

## Executive Summary

The field of high-pressure geosciences is dedicated to increasing our knowledge of the materials that make-up the overwhelming majority of planet Earth—those that reside below the surface, and are compressed by the overlying burden. It is from the interior that the planet's atmosphere and hydrosphere were originally degassed, and melting processes at depth created (and continue to create) our ocean basins and continents. Thus, the starting points for Earth's habitable environment—its atmosphere, its surface—originate from our planet's voluminous interior. The deep interior produces the forces that generate virtually all non-weather related natural hazards: earthquakes, volcanic eruptions and plate tectonics. Its impact on the surface perhaps has no better illustration than the annihilation ~250 million years ago of 95% of Earth's life due to a massive volcanic eruption from depth. In short, the planet's interior has provided an integral and controlling influence on the evolution of the Earth--and its effects are dictated by the physical and chemical properties of the materials of the interior, which are the domain of the high-pressure geosciences.

The challenges associated with simulating the Earth's interior through both experiment and theory are formidable. Probing and synthesizing materials at the conditions of the interior, which are critical for understanding the properties of materials at depth, require extraordinarily high pressures and temperatures. Correspondingly, state-of-the-art approaches are necessary to theoretically calculate material properties under these conditions. The high-pressure geosciences community has spearheaded the development of new techniques to probe materials at high pressures (and has seen its

techniques adopted by a broad range of other scientific disciplines), deployed emergent technologies, including those developed at national facilities, and conveyed this high-level expertise to new generations of students. From making better and larger diamonds to understanding the physical properties of hydrocarbon clathrates (which make up the largest natural gas reservoirs of the planet), the high-pressure geosciences community has also played a key role in developing and understanding materials of direct societal importance—and particularly those materials that have required high pressures to manufacture.

This report describes what the high-pressure geosciences community does, the broad rationales for the science done by the field, the technical developments that the discipline has made, and where the future directions of the field likely lie. Yet, predicting the future is difficult for this vibrant and fast-moving field: the last decade has seen new and unexpected discoveries that have changed the views of the deep reaches of our planet, including the recognition of novel electronic and structural properties of Earth materials at the extreme conditions of the interior. With new and improved techniques and infrastructure, the community is poised over the next decade to continue to produce dramatic new discoveries and truly engender a profound understanding of the deep Earth's critical role in producing our habitable planet.