Deep-sea Miners Engage Physical Oceanography

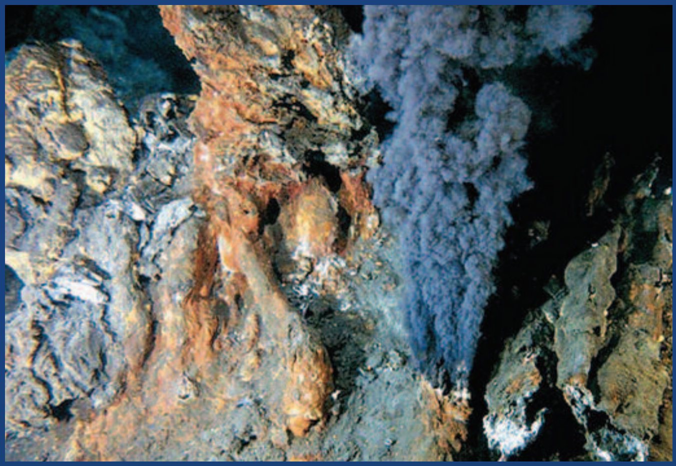
By: Rick Cole, President, RDSEA International, Inc.

RDSEA International, Inc. (RDSEA) (St. Pete Beach, Florida) has recently been engaged by the Seafloor Massive Sulfide (SMS) exploration community (i.e., deep-sea mining). RDESA is an oceanographic and ocean engineering consulting company that provides physical oceanographic data and support to the academic, federal, and private oceanographic, engineering, and offshore energy communities worldwide. Deep-sea mineral explorers, new to our list of clientele, search out submarine hydrothermal vents near plate boundaries long recognized to contain SMS deposits of high-grade copper, zinc, silver, gold, and other trace minerals typically found in water depths exceeding 1,000 m. In parallel to AUV and ROV efforts, drilling operations, and multibeam bathymetric surveys of the seafloor, RDSEA is contracted to provide complete water column current velocity and direction of mining tenement areas based on in situ measurements (Acoustic Dopper Current Profiler [ADCP] deployments), including analysis and description of the variation in currents throughout the record. Analysis of water column conductivity/temperature/depth (CTD) data collected during exploration cruises is included. Wind and wave hind-cast modeling is used to complement the full metocean picture and physical structure of the ocean surface within each mining region. Geochemistry studies will also be conducted simultaneously by collecting flux of settling particulate matter from the seafloor within the tenements and on moorings using sediment traps with rotating carousels at specified deployment intervals.

A new ocean industry is quickly forming with much attention being directed towards deep-sea mining. The majority (basically 100%) of the minerals and metals used today in our world come from terrestrial-based mines. Some forecasts show that offshore mining can be more economically efficient and environmentally friendly. Questions concerning environmental sustainability, the impact on ecosystems, and ocean policies are on the table for discussion. Once deemed too deep, SMS deposits are now found within depths worthy of investigation (1,000 to 2,000 m). These deposits are associated with both active and inactive hydrothermal vents containing high concentrations of mineral resources. Venting in the seafloor allows cold water to flow in and hot seawater to flow out, creating a plume or hard chimney-like structure known as a "black smoker."

Smokers

SMS are formed as cold seawater moves down through cracks in the seafloor and is superheated by the molten magma deep within the crust. This heated water mixes with cold, 2°C bottom water, reacts, and forms iron sulfides and other metals to precipitate along the ridge of the vent fields. Active hydrothermal vents support productive concentrations of various animals and microbes that have evolved under some of the most extreme conditions on Earth. Much research has been conducted surrounding hydrothermal vent ecosystems since the first discovery in the late 1970s by scientists off the coast of Ecuador along with the unusual sea life that lives in this environment. The first "smoker" was seen by divers on board the submersible Alvin in 1979 along the East Pacific Rise (WHOI).



Black smoker (Photo courtesy of WHOI).

The environment

Potential mining operations now being discussed revolve around "inactive" vent fields where some data already exist and are slightly understood. Environmental concerns are high pertaining to the exploration and extraction of SMS deposits, including physical disturbance of the seafloor, acoustic impacts, waste disposal, surface support vessel, and subsurface machinery issues to name a few. Until all environmental assessments are in and studied, this new industry will not know its full impact on our oceans and seas. Regulations on deep-sea mining are governed through the United Nations Conventions on the Law of the Sea, enacted in 1994. The convention set up the International Seabed Authority (ISA), which regulates deep-sea mining ventures outside of each nation's Exclusive Economic Zone (EEZ). The impacts of deep-sea mining will ultimately depend on the type of technology used.

Mining technology

Deep-sea mining can begin exploration with successful technology already in use in the field. Active vents can be located by detecting compounds and elements that occur around the source. Locating a plume is also a good lead. Finding inactive venting is more challenging, but they are usually found close by active areas. SMS deposits can then be located using side-scan sonar and/or seismic survey technology along with towed cameras. Sampling a mound is done by employment of ROVs or submersibles that have various tools on board to take samples of the mining region and transport them to the surface for testing. Full drilling operations are then conducted to determine the volume of deposits throughout the area.

Offshore industry vessel support, such as the Skandi Hawk, designed for offshore construction, ROV, and seafloor survey work in blue-water environments.

SMS extraction

Seafloor terrain may not always be accommodating. Normally, regions of mining have undergone major plate tectonic activity and will require a combination of technologies for removal. The major tool used for SMS mining is the ROV. Breaking up the deposits is done using a "crusher," similar to that used by the coal mining industry, also known as a "cutter drum." A lifting system is then installed to get the SMS to the surface and prepared for processing. A couple of designs are planned: 1) a riser pipe using cold deep-sea water transports ore to a surface support vessel, samples are removed, and the lift water is returned to the sea or 2) the continuous-line-bucket (CLB) approach where buckets connected to a wire are conveyed to the surface. All proposed processes are under review as per environmental impact. The SMS will then be transported to shore and prepared for processing.

Rick Cole with RDSEA's "Dual-ADCP Buoy System" (2 x 75kHz and CTD) Provides Water-Column Current Velocity and Direction Profiles of 1,000 Meters or Greater.

RDSEA's tasks

Oceanographic monitoring of deep-sea mining tenements is critical. Understanding water column physics and bottom boundary layer dynamics of the region will help with engineering and infrastructure design. Due to the sensitivity of this work, specific site location is not discussed, but we did deploy in the Pacific Ocean in fall 2012. A 12-month deployment of a dual 75-kHz ADCP system (Teledyne RD Instruments [TRDI]) was chosen for collecting full water column currents on site. A 300-kHz ADCP (TRDI) was inserted into the mooring 100 m off the bottom, looking down. Above this is a sediment trap with rotating carousel (McLANE Labs) for collection of particulate matter falling from the surface.

Sedimentation data are collected following protocol set by the Joint Global Ocean Flux Study (JGOFS). Two methods have been employed: 1) separate PVC cups at the seafloor level in strategic locations (via ROV), and 2) deployment of a sediment trap with rotating carousel on the mooring a few hundred meters off the bottom; the carousel is on a timer set to rotate throughout the deployment. Recovered samples will be processed according to JGOFS standards (including total organic carbon, total inorganic carbon, total nitrogen, biogenic silica, and total particulate phosphorous [inorganic, organic]). Recovery of this SMS mooring system is in discussion now, with plans to return to the site in late 2013 or early 2014.

Conclusion

A new industry is forming in our oceans as mineral resources on land are diminishing and becoming harder to extract. Deep-sea mining has begun, although due to many environmental unknowns and concerns, full commercial implementation is probably a decade away. RDSEA has designed, built, and deployed an oceanographic monitoring system for the SMS ocean mining community. Deliverables at the end of this project will consist of site-specific meteorology based on existing data and models, wave field climate based on existing data, currents based on in situ data collected, and site-specific sedimentation analysis based on in situ data collected at locations throughout the mining tenement. CTD structures of the water column collected from various exploration cruises will also be analyzed. These data will be used to form an environmental impact assessment of the mining tenement that stakeholders wish to develop in the Pacific Ocean as per ISA requirements.

Acknowledgements

We thank all stakeholders of this particular project for the opportunity to do what we do — "measure the ocean." Also, Woods Hole Oceanographic Institute, Precious Metals from Deep-Sea Vents, Miningtechnology.com; Buried Treasure, Deep Sea Mining, Infographics: Deep Sea Mining Poses Environmental Risks; A Case Study in Papua New Guinea (K. Birney et al.); and collaboration with the Marine Sediments Research Lab., Dept. of Geological Sciences, Univ. of South Carolina. Manufacturer support from Mooring Systems, Inc., Teledyne RD Instruments, Sea-Bird Electronics, McLANE Labs, ROMOR Ocean Solutions, EdgeTech, and Xeos Technologies, Inc., and PixelPresto.