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Editorial

Editorial for Special Issue "Mantle Strain Localization—How Minerals Deform at Deep Plate Interfaces"

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Understanding Earth's interior dynamics, the origin and factors of which maintain the present-day plate-like behavior of the lithosphere on our planet, is one of the main goals of geosciences. In the theory of plate tectonics, strain is concentrated at plate interfaces, leading to the localized production of earthquakes and volcanic activity. However, the origin and mechanisms allowing strain localization throughout the lithosphere remain puzzling and require more investigations on rock deformation at plate interfaces through multi-disciplinary approaches.

The main available tools to constrain rock deformation processes nowadays include field observations (together with geophysical observations) and lab experiments. While the former provides partial snapshots of geological processes at different scales, the latter attempts to reproduce natural processes at a micrometric scale using specific conditions in the laboratory, with some access to mechanical properties. Both types of investigations may be independently performed, but the comparison of their respective micro-structural features remains essential to compare and extrapolate experimental outputs and the resulting rheological laws to 'geological' time and space scales. This Special Issue gathers papers that use and/or combine results from these two different approaches, providing new insights on minerals and rocks that deformed at conditions representative of the lithosphere and asthenopheric upper mantle.

The study of Boneh et al. [1] is a perfect illustration of the value of making this link between natural observations and lab experiments using micro-structural features. Because lab conditions imply strain rates of several orders of magnitude higher than "geological" ones, requiring substantial extrapolation of the experimental outputs to geological conditions, Boneh et al. indeed examined xenolith samples deformed at strain rates comparable to a laboratory shearing time scale. Using the Electron Backscatter Diffraction (EBSD) technique to describe deformation features in three dimensions, which is at the forefront of microstructural studies, they demonstrate how mantle xenoliths may serve as a reference to compare lab tests and natural features. EBSD is also extensively used in the studies of Newman et al. [2], Linckens et al. [3], and Jung et al. [4] to describe the deformation features of highly deformed minerals in mantle shear zones, typically where strain has been localized. They respectively discuss how stress, melt and amphibole affect strain localization or may be used to decipher deformation mechanisms in upper mantle rocks. The role of ultrahigh pressure in affecting rock deformation at plate interfaces is further addressed in the paper of Asano et al. [5] through EBSD acquisitions, with a particular focus on the quartz–coesite transition.

In addition, this Special Issue highlights new discoveries from deformation experiments. The study of Akamatsu et al. [6] first focuses on the role of H_2O in modifying the strength- and strain-related behavior of the oceanic lithosphere. From measurements of elastic wave velocity during low-pressure rock deformation experiments, they show how hydrated olivine may reduce the strength of olivine gabbro and prevent any dilatancy before rock failure in the brittle regime. Gasc et al. [7] then considered the processes taking place at far higher pressure to experimentally explore the role of polymorphic reactions on rock deformation at the base of the upper mantle. Based on acoustic emissions recorded during deformation of Germanium olivine, they show how an analogue of the olivine–ringwoodite transformation may interact with strain localization and rock embrittlement. Finally, this volume is closed by the experimental study of Ferrand and Deldique [8] and a review study by Ferrand [9], both focusing on the nature of the lithosphere–asthenosphere boundary (LAB). While experimental data highlight a solid-state process commonly observed in metals to account for rock weakening through the LAB, the second study discusses and suggests the presence of garnet-rich pyroxenite layers at the LAB to explain the anomalies of electrical conductivity within the Cocos and Nazca plates offshore Nicaragua.

Conflicts of Interest: The authors declare no conflict of interest.

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