

---

# Black Smokers on the Modern Seafloor: Exploration, Distribution, Genesis, and Economic Significance.

/ SVEN PETERSEN

Leibniz-Institute for Marine Sciences (IFM-GEOMAR) Kiel, Germany  
e-mail: [spetersen@ifm-geomar.de](mailto:spetersen@ifm-geomar.de)

Despite the economic downturn in the past months, there is growing interest in the economic potential of seafloor massive sulfides. There are currently a few companies that are claiming areas for exploration licenses in the territorial waters of Papua New Guinea (PNG), Tonga, Fiji, New Zealand and other countries. This presentation deals with the variability of presently known seafloor hydrothermal systems, the techniques that are used to explore for them, and their likelihood to become an economic target or even a major metal resource in the future.

More than 210 sites of high-temperature venting and polymetallic sulfide deposits have now been found in all of the ocean basins. They occur at mid-ocean ridges, in back-arc basins, and on submarine volcanic arcs. Recent advances in technology have increased the speed at which such systems are found on the modern seafloor. Investigations of seafloor hydrothermal systems over the past decade revealed important variations in their geological setting not previously recognized on the modern seafloor. Deposits have now not only been found to be associated with basaltic volcanism typical for mid-ocean ridges, but also with enriched lavas, at least partially influenced by hot-spot volcanism, with gabbros and serpentinites in areas of crustal uplift at slow- to ultra-slow spreading ridges, and with more evolved volcanic suites in

both oceanic island arcs and continental crust.

Hydrothermal systems along mid-ocean ridges vary dramatically, from small scale sulfide pinnacles, conventional mound-like, Cyprus-type massive sulfides, large steep-sided sulfide/sulfate chimneys directly forming on basaltic substrate, to massive talc-anhydrite deposits, and huge carbonate-rich towers occurring in water depths ranging from 4100 m to as shallow as 100 m. However, even greater variability is found along submarine portions of volcanic arcs and back-arc basins. Tectonic complexity arising from subduction zone processes leads to considerable variability in styles of mineralization, and recent exploration has led to the discovery of several new deposit types not recognized on the mid-ocean ridges. Here, hydrothermal systems dominated by CO<sub>2</sub>-discharge as well as systems with lakes of native sulfur related to the disproportionation of magmatic SO<sub>2</sub> have been observed.

Economic feasibility of seafloor massive sulfides can only be shown by drilling. Several attempts were made in the past, however, often showed disappointing results from an economic point of view. These results highlight the importance of seafloor drilling to validate grades and tonnages of seafloor massive sulfides often only characterized by surface sampling using submersibles,

ROV's or TV-guided grabs. Based on existing data and lacking information on the third dimension it seems premature to comment on the economic significance of seafloor massive sulfides. Published geochemical analyses of sulfide samples indicate that some deposits may contain important concentrations of base and precious metals. However, currently only about 10 deposits may have sufficient size and grade to be considered for future mining. Additionally, other factors such as water depth, distance to land, and jurisdiction may also impact the economic potential. Marine mining appears to be feasible under specific conditions ideally including (1) high gold and base metal grades, (2) site location close to land, i.e., commonly within the territorial waters (200 nm Exclusive Economic Zone) of a coastal state, (3) shallow water depth. Under these circumstances, massive sulfide mining can be economically attractive considering that the mining system is likely portable and can be moved from one site to another. Given the limited sulfide tonnage presently known on the modern seafloor when compared to the geological record, mining of black smoker deposits might occur in the not so distant future, but it seems unlikely, that seafloor massive sulfides will be a substantial metal resource for humankind as often suggested.