A new Mg2SiO4 polymorph "poirierite" in shocked meteorites and its possible high-pressure synthesis conditions

*Naotaka Tomioka[1], Takuo Okuchi[2], Luca Bindi[3], Masaaki Miyahara[4], Toshiaki Iitaka[5], Zhi Li[6], Xiande Xie[7], Narangoo Purevjav[2,8], Kiyoshi Fujino[9], Tetsuo Irifune[9], Riho Tani[4,1], Yu Kodama[10]

1. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2. Institute for Planetary Materials, Okayama University, 3. Università degli Studi di Firenze, 4. Hiroshima University, 5. RIKEN, 6. Nanjing University of Science and Technology, 7. Guangzhou Institute of Geochemistry, 8. Bayerisches Geoinstitut, University of Bayreuth, 9. Geodynamics Research Center, Ehime University, 10. Marine Works Japan Ltd

A new spinelloid-structured $(Mg,Fe)_2SiO_4$ polymorph named poirierite, whose structure was theoretically predicted three decades ago [1], was discovered successively in Tenham [2], Miami, and Suizhou shocked ordinary chondrites. HRTEM observations clarified that the nano-scale lamellar poirierite in Tenham and Miami is topotactically intergrown with polycrystalline ringwoodite and wadsleyite, respectively. The topotaxy demonstrated that the ringwoodite/wadsleyite to poirierite transformations were promoted by shear mechanisms after supercooling at peak shock pressure or during a subsequent decompression process in the shock metamorphism. Single-crystal X-ray diffraction analysis of poirierite from Suizhou, as well as results of first principles calculations, confirmed that the mineral has a minimum unit-cell size with dynamical stability among all the spinel-related structures. Due to structural similarities also with olivine, the poirierite structure would be a relay point in all the shear transformations in $(Mg,Fe)_2SiO_4$, thus enhancing its kinetics.

To understand the formation conditions of poirierite, we have also performed high-pressure experiments of San Carlos olivine (Fo_{90}) powder with heterogeneous grains size (<~100 μm) at 16 GPa and 900 °C by using a Kawai-type multianvil apparatus. The olivine grains were partially transformed into polycrystalline ringwoodite aggregates. TEM observations clarified that the ringwoodite grains have a high density of stacking faults on {110} as well as those in heavily shocked chondrites. Some of the grains showed weak electron diffraction spots corresponding to the poirierite structure in addition to those of ringwoodite. Fe-free wadsleyite, which was formed in the rim of a single crystal olivine (300 μm) surrounded by olivine powder (10 μm) at 15.5 GPa and 1000 °C [3], was also examined by TEM. Some of the wadsleyite grains with pervasive stacking faults on (010) plane showed the poirierite diffraction spots. Although detailed formation conditions need to be further evaluated, poirierite would form within the stability fields of wadsleyite and ringwoodite when a large differential stress is applied at relatively low temperatures.

References: [1] Madon M. and Poirier J. P. (1983) *Physics of the Earth and Planetary Interiors* 33:31–44. [2] Tomioka N. and Okuchi T. (2017) *Scientific Reports* 7:17351. [3] Fujino K. and Irifune T. (1992) in *High-Pressure Research: Application to Earth and Planetary Sciences*, 237–243.

Keywords: Shock metamorphism, meteorite, olivine, high-pressure phase transition