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Editorial: High-pressure physical behavior of minerals and rocks: Mineralogy, petrology and geochemistry

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Editorial on the Research Topic
High-pressure physical behavior of minerals and rocks: Mineralogy, petrology and geochemistry

The 8th "From Atom to Earth" Symposium on High-Pressure Science and Earth Science was held at the Institute of Geochemistry, Chinese Academy of Sciences (IGCAS), Guiyang, China between July 2nd and 5th, 2021. Professor Lidong Dai from the IGCAS Key Laboratory of High-temperature and High-pressure Study of the Earth's Interior (HTHPSEI) was the conference president. 156 prominent Chinese scholars, such as from Peking University, Chinese Academy of Sciences, etc. participated in the conference. Professors Xi Liu, Duanwei He, Lidong Dai, Chun-An Tang and Zizheng Gong delivered the specific conference speeches (Figure 1). As distinguished and invited delegates, professors Hongsen Xie and Heping Li attended this conference. CAS Key Laboratory of HTHPSEI, together with IGCAS and Chinese Society of Mineralogy, Petrology and Geochemistry, provided the conference service.

This Research Topic, hosted by Frontiers in Earth Science, is the accessory Volume II that follows the special Volume I entitled "Earth Deep Interior: High-pressure Experiments and Theoretical Calculations from the Atomic to the Global Scale" on the basis of the 8th "From Atom to Earth" Symposium on High-Pressure Science and Earth Science, held at the CAS Key Laboratory of HTHPSEI (Dai et al.). The volume contains fifteen papers, including original studies and a review article reporting on the high-pressure physical behavior of minerals and rocks, recently obtained by using experimental measurements and theoretical calculations under high-temperature and high-pressure conditions. High-*P* electrical transport characterizations, phase transition, ultrasonic elastic wave velocity, Raman spectroscopy, stress-strain-sorption properties and deformation on some representative minerals and rocks are presented in the light of experimental investigations. Some new progress based on theoretical calculations pay attention to the *P*–*T* phase boundary, thermal capacity, thermal

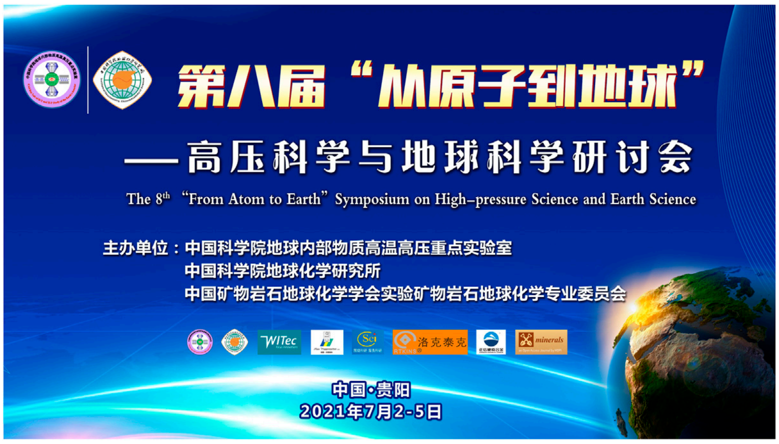

FIGURE 1
The 8th "From Atom to Earth" Symposium on High-Pressure Science and Earth Science held in IGCAS, Guiyang, China between July 2nd and 5th, 2021.

expansion coefficient, elastic moduli, rock physical parameters, and solidification of liquid/molten substance in the Earth's interior, etc.

Ren and Li present a comprehensive review on the development of high-temperature and high-pressure experimental apparatuses capable of generating differential stress, in order to accurately simulate the temperature field, the hydrostatic pressure environment and the differential stress distribution of deep Earth's interior, such as Griggs press, Paterson rheometer, D-DIA press, RDA press and torsional diamond anvil cell. By comparing the advantages and shortcomings for each corresponding high-pressure equipment in the measurement of sample size, accuracy, temperature range and stress distribution, the future development of high-*T* and high-*P* experimental apparatus with differential stress has good prospects.

Some new obtained high-P experimental results and theoretical calculations have been reported for a selection of minerals and rocks. Using Electrochemical Impedance Spectroscopy (EIS), Hu et al. investigated the electrical conductivity of natural siderite at conditions of 1–3 GPa and 100°C–700°C in YJ-3000t multi-anvil high-pressure apparatus. Their results indicate that the incipient decarbonation temperatures are considerably lower than the decomposition boundary of siderite determined by phase equilibrium experiments, implying that the initial decarbonation reaction in subducting oceanic crust occurs at a shallower depth. The 30 vol% of siderite is required to enhance the electrical conductivity of $(Mg,Fe)CO_3$ solid solutions. The recovered products of magnetite and graphite generated from the decarbonation reaction of the siderite component of Fe-bearing carbonate make a significant contribution to the high conductivity anomaly observed in the slab-mantle wedge interface. Similarly, Sun et al. determined electrical conductivities of the olivine–ilmenite systems with various contents of ilmenite (V_{Ilm} = 4, 7, 10, 11 and 15 vol%) and pure ilmenite aggregates using EIS at 1.0–3.0 GPa and 773–1273 K. They proposed that the percolation threshold of the ilmenite grains in the dry olivine–ilmenite systems was about 11 vol% resulting in the interconnection of ilmenites, which can dramatically enhance the conductivities of the olivine–ilmenite systems. Hong et al. studied the structural phase transition and its corresponding *P–T* phase diagram in conjunction with high-P electrical conductivity and Raman spectroscopy experiments of natural barite under the conditions of 298–873 K and 1.5–35.0 GPa, using a diamond anvil cell. They observed a positive correlation between pressure and temperature of phase transformation and proposed that the obtained phase diagram of natural barite can improve the knowledge of the structural and electrical properties for other barite-group minerals MSO_4 (M = Sr and Pb) under high-T and high-P conditions. Chen measured the electrical conductivity of synthetic carbon-bearing gouges along a fault-parallel direction under progressive fault slip, under conditions of a slip rate of 1 mm/s, a normal stress of 2 MPa, at ambient temperature, and a pure N_2 atmosphere using a rotary shear low to high-velocity friction high-pressure apparatus. They concluded that some representative carbonaceous minerals represented by the mixtures of identical 6 wt% graphite may complicate the frictional properties of fine-grained fault gouges in mature faults. Zhao et al. determined the high *P–T* calcite–aragonite phase transitions under hydrous and anhydrous conditions. Their results suggest the phase transition of calcite-aragonite in the subduction zone, where the solid recrystallization–reconstructive phase transition can exist in slabs under wide *P–T* conditions (1–2 GPa and 160°C–400°C) whereas, the dissolution–precipitation–dehydration process can only occur under lower *P–T* conditions (less than 1.5 GPa and 110°C). Miao et al. measured the ultrasonic elastic *P*–wave velocity of typical rocks (i.e., granite, granodiorite, granodiorite mylonite, anorthosite, diorite, mafic granulite, gabbro, diabase and pyroxenite) in the Anninghe fault zone under pressures of 50–600 MPa. They argue that the lithologic difference between the southern and northern sections of the Anninghe fault zone within the middle and upper crust at depths less than 25 km, is primarily that the rocks in the southern section (Xichang) are more felsic than those in the northern section (Shimian). Zhang et al. performed the multiple stepwise axial loading and unloading, oedometer-type experiments on ~1 mm thick discs of pre-pressed Na-SWy-1 and of Ca-SAz-1 montmorillonite. Their results can provide a first step towards modelling stress-strain-sorption effects in smectite rich caprocks penetrated by CO_2, though further refinements are needed for broader application to the smectite-CO_2-H_2O system. Dai et al. analyzed the microstructures of samples for mylonites, pseudotachylyte and cataclasite by the optical microscopic observation, SEM and EBSD from the Red River fault in southwest China. Based on the analysis of the microstructures and deformation mechanism of fault rocks, they proposed the oscillation deformation model to explain transient creep of the brittle–plastic transition zone during the seismic cycle in the Red River fault.

On the other hand, some recently obtained theoretical modeling results on the *P*–*T* phase boundary, thermal capacity, thermal expansion coefficient, elastic moduli, rock physical parameters, and solidification of liquid/molten substance in the Earth's interior, etc. are displayed in this special topic. Li et al. investigate the characteristics of acoustic wavefields associated with logging-while-drilling (LWD) in an unconsolidated formation using the time–domain finite difference (FDTD) method to simulate the wavefields corresponding to a ring dipole source. These simulation results can provide a theoretical foundation for the borehole detection by LWD single-well acoustic imaging technique in unconsolidated formations. Yang et al. carry out numerical acoustoelasticity simulations for wave propagation in single– and double–layer models under four states of prestresses, confining, uniaxial, pure-shear, and simple-shear. Their theoretical calculations can display the significant impact of prestressed conditions on seismic responses in both phase and amplitude.

Applying the Clausius-Clapeyron equation in combination with molar volumes and entropies of both compositions, the phase transition boundary of Fe–bearing olivine and wadsleyite was estimated by Su et al. Their research results suggest that the existence of Fe might decrease the transition pressure from olivine to wadsleyite, which would consequently cause a higher temperature at the 410 km discontinuity. Li et al. investigated the geodynamic solidification of liquid/molten substances in the Earth's interior using three sets of observations including Global Positioning System data, length of day data, and the latent heat of Earth solidification. They put forward that the liquid solidification in the Earth's interior is the main source for the movement of plates.

In addition, Li et al. performed zircon SHRIMP (sensitive high resolution ion microprobe) dating in ore-forming veins of weathered residual Kaolin deposits from the northern the Qinzhou-Hangzhou Metallogenic belt margin within the Yangtze and Cathaysia plates Their research results indicate that the ore-forming granite veins intruding into the Jiuling rock masses are Neoproterozoic in age (843 ± 10 Ma) and the ore–forming granite porphyry veins intruding into Neoproterozoic Anlelin formation strata are late Jurassic (152.3 ± 1.8 Ma). Yang et al. developed a convenient and fast model for processing soil temperature time series, which can provide a crucial technical support for the comprehensive utilization of geothermal resources in highland areas or the assessment of the geothermal potential of the region. In this method, the soil thermal diffusion coefficients corresponding to different depths can be obtain, the temperature can be calculated at these different depths, and finally, the approximate soil temperature gradient of the measured area will be successfully obtained to apply in geothermal heat flow.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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