Overview of the Special Issue
“2022 Year of Mineralogy”

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“Year of Mineralogy 2022” is a global initiative that aims to highlight the importance of mineralogy not only as a basic science, but also in our everyday lives (Fig. 1). It consists of coordinated activities at regional, national, and international levels, and takes place under the patronage of the International Year of Basic Science for Sustainable Development, which is supported by UNESCO. 2022 marks the bicentennial of the death of French mineralogist René-Just Haüy (1743–1822), who is known as a father of modern mineralogy and crystallography. It is also the 200th anniversary of the publication of “Traité de mineralogy” and “Traité de cristallographie,” which were authored by Haüy. It is, therefore, significant that we have been given an opportunity to publish a special issue of this journal, which reviews contributions of minerals and mineralogy to geology, as a part of our activities during the “Year of Mineralogy.”

Minerals are not only interesting natural materials that play significant roles in industry as resources, but are also important in geology and other sciences for providing evidence of research results and as specimens to be preserved for future generations. Mineralogy is a science with a long history. It has played a key role in the development of science and technology, including our understanding of the nature of materials. This special issue consists of eight review articles and one original article by expert mineralogists, petrologists, crystallographers, and geologists in Japan who are leaders in the mineral sciences.

Theophrastus wrote that stone comes from earth, based on Aristotle’s four elements—earth, fire, air, and water. Pliny featured stone extensively in his “Natural History.” In the 16th century, when Agricola wrote “De re metallica” and “De Natura Fossilium,” stone was collectively referred to as fossil (dug up), along with current fossils and stone tools. Tagai (2022) traces the history of mineralogy back to the Greek and Roman periods, covering contributions to classical mineralogy by Werner and others, the establishment of classical crystallography by Steno and Haüy, and the inception of modern mineralogy and modern crystallography through the discovery of X-rays by Röntgen and X-ray diffraction experiments by Laue and Braggs. He also reviews the progress in mineralogy and crystallography in modern Japan, which is based on work by Wada.

A mineral substance is a naturally occurring solid that has been formed by geological processes, either on the Earth or in extraterrestrial bodies (IMA Nomenclature; Nickel and Grice, 1998). A mineral species is a mineral substance with well defined chemical composition and crystallographic properties, such as an arrangement of chemical bonds in a crystal structure, and which merits a unique mineral name. The Commission on New Minerals and Mineral Names, a predecessor of the Commission on New Mineral, Mineral Name and Classification, of the International Mineralogical Association was established in 1959 for the purpose of controlling the introduction of new minerals and mineral names and, of rationalizing mineral nomenclature. Matsubara (2022), in this special issue, outlines the definition of a
mineral, solid solutions in mineral nomenclature, rules for naming minerals, and procedure for establishing a new mineral by the Commission on New Minerals, Nomenclature and Classification. He also discusses the implications of new minerals and minerals first found in Japan. In particular, he gives a detailed account of new minerals from Japan.

The discovery of a new species means the discovery of a new geomaterial in the Earth or in extraterrestrial bodies, which means that we have new clues to our understanding of celestial bodies. The occurrence and physical properties of each mineral species provide knowledge on the conditions of formation and growth. Such clues have more significance, acting like a geothermometer or a geobarometer, in deepening our understanding of the Earth and other celestial bodies. Today, we have reached the deep oceans and space, and can obtain more and more accurate clues through direct observations and the collection of samples. However, we have not been able to directly observe or collect samples from depths greater than 10 km underground. Studies on the deep Earth and space beyond the reach of exploration are steadily advancing through analyses of physical signals such as electromagnetic waves and seismic waves, synthetic experiments, and computer simulations. The results have led to evaluations of the origins of geomaterials from the deep Earth, such as diamond and jadeite, and from space, such as minerals in meteorites. They have also further strengthened our understanding of the Earth and other celestial bodies by providing more reliable clues to the formation of diamonds, jadeite, and meteorites, among others.

Yurimoto (2022) reviews the elemental abundance of the Earth, which is one of the most fundamental interests of Earth and planetary science, in relation to the abundance of elements in the bulk solar system, chondrites, and the bulk Earth. He points out that the composition of bulk silicate Earth can be empirically estimated from the chemical variations of mantle rocks without referring to the elemental abundances of bulk solar system and chondrites. He suggests, on the other hand, that the chemical composition of bulk Earth still involves large uncertainties because it is difficult to estimate chemical compositions of the central core and the lower mantle without formation models of the Earth.

Various phase transitions occur in the Earth’s interior, causing discontinuities in seismic velocity and density profiles, and these boundaries become discontinuous surfaces that cause seismic wave refraction. Ohtani (2022) reviews the following phase transitions; olivine-wadsleyite transformation and decomposition of ringwoodite into ferropericlase (Fe$^{2+}$-bearing periclase) and bridgmanite in the shallow lower mantle, as well as the spin transition of mantle minerals including iron and ferrite and the post-perovskite transition of bridgmanite at the bottom of the lower mantle, which is considered to correspond to the D$^\prime$ layer of the core-mantle. He mentions seismic wave velocity anomalies, including low-velocity anomalies associated with hot rising mantle plumes and oceanic ridge areas, and high-velocity anomalies associated with cold slab subduction. Other interesting regions of anomalies at the base of the lower mantle are the Large Low Shear Velocity Province (LLSVP), a region of iron enrichment in the hydrous phase under high pressures, which is thought to be caused by the return and accumulation of seawater in the mantle through hydrous minerals stored in the slab, and the Ultra-Low Velocity Zone (ULVZ), a region of dense iron-rich melt at the core-mantle boundary. Referring to phase differences between the melted outer core and the solid inner core, he recommends further work to obtain a better understanding of the Earth’s core. High-pressure experiments are import-
ant not only in high-pressure material science but also in geophysics. Bridgmanite was known as perovskite-type (crystal structure) magnesium silicate until the mineral and mineral name were approved in 2014. It was often abbreviated as perovskite, which caused confusion because it could not be distinguished from certain perovskites (CaTiO$_3$), but the problem was solved with the description bridgmanite (Tschauner et al., 2014).

Chondritic-porous interplanetary dust particles (CP IDPs) originating from comets and carbonaceous chondrites from asteroids are primitive materials in the Solar system. (Tsuchiyama and Matsuno, 2022) summarize recent results of their research on primitive materials that took mineralogical approaches, including the reproduction of amorphous silicate nanoparticles encapsulating metals and sulfides (glass with embedded metal and sulfide: GEMS) in CP IDPs, the discovery of ultra-porous lithology as a fossil of ice in a primitive carbonaceous chondrite, and the discovery of a CO$_2$-rich fluid inclusion in calcite in aqueously-altered carbonaceous chondrites through multi-scale three-dimensional observations.

According to the IMA definition of minerals, both amorphous and organic compounds can be minerals, as long as they are natural solid materials formed by geological processes. Biogenic rocks, such as limestone and chert, and amber are aggregates of biogenic minerals. Although hard tissues of organisms such as bones and teeth are not treated as minerals because they are not directly involved in geological actions, interactions between the biosphere and minerals, such as biogenic minerals and biochemical weathering of minerals, are interesting from the viewpoint of mineral science. In particular, interactions between minerals and microbes are closely related to the evolution of the Earth’s surface environment, suggesting a key to solving global environmental problems in the context of SDGs (Akai, 2022). Basic knowledge of biominerals, interactions between biosphere and minerals, and expanding knowledge of the biosphere are introduced in this review. In relation to environmental issues, the origins of life are mentioned, and the significance of high-resolution transmission electron microscopy as a method for exploring the microscopic world is reviewed.

As an example of mineralogical explorations of the Earth’s crust (the surface of the Earth), Imaoka and Nagashima (2022) take up Li minerals of Iwagi Islet and summarize these from the viewpoints of both macroscopic petrology and microscopic crystallography. Metasomatic albitites scattered in Late Cretaceous granites of the Seto Inland Sea include lithium-rich albitites, and Iwagi Islet is the type of locality where Sugilite, Katayamalite, and Murakamite occurred as new species of Li minerals. They discuss the formation of lithium minerals and the effects of ionic radius on the partitioning of chemical elements, and speculate on the fluid that caused the alternation, based on a Li isotope analysis and crystal chemistry of Murakamite and other related minerals.

Mineralogy is an essential part of resource geology, along with geology and geochemistry. Shimizu (2022) outlines the history of resource development and the progress of mining and ore deposit research in Japan from the 16th to 20th centuries. He lists the achievements of researchers and engineers who promoted resource geology and mineral deposits in Japan.

Gemstones are essentially natural materials, mostly minerals that are naturally occurring solids formed by geological processes. However, gems have cultural aspects in their applications. Miyata (2022) outlines, from the viewpoint of mineralogy, how gems, with such a duality of nature and culture, have become objects of academic study, looking back at the history of gems. In gemology, which is built on trust with society, it is important to appraise a gemstone, and especially to identify the variety and whether the gemstone is a real gem or not. It is critical to distinguish synthetic, artificial, imitation, and composite from natural when evaluating the treatment, quality (grade), and origin of a product, and in some cases to identify an individual piece.
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References


