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Nanoindentation of lunar basalts: mechanical proeprties of the NWA 12008 meteorite

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Introduction: Nanoindentation is a powerful quasi-nondestructive technique in which the sample is indented with a nanometer-sized sharp end. The amount of displacement as a function of the applied load is parametrized to extract its local mechanical properties. This technique is widely used in material science as it is arising as a promising tool for extraterrestrial material characterization. In this work, we analyze the mechanical properties of olivine ((Mg,Fe)2SiO4) in the highly-shocked NWA 12008 lunar basalt.
Technical procedure: Nanoindentation was conducted with an Anton-Paar nanoindenter (NHT2 model) with a Berkovich tip (diamond pyramidal-shaped). A total of 92 nanoindentations were performed in 5 regions of the sample. Minerals were identified by SEM-EDX using a Hitachi TM4000plus tabletop microscope equipped with a Bruker EDX detector. Around one third of the nanoindentations turned out to be too close to fractures in the NWA 12008 meteorite. Data from those regions were not considered for the present study. We also conducted 91 additional nanoindentations of terrestrial olivines to act as sample control.
Results and discussion: Olivine hardness in NWA 12008 is sizably lower than that measured in terrestrial olivine crystals and also in the Chelyabinsk meteorite. On the other hand, olivine in NWA 12008 also appears to be more elastic (smaller elastic modulus) than in the Earth counterparts, but more similar to that from Chelyabinsk meteorite. Thus, it appears that the mechanical properties of olivine do depend on the origin of its host rock (terrestrial, lunar or asteroidal). We consider that lunar mineral intrinsic porosity or a high microfracture degree may induce such differences.

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