Engineering 5 (2019) 351

Contents lists available at ScienceDirect

Engineering

journal homepage: www.elsevier.com/locate/eng

Editorial

Editorial for the Special Issue on Deep Matter & Energy

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772-2019

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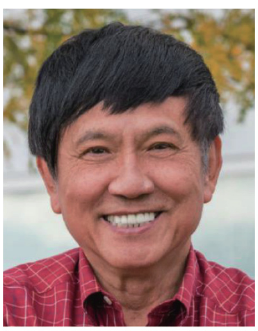

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Volatile elements—such as carbon, hydrogen, sulfur, nitrogen, and halogens—are minor constituents of Earth's deep interior. Despite their low abundances, deep volatiles mediate major Earth processes, including magma generation, volcanism, mantle convection, and plate tectonics, which control the exchange of volatiles between Earth's deep interior and its surface. Over geological time, deep volatiles play critical, primary roles in governing energy resources, natural hazards, atmospheric composition, climate, and planetary habitability. Human activities after the industrial revolution have played an impactful, secondary role, and the resulting risk of add-on effects that could lead to irreversible runaway catastrophes has greatly increased. To counter these detrimental effects and enhance the planet's habitability, a new generation of engineering must consider emission control, alternative energy sources, available mineral resources, geological hazards, ecological management, and so forth. These engineering efforts must be built upon a sound knowledge base of the primary natural trends dictated by deep volatiles.

This special issue of *Engineering* focuses on the science and technology of deep volatiles, which span the multidisciplinary boundaries of mineralogy, geophysics, geochemistry, biology, and fundamental physics and chemistry at depths ranging from the deep ocean to the Earth's core, under the common theme of the high-pressure dimension.

The extreme pressure and temperature conditions in Earth's deep interior drastically alter the physics and chemistry of ordinary matter, and the pressure effects are particularly remarkable in regards to highly compressible volatiles. The new high-pressure dimension, however, is an even more basic topic, and our understanding of it will thrive on a close integration of science and engineering. Pressure has long been recognized as a fundamental thermodynamic variable for all matter, but its application was previously limited by our engineering capability to reach high pressures and probe sample properties. During the past decade, developments in powerful first-principle computational methods and high-pressure/temperature experimental technologies capable of mimicing the conditions in Earth's very center—together with a battery of *in situ* diagnostic tools—have opened a vast new window. We are facing a new world with an order of magnitude more materials to be discovered in comparison with all the materials that have been explored at ambient pressure. Pressure drastically and categorically alters all elastic, electronic, magnetic, structural, and chemical properties, and pushes materials across conventional barriers between insulators and superconductors, amorphous and crystalline solids, ionic and covalent compounds, vigorously reactive and inert chemicals, and so forth. In the process of doing so, pressure reveals surprising high-pressure physics and chemistry and creates novel materials. Here at *Engineering*, we would like to initiate a series of interactions between high-pressure engineering and science in order to advance our high-pressure technical capability and various branches of materials applications.

This special issue contains papers presented at the Deep Volatiles, Energy, and Environments Summit (DVEES 2018), which was sponsored by the Chinese Academy of Engineering (CAE) and the Deep Carbon Observatory (DCO), and was held on 13–14 March 2018 at the Shanghai Synchrotron Radiation Facility (SSRF) in Shanghai, China. The Summit, which was organized by the Center for High Pressure Science and Technology Advanced Research (HPSTAR), brought together about 170 scientists from nine nations.

DVEES 2018 strengthened and broadened complementray scientific partnerships between the DCO and researchers in China. For example, the Summit helped facilitate the launch of the International Center for Deep Life Investigation (IC-DLI) at Shanghai Jiao Tong University (SJTU) in Shanghai, China. On 30 October 2018, the IC-DLI convened its inaugural symposium at SJTU in conjunction with a meeting of the DCO's Deep Life Community.

https://doi.org/10.1016/j.eng.2019.05.002
2095-8099/