Geophysical Research Abstracts
Vol. 19, EGU2017-8806, 2017
EGU General Assembly 2017

Finding Massive Sulfides at Mid-Ocean Ridges

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The formation of Polymetallic Massive Sulfides is connected to hydrothermal activity concentrated in small areas close to mid-ocean ridges. Other geological settings of hydrothermal activity exist of course (like backarcs), but these are typically not located in The Area and therefore not under the regime of the International Seabed Authority (ISA). The ISA grants license areas for mineral exploration of up to 100 blocks of 10 km x 10 km size. The areas in which Polymetallic Massive Sulfides are exposed on the seafloor are tiny compared to the size of the license areas (typically in the order of 100-200m in diameter), and until recently were in most cases detected only be chance.

For localizing and investigating Polymetallic Massive Sulfide deposits, geophysical methods are used at a wide range of scales. Ship-mounted overview surveys include multibeam bathymetry, magnetic and gravity measurements and are supplemented with high density sea surface investigations, and deep tow surveys close to the seafloor. Once a Massive Sulfide deposit has been surmised, ROV based video observations and measurements directly at the seafloor are used to confirm the deposit. It turns out that hydrothermal vent sites (“Black Smokers”) near mid-ocean ridges are far more common than previously thought, however, due to their small size and location in rugged terrain in the deep sea they are not easy to find. Even though we have no full understanding yet of the geologic and tectonic settings in which long lasting hydrothermal systems can develop, the hydrothermal vent fields known so far seem to have some characteristics in common which can be used to define promising areas on the basis of the bathymetric overview maps.

At a dense line spacing of 2.5 km, distinct magnetic anomalies can be observed in surface towed data which are connected to known hydrothermal vent fields. This means that similar magnetic anomalies observed in other places are potential sites of recent or former hydrothermal activity. In cases where these magnetic anomalies coincide with structural features like major or crossing fault zones, a detailed investigation with deep towed instruments follows.

A combination of particle and redox-anomaly observation in the water column a few hundred meters above the seafloor and an ultra high resolution (1m) deep tow bathymetric survey has proven capable of detecting active and inactive hydrothermal vent sites with their associated Massive Sulfides deposits. Once these deposits have been detected and confirmed by video camera observation and geologic sampling, further geophysical surveying at the seafloor with specialized electromagnetic tools provides the opportunity to map the horizontal extension of the deposits, even where buried under sediments or talus, and ultimately to give estimates on the volume of the ore body. Further geophysical surveys including reflection and refraction seismic studies can be helpful to understand the large scale tectonic setting of the hydrothermal systems.