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Editorial: Collaborative exploration of Earth's deep interiors (CLEEDI)

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Editorial on the Research Topic
Collaborative exploration of Earth's deep interiors (CLEEDI)

Everything started in Foix, Ariège, southwest France, in August 2021. The first edition of collaborative Exploration of Earth's Deep Interiors (CLEEDI) was one of the first in-person workshops held after the covid crisis—we enjoyed reuniting with one another again after a long silence. On Monday morning, we were split into three small classrooms to form teams and define collaborative projects. We are eager to see the forthcoming second edition that will take place in this August 2023. Commencing this editorial with such a statement may entail an element of exaggeration since the deadline was somehow too early for the projects born during the hackathon-workshop and this "first" collection of scientific contributions is coming rather from those who were not in Foix back then. However, I feel that a discernible spirit of "CLEEDI" is emerging amongst geoscientists who would like to quantitatively integrate diverse observations and theories to constrain the history of the Earth's and planetary interiors across different temporal and spatial scales.

The geodynamical evolution of the Earth's and planetary interiors at any scale has been partially constrained only by observations made at and/or above the surface of the Earth and planets, through geodesy, geomagnetism, seismology and geochemistry. Within the geoscience community, estimation of seismic wave velocity structure had been one of the principal tasks when investigating the Earth's interior but it is indeed the thermo-chemical initial conditions and their subsequent evolution that we ultimately seek to characterise. Seismological structure obtained using inversions of seismic waveforms or its attributes, for instance, provides us with some *hints* that represent a snapshot of Earth's geological history. These parameters are then translated to thermochemical parameters that are 'more familiar to geodynamicists' via parameter look-up tables from *ab initio* first-principle or *in situ* high-pressure and high-temperature experiments. Geodynamicists generally have had a hard time reproducing patterns observed through seismic inversion in their Earth-like (or other planets-like) models. Throughout this chain of inversion procedures, each field often fails at taking into account the error bars (and their propagation) originating from other disciplines. This difficulty largely stems from the fact that we *had not* yet used the same "language (=parameters and their error bars)" to work together.

This Research Topic has called such contributions that seek to integrate different disciplines in geosciences and we are grateful that there are seven articles accepted in time. We here summarise this Research Topic, starting from the birth of our planet. Le Losq and Sossi assesses the dynamics of magma ocean at the surface of the early Earth, with laboratory-based measurements and extrapolation with the aid of machine learning technique. They claim that ionic compound ratio of iron within the peridotite melt atomic structure merely changes the Rayleigh number, suggesting that the oxidation state of iron contents would not have affected the dynamics during the early-stage of the Earth's formation. Iwamori et al. then revisits global geodynamics of the Earth's interior, directly reconciling geochemical and geophysical observations in the same manner, finding degree-1 structures at shallow mantle and inner core, whereas a degree-2 structure at deep mantle. They propose a top-down hemispherical dynamics for the entire Earth, focusing subduction towards the supercontinent.

There are two contributions concentrated on the deep Earth dynamics. Maderer et al. investigates potential next-generation neutrino tomography of outer core for density and composition. This approach presents an opportunity to complement seismic tomography studies in the near future. Its potential capability of detecting presence or absence of light elements in the outer core would be able to strongly constrain mantle dynamics. Deschamps and Cobden is a fruit of a long-lasting collaboration between thermodynamics and seismology, proposing a method to infer CMB temperature from seismic elasticity and anelasticity. The key process to deconvolve different geodynamics-related parameters out of seismic parameters are now described in probabilistic manners, which encourages quantitative direct and inverse problems in the deep Earth physics.

There have been several contributions on subduction initiation and process. Katayama et al. investigates the initiation of plate subduction, attempting to answer why the subduction dynamics is observed only on Earth. The rheology and numerical modelling studies proposes soft lithosphere and seawater penetration as the key factors for the subduction initiation, which were satisfied only here on our planet throughout the early stages. Nakao et al. tries to answer a famous yes-no question in geodynamics: whether a subducting plate stagnates or penetrates at the 660-km discontinuity by proposing a set of parameters with the aid of machine-learning analysis. They find that the back-arc spreading does not necessarily characterise plate behaviour, although back-arc spreading and a stagnant slab could coincide. Ueki et al., on the other hand, classifies magma formations in different tectono-magmatic situations with the aid of the aid of machine-learning analysis as well. Their main finding is that in addition to thermal structure of the subducting slab and mantle wedge, chemical fractionation can differ the overriding plates.

I thank all the authors and reviewers who contributed to this Research Topic. I especially thank Jean-Arthur Olive and John Hernlund for being on board for this Research Topic. I then thank those who devoted their time and energy to organise CLEEDI workshop(s): Jean-Arthur (again), Milena Marjanović, Cécile Prigent, Charles Le Losq, Institut de physique du globe de Paris, École Normale Supérieure Paris, Institut national des sciences de l'univers (Centre national de la recherche scientifique), Agglo Foix-Varilhes, European Association of Geoscientists, Frontiers, La Dépêche and La Gazette Ariégeoise.

Everything started in Foix, Ariège, southwest France, in August 2021: we hope to see more and more CLEEDIers in Foix in coming summers.

Author contributions

NF wrote this editorial, thanking all authors contributed to the article and approved the submitted version.

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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