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The mysteries of the sea: How magnetics can help to solve them

Udo Barckhausen
Federal Institute for Geosciences and Natural Resources, Hannover, Germany (udo.barckhausen@bgr.de)

Determination of the Earth's magnetic field over the oceans played a key role in understanding plate tectonics in the 1960s and has helped to answer many geodynamic questions since then. Satellite missions have nicely charted the Earth's magnetic field over its entire surface during the last 20 years. However, at the altitude of satellite orbits merely wavelengths greater than $\sim$ 100 km can be resolved, thus, implying that most of the geologically interesting anomalies with sources in the Earth's crust can only be measured on the ground. For a long time these ground measurements have been carried out with the robust and easy-to-use Proton Precession magnetometers towed astern of research vessels. By using oriented Vector Magnetometers we are now returning to the Gaussian roots of measurements, quantifying the magnetic field in its components. This is realised either with towed instruments or with sensors mounted to the superstructure of research vessels.

Applications for the use of modern instruments and methods applicable to vector data range from large scale analysis of seafloor spreading anomalies over addressing long standing tectonic questions in isolated ocean basins to high resolution investigations of mineral deposits at the seafloor. In the equatorial Eastern Pacific it was possible to precisely date the age of the oceanic crust over large areas between the Clarion and Galapagos fracture zones, where differences to existing global age models of more than 10 m.y. in some places could be found. In the Colombia Basin of the Caribbean, the analysis of vector data provides an unexpected new insight into the tectonic origin of at least one part of the Caribbean platform. High-resolution magnetic mapping at the sea surface and deep tow profiles reveal hydrothermally-altered rocks near active spreading centres and associated polymetallic sulphide deposits.
During marine survey expeditions, magnetic measurements can be carried out almost any time and in combination with a wide range of other geophysical investigations. Modern magnetometers can be piggy-backed to many deep towed instruments, providing additional information with little extra effort.

Latest technical developments combine deep tow magnetics with electromagnetic methods, opening a further fascinating window to the mysteries of the sea.