



**HAL**  
open science

## Editorial for Special Issue “Mantle Strain Localization-How Minerals Deform at Deep Plate Interfaces”

Jacques Précigout, Cécile Prigent, Bjarne Almqvist

► **To cite this version:**

Jacques Précigout, Cécile Prigent, Bjarne Almqvist. Editorial for Special Issue “Mantle Strain Localization-How Minerals Deform at Deep Plate Interfaces”. *Minerals*, 2022, 12 (12), pp.1625. 10.3390/min12121625 . insu-03930754

**HAL Id: insu-03930754**

**<https://insu.hal.science/insu-03930754v1>**

Submitted on 9 Jan 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Editorial

# Editorial for Special Issue “Mantle Strain Localization—How Minerals Deform at Deep Plate Interfaces”

Jacques Précigout <sup>1,\*</sup>, Cécile Prigent <sup>2</sup> and Bjarne Almqvist <sup>3</sup>

<sup>1</sup> Institut des Sciences de la Terre d’Orléans (ISTO), UMR 7327, Université d’Orléans, CNRS, BRGM, 45071 Orléans, France

<sup>2</sup> Institut de Physique du Globe de Paris (IPGP), UMR 7154, Université Paris Cité, CNRS, 75238 Paris, France

<sup>3</sup> Department of Earth Sciences, Uppsala Universitet, 752 36 Uppsala, Sweden

\* Correspondence: jacques.precigout@univ-orleans.fr

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 asthenospheric 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<sub>2</sub>O 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



**Citation:** Précigout, J.; Prigent, C.; Almqvist, B. Editorial for Special Issue “Mantle Strain Localization—How Minerals Deform at Deep Plate Interfaces”. *Minerals* **2022**, *12*, 1625. <https://doi.org/10.3390/min12121625>

Received: 7 December 2022

Accepted: 14 December 2022

Published: 16 December 2022

**Publisher’s Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

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 Deldicque [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.

## References

1. Boneh, Y.; Chin, E.J.; Hirth, G. Microstructural Analysis of a Mylonitic Mantle Xenolith Sheared at Laboratory-like Strain Rates from the Edge of the Wyoming Craton. *Minerals* **2021**, *11*, 995. [[CrossRef](#)]
2. Newman, J.; Chatzaras, V.; Tikoff, B.; Wijbrans, J.R.; Lamb, W.M.; Drury, M.R. Strain Localization at Constant Strain Rate and Changing Stress Conditions: Implications for Plate Boundary Processes in the Upper Mantle. *Minerals* **2021**, *11*, 1351. [[CrossRef](#)]
3. Linckens, J.; Tholen, S. Formation of Ultramytonites in an Upper Mantle Shear Zone, Erro-Tobbio, Italy. *Minerals* **2021**, *11*, 1036. [[CrossRef](#)]
4. Jung, S.; Yamamoto, T.; Ando, J.; Jung, H. Dislocation Creep of Olivine and Amphibole in Amphibole Peridotites from Åheim, Norway. *Minerals* **2021**, *11*, 1018. [[CrossRef](#)]
5. Asano, K.; Michibayashi, K.; Takebayashi, T. Rheological Contrast between Quartz and Coesite Generates Strain Localization in Deeply Subducted Continental Crust. *Minerals* **2021**, *11*, 842. [[CrossRef](#)]
6. Akamatsu, Y.; Nagase, K.; Katayama, I. Non-Dilatant Brittle Deformation and Strength Reduction of Olivine Gabbro Due to Hydration. *Minerals* **2021**, *11*, 694. [[CrossRef](#)]
7. Gasc, J.; Gardonio, B.; Deldicque, D.; Daigre, C.; Moarefvand, A.; Petit, L.; Burnley, P.; Schubnel, A. Ductile vs. Brittle Strain Localization Induced by the Olivine–Ringwoodite Transformation. *Minerals* **2022**, *12*, 719. [[CrossRef](#)]
8. Ferrand, T.; Deldicque, D. Reduced Viscosity of Mg<sub>2</sub>GeO<sub>4</sub> with Minor MgGeO<sub>3</sub> between 1000 and 1150 °C Suggests Solid-State Lubrication at the Lithosphere–Asthenosphere Boundary. *Minerals* **2021**, *11*, 600. [[CrossRef](#)]
9. Ferrand, T.P. Conductive Channels in the Deep Oceanic Lithosphere Could Consist of Garnet Pyroxenites at the Fossilized Lithosphere–Asthenosphere Boundary. *Minerals* **2020**, *10*, 1107. [[CrossRef](#)]