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Magmatic and plastic processes in primary planetary bodies: the brachinite meteorites as witness of the early differentiation

NEIL MEUNIER-MILI[1], **MARY-ALIX KACZMAREK**[2] AND MICHA BYSTRICKY[3]

[1]Géosciences Environnement Toulouse

[2]Géosciences Environnement Toulouse (GET), Université Toulouse III, Observatoire Midi Pyrénées

[3]Institut de Recherche en Astrophysique et en Planétologie (IRAP)

Presenting Author: mary-alix.kaczmarek@get.omp.eu

In primary planetary bodies, despite recent advances, the magmatic and deformation processes involved during the earliest stages of deformation or differentiation are still not well constrained. As of today, there is no consensus regarding whether brachinites are partial melt residues or cumulates. To decipher the impact and estimate weights between igneous (e.g. mantle flow) and high temperature deformation (e.g. dislocations) processes, this study presents detailed petrologic and microstructural data of nine brachinites and one ungrouped achondrite related to brachinites. Brachinites are igneous, ultramafic and unbrecciated primitive achondrites mainly composed of olivine and clinopyroxene. Observation and data have been done through secondary electron microscope, microprobe, and EBSD (electron backscatter diffraction). New data provide mineralogical maps displaying phases distribution, grain shape and grain size as well as internal deformation of this set of samples. Crystallographic Preferred Orientation (CPO) of olivine and pyroxenes have been rotated for an easier comparison. Elongation of olivine grains is coinciding with [001] axis concentration point (which is a possible lineation axis for olivine), and also because there are coinciding with clinopyroxene [001] axis concentration points. This led us to infer lineation as olivine [001] axis parallel to X for all our samples. Olivine CPO display a strong or medium concentration of [001] axis parallel to X and [010] axis parallel to Z indicating a possible (010)[001] B-type fabric. The shape preferred orientation of olivine (long axis of olivine grains), when visible, is coherent with olivine [001] axis. Grain misorientation distributions are similar to those found in untextured rocks, strengthening the idea that CPOs are not the result of dislocation activity, but could be the result of crystallographic orientation during crystal settling. A closer inspection of olivine misorientation axes suggest activation of (100)[001] C-type and (001)[100] E-type slip systems. The olivine internal deformation is weak showing rare low angle boundaries and distribution of misorientation axis could be the result of primary plastic deformation during or after crystal settling. Brachinites are magmatic cumulates derived from partial melting residues, that accommodated only weak and early plastic deformation, witness of early differentiation processes.