Deep-sea massive sulfide deposits may not represent a major resource potential

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The ocean floor, covering 70 % of our planet, is increasingly seen as a valuable potential resource for mineral and energy supply. Gravel, sand and hydrocarbons have been exploited from the ocean floor for many years. In addition, diamonds, gold, tin, and other minerals that were transported to the coastal ocean from the continents are being mined from shallow-water and beach areas. Efforts to expand ocean mining into deep-ocean areas have recently begun and we will likely see exploitation of massive sulfides formed at black smokers by the year 2014. However, fundamental data on the distribution, size, and grade of these deep-ocean massive sulfide deposits is still lacking and therefore the resource potential of this commodity is largely unknown.

The discovery of submarine hydrothermal venting in 1977 started a period of intensive seafloor exploration for hydrothermal activity and related mineral deposits. Because the ocean floor covers more than 70% of the Earth's surface, many expect the oceans to contain a proportionate amount of the world's mineral resources, comparing the resource potential of seafloor massive sulfide deposits to that of ancient deposits that are now mined on land and are important producers for zinc, copper, and gold. The rising metal prices enhance the possibility of mining seafloor massive sulfides, which has stirred debate about the sustainable use of this resource and whether its development is worth the risk. While currently only a few commercial companies are exploring the exclusive economic zones throughout the world's oceans, an increasing number of countries such as Russia, China, Korea, USA, but also France, Portugal and Germany are becoming more and more interested in this resource and are actively exploring at sea. Recently, China and Russia acquired large sulfide exploration license areas from the International Seabed Authority in the open ocean. Among the outstanding questions are, however, how many deposits might actually be there and what is their resource potential.

Since large parts of the worlds spreading centers are not explored at all, geologists from the University of Ottawa (Canada), the Colorado School of Mines (USA), GEOMAR, and Woods Hole Oceanographic Institution (WHOI, USA) have used a growing global database of seafloor hydrothermal systems and gathered detailed information on the number, distribution, and size of known sulfide deposits in order to extrapolate the abundance of seafloor massive sulfides in the neovolcanic zones of the global oceans and their resource potential.

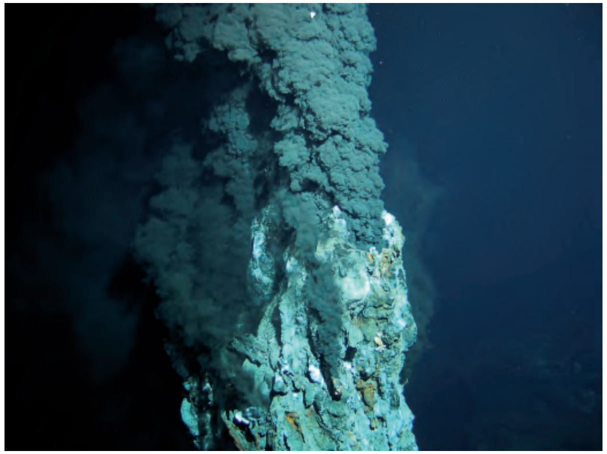

Fig. 1: Black smoker at the slow-spreading Mid-Atlantic Ridge, an important exploration target for the future.

More than 300 sites of high-temperature More than 300 sites of high-temperature hydrothermal venting have so far been identified since the discovery of black smokers. Previous estimates of the total number of active vent fields in the global oceans are based on the heat budget of young oceanic crust and by analyzing water column evidence for hydrothermal activity. This approach, however, is only considering active hydrothermal venting along the spreading axis and is not accounting for old, inactive deposits that might be accessible for mining. At the same time this method provides no information on the size of the deposits or whether sulfides are, at all, formed at the seafloor. To better constrain the abundance of sulfide deposits and their resource potential, the current study used geological information of a number of well known control areas containing active and inactive deposits and calculated an average density of one sulfide deposit

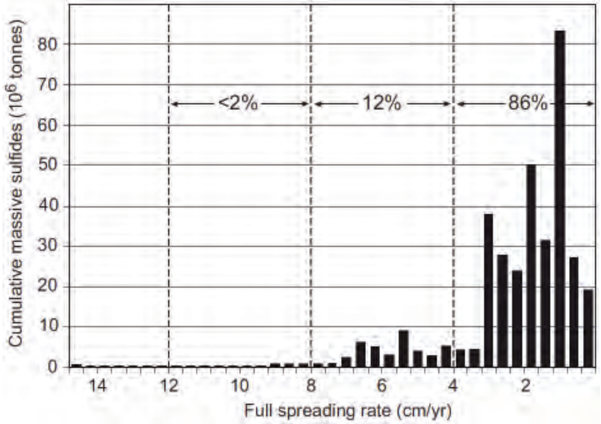

Fig. 2: Estimated size distribution of seafloor massive sulfide deposits as a function of spreading rate showing the resource potential of slow-spreading ridges.

every ~100 km for this dataset. Based on the cumulative strike length of the oceanic plate boundaries (89,000 km) the total number of deposits expected in the global neovolcanic zones is therefore ~900. Taking into account the actual range of deposit densities, the expected number of such seafloor deposits could range from 500 to 5,000.

The abundance of sulfide deposits at the seafloor is, in itself, not a measure of its resource potential. Only deposits with a certain metal content and size will be commercially attractive. Since copper and zinc are the main metals of interest in these deposits, the study focuses on these metals. Most seafloor hydrothermal deposits are not characterized well enough to quantify their true potential, but using a statistical approach the study suggests that most deposits are very small (median 70.000 tonnes) and that only few large deposits exist. These estimates are hampered by the poor knowledge of the vertical extent of the seafloor deposits and the lack of information on inactive deposits or buried deposits that are difficult to identify with current exploration methods.

However, extrapolation of the number and size of the known seafloor systems and comparison to land-based sulfide deposits that formed by similar processes throughout Earth's history allow the first calculation of the total tonnage of seafloor massive sulfide in the global neovolcanic zones and to place this resource potential into a global framework.

Taking the calculated existence of ~ 1000 deposits with a size distribution comparable to land-based deposits and a grade of 5 % of combined copper and zinc, the total sulfide tonnage within the neovolcanic zone is estimated to be on the order of 600 million tonnes, containing ~30 million tonnes of copper and zinc. Most of this metal is suggested to occur at slow-spreading centers, which account for ~60% of the total ridge length and have been shown to host the largest deposits. From a global resource perspective the total combined copper and zinc content in the neovolcanic zones of all oceans is comparable to the annual production of copper and zinc from land-based deposits, insufficient to contribute significantly to an ever growing global demand for these metals.

It is important to understand that the predicted amount of metal within seafloor massive sulfide deposits calculated in this study is far short of the amount of metal that is actually delivered to the seafloor by black smoker vents (~106 tonnes per year). At this rate the calculated metal content in massive sulfides could be produced in only 600 years while the neovolcanic zone comprises rocks that are several thousand or several ten thousand years old. The fate of the missing metal is unclear, but can only be addressed by a better understanding of the true regional distribution and vertical extent of such deposits. Development of technologies to investigate the third dimension and to search for buried deposits, either under volcanic rocks or sediments, is a key component to understand the fate of the missing metal. Additionally, the metal content of the seafloor deposits is poorly defined due to the lack of information from the interior of the deposits and more research is needed about the processes affecting metal distribution within the deposits. On the other hand, sulfide exploitation from the seafloor will have a large impact on the marine environment with concerns about complete destruction of entire ecosystems on a local, regional and global scale. Investigations of the environmental impact of mining activities in the deep-sea are necessary and need to address reaction of faunal communities to and recovery from such activities.

References

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Scientific Highlights