What can magnetism tell us about oceanic tectonics? New insights from scientific drilling.

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Seafloor spreading and subduction in the oceans are the most significant geodynamic processes on Earth, and together drive the plate tectonic cycle. It is widely known that magnetic studies played a key role in understanding how oceanic lithosphere forms at mid-ocean ridges. Indeed, Vine and Matthews ground-breaking realization in the 1960's that linear marine magnetic anomalies result from oceanic crust having acquired magnetizations in different polarities of the geomagnetic field during accretion at mid-ocean ridges must rank as one of the great scientific discoveries of the twentieth century. This lecture will show how magnetic analysis of core samples recovered by scientific ocean drilling by the International Ocean Discovery Program (IODP) and its predecessors continues to provide new insights into globally significant tectonic and magmatic processes in the oceans. A focus will be how our understanding of slow and ultraslow spreading axes has changed radically following the discovery of so-called "oceanic core complexes" along ridge systems. These enormous massifs on the seafloor form by unroofing of lower oceanic crust and upper mantle rocks by crustal-scale faulting. Palaeomagnetic data from rocks drilled at several core complexes have quantified this process and demonstrated that their formation involves large tectonic rotations that bring rocks formed at depth up to the ocean floor. These rotations provide the key to recognizing this important tectonic process in ophiolites (fragments of ancient oceanic crust emplaced tectonically onto the continents), allowing the record of "detachment-mode" seafloor spreading to be extended back beyond the age of the oldest crust in the modern oceans. Finally, the lecture will show how scientific ocean drilling is also providing new information on the nature of the magnetization of the oceanic crust. Analysis of lower crustal gabbros recovered in both the Atlantic and Pacific Oceans reveals that these rocks often record multiple polarities of the Earth's magnetic field within *individual* samples, contrasting with the simpler magnetizations of upper crustal rocks responsible for most of the marine magnetic anomaly signal.