.

The major fundamental issue remains that of technical and economic feasibility of nodule mining. Although there are trillions of tons of nodules in the oceans, the gathering or exploiting is a good deal more complicated than simply raising enough nodules to make a profit. One must raise enough high grade nodules to make a profit. This focuses attention on an important mining principle, the necessity of obtaining long term assured access to specific mining sites. Some observers unfamiliar with mining economics have suggested that mining companies simply fish for nodules, without obtaining concessions to a specific site. Because of the variability of manganese nodule metal content, the company must have exclusive access to high grade nodules and nodules that are consistent compositionally which is important for efficient processing.

## **Polymetallic Sulfide Deposits**

Polymetallic sulfide deposits are products of the circulation of seawater through the hot volcanic rocks which well up along spreading ridges of the oceans and back-arc basins. Upon coming in contact with cooler water, the minerals precipitate producing mineral deposits of zinc, copper, lead, barium, silver, and gold in widely varying proportions in sulfides and oxides. Some deposits in heavily sedimented environments appear to contain several millions of tons of ore and compare with some of the largest massive sulfide deposits that are being mined on land. Except for the Atlantis II Deep in the Red Sea, none of the deposits have been surveyed and sampled sufficiently to determine their grade and tonnage.

Deposits are known from about 100 locations in the Pacific, two in the Atlantic, one in the Mediterranean, one in the Indian Ocean, and in several "deeps" of the Red Sea. Deposits at six sites (Atlantis II Deep, Escanaba Trough, Middle Valley, TAG, seamount at 13° N, and southern Explorer Ridge) are within the size range of deposits that would be mined on land under favorable economic conditions.

Many marine mineral specialists believe that some polymetallic sulphides will be extracted before mining ferromanganese crusts and nodules. Mining will focus on sediments of the Red Sea type. Where polymetallic sulphides occur as loosely consolidated sediments, they should be easier to exploit. The Red Sea sediments measure 10-20m deep within a 5-km-wide and 13-km-long area of about 56 million m<sup>2</sup>. The sediments contain an estimated 32 million tons of metal and are about 35m thick at the main mine site. Of this total, iron measures 29 percent, zinc 1.5 percent, copper 0.8 percent, and lead 0.1 percent. Mining activity will be dependent on an increase of the presently unfavorable metal prices, solving technical problems in recovery and processing and environmental problems and regulatory problems. The resource is substantial, but unfavorable metal prices and problems in recovery and processing make it unlikely that exploitation will begin soon.

## **Political and Legal Aspects**

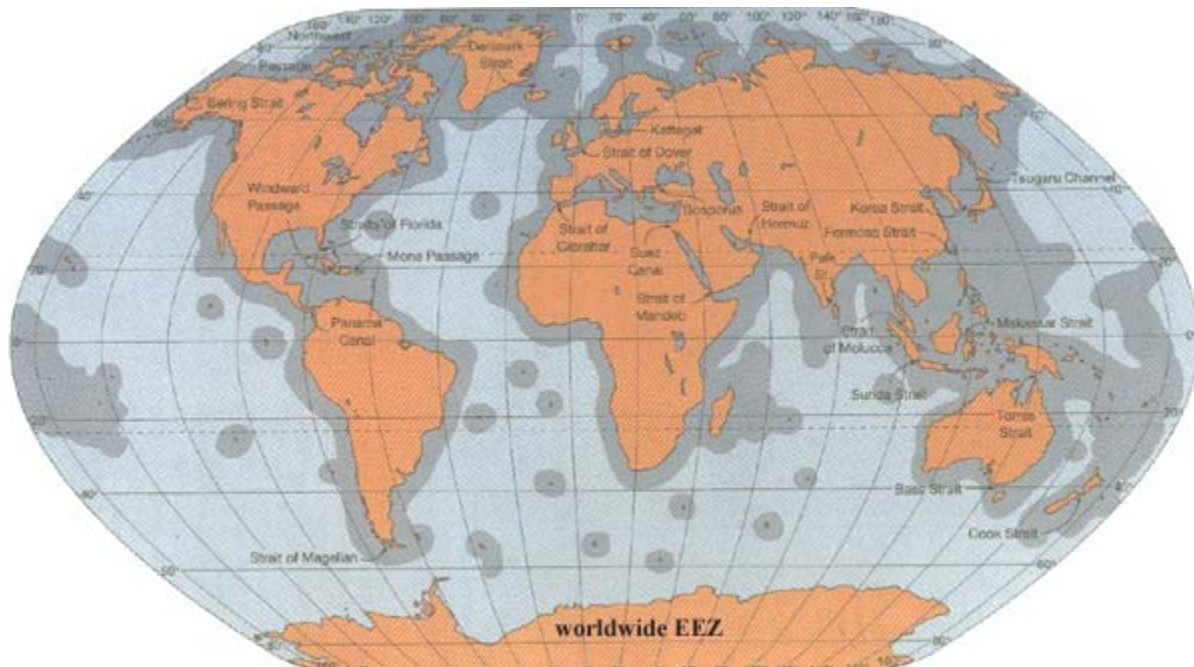
The most limiting factors associated with deep-sea marine mining are the political and legal aspects. Legal and political issues surrounding exploration, exploitation, and marketing of sea floor minerals must be resolved. Even waters within the sovereign rights of territorial seas present difficulties because of inequalities of operational laws, royalties, lease agreements, and political stability. Conflicts between user groups, especially nearshore, and concerns about pollution need to be resolved with a set of regulations controlling and defining activities. Even where coastal zone management programs are in effect,

resolving conflicts can still be a long process. We need to develop new efficient techniques of mining which are environmentally clean.

Three United Nations Conferences on Law of the Sea were held. The first, the 1958 Geneva Convention produced a treaty stating that consent of coastal state shall be obtained in respect to any research concerning the continental shelf, and also the coastal state exercises sovereign right over the continental shelf for the purpose of exploring and exploiting resources. The 1982 convention proposed the Law of the Sea, which defines specific rights for international and territorial waters. The Law of the Sea treaty (LOS) was signed by a total of 138 nations.

The main dispute about the LOS treaty is the legislation on deep sea mining. The law states that if a company or government wants to mine within a given area it should take out a license to mine it. The company should mine one part of the area for itself and the other part for the United Nations. Also the company should transfer its technology to other nations. The operating climate for U.S. mining activities embodied in this treaty led to refusal of the U.S. to join. The third conference in 1992 established seaward boundaries and more explicit rules on mining development that controlled pre-exploitation surveys or prospecting.

As coastal states become sensitive to mineral exploitation, they are reluctant to permit foreign scientists to work there -- but unless research is done, neither the resources or associated environmental factors are likely to be revealed. Commercial development of ocean minerals will not become reality until scientific, engineering, legal, and social needs are met.



For the U.S., development of environmental regulations and awarding of mineral claims rests with the Office of Ocean Minerals and Energy, a part of NOAA. Although the United States has not signed the LOS treaty, it has accepted part five of the treaty which proclaims an Exclusive Economic Zone (EEZ). In 1983, President Reagan declared a 200 nautical mile Exclusive Economic Zone for the United States and its possessions. This has allowed the United States to have rights over 4.9 billion acres of ocean, including areas such as Puerto Rico, the Northern Mariana Islands, Guam, American Samoa, Johnston Island, Jarvis Island, and The U.S. Virgin Islands Figure 9.14.

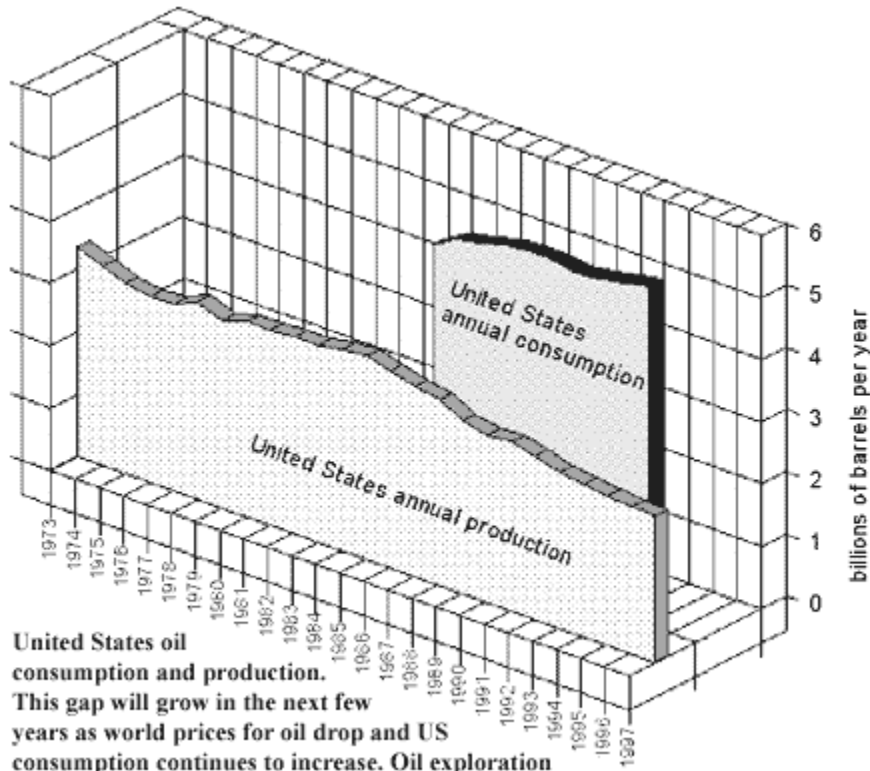
The EEZ concept solves many problems politically and socially, but it also creates a great many problems. For example: who is the enforcer the this zone, what about navigation through these zones, and

what happens if two nations boundaries overlap. All of these problems have limited the amount of marine mining being done at the present time. Manganese nodule recovery is low due to the controversies of the LOS treaty. Oil discoveries and subsequent production has decreased due to legal and political problems. Industries are not going to invest money into areas that may become problematic, and governments will not fund such risky projects. This causes a decrease in research and development. Also the increased problems may increase the cost thus making onshore mining much more profitable than going offshore.

Pollution from a land-based mining operation may be confined to a local area, and resolved locally. Those instances where pollution from mining or refining cause river pollution or atmospheric pollution that can travel to neighboring political states, create situations difficult to resolve. The waters overlying marine resources freely spread any pollution and the environmental problems cross political boundaries unless the operation is very small and local. Use of the oceans will be similar for the next decade --more oil and gas, more transportation, more recreation -- and with this, more pollution, more congestion, more conflict and controversy, more depletion and more economic waste.

## Summary

The world has a great need to find new resources. Marine resources provide additional resources. Oil resources are being used up quite rapidly and our energy future has only coal as an alternative. The most favorable estimates for discovery of new fields and improvements in recovery suggest that demand will pass production shortly after 2000 A.D., and by then we should be adjusting for a transition to other energy sources. Through the year 2010, there is no alternative to oil and gas. Start up of nuclear plants, coal processing techniques, or oil shale extraction will take at least 10 years to develop if they were started this week. Geoscientists have not been effective in educating the public about the role of natural resources in industrial economies, nor have we really communicated the uneven distribution of resources and the problems of continued supply of dwindling resources.

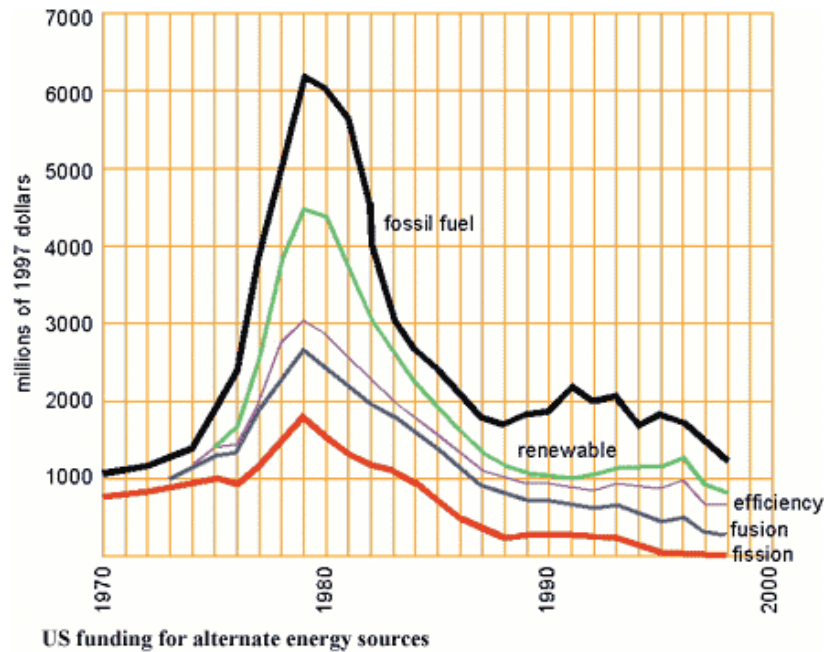


**United States oil consumption and production.**  
**This gap will grow in the next few years as world prices for oil drop and US consumption continues to increase. Oil exploration has shifted from domestic to foreign**

Marine resources provide additional reserves to our resources. The offshore oil potential is high, but due to the low market value of oil and a surplus worldwide, little research is going into new domestic sources. The story seen in this chapter is that demand has passed production for the United States and we should be adjusting for a transition to other energy sources shows the gap between production and consumption for the United States. Figure 9.15

A strong program for development of alternate sources of energy has been drastically reduced Figure 9.16. The demand for alternates to a rapidly depleting pool of energy resources is not being met and the problem will land directly on the next generation.

The oceans are a major resource for mankind, which are yet to be explored and exploited to their full potential. The oceans and interconnecting seas form a continuous territory that covers about three-fourths of the earth's surface. Within this realm, we have sources of minerals and energy that are largely untapped. Just the continental shelves are greater in area than the moon and they offer an almost virgin territory to explore. Between 1975 and 2000 the world population will increase by almost 4 billion, this is an increase of 20 times the population of the United States; the increase in the population of



India alone is equal to the total U.S. population. This increase will place even more demand on the world's presently defined resources, and marine mining must become a reality in the next century.

### Internet links

<http://www.popexpo.net/english.html> population count

<http://www.mms.gov/> minerals management us gov

<http://www.cnie.org/nle/mar-20/> Marine Mining within the U.S. EEZ

[http://seawifs.gsfc.nasa.gov/OCEAN\\_PLANET/HTML/peril\\_pollution1.html](http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/peril_pollution1.html) marine pollution