MONOCLINIC BADDELEYITE IN SHERGOTTY: TEM EVIDENCE OF ORTHOGONAL DOMAINS INDUCED BY PHASE TRANSFORMATION FROM A DENSE POLYMORPH AND NOT BY IGNEOUS ORIGIN.

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Introduction: Origin of monoclinic ZrO_2 baddeleyite in shergottites is controversially debated if evolved through: (1) pristine igneous crystallization in Martian basaltic flow in the young geologic history of Mars [e.g. 1, 2] or, (2) decompression recovery from a shock-induced dense polymorph in a young dynamic episode on Mars [e.g. 3, 4]. This controversial debate also promoted the "*shergottite age conundrum*" that plagued the shergottite chronology for more than three decades [4] thus impeding possibilities to explore details of the igneous activities on Mars. The sources of discrepancy are multifold emerging from details of the different investigation techniques, entire negligence of kinetic effects, unrealistic belief that the magnitude of natural dynamic deformation and the resulting radiometric resetting could be convincingly calibrated by the several orders of magnitudes shorter laboratory dynamic experiments. A further source of error is the common assumption that the sole **confirmation** of the monoclinic nature of ZrO_2 in shergottites automatically reveals undisputable evidence for igneous origin [1, 2]. We investigated seven baddeleyite grains in their shocked assemblages in Shergotty by: SEM, EPMA, and FIB-TEM and compared their submicron structure with natural terrestrial monoclinic baddeleyite.

Results: Baddeleyite grains in Shergotty coexist with molten and quenched maskelynite and seifertite constraining a P-T condition of ~22 GPa and 1900<T<2200ºC [3]. The ZrO_2 grains depict complicated mosaic-like structure of (100) and {110} orthogonal twin pattern in three directions similar to results by [5-6] produced by inversion of dense species to monoclinic ZrO_2.

Discussion: TEM investigations unambiguously indicate that the originally igneous ZrO_2 grains in Shergotty lost their igneous integrity. Their present state resulted from phase transformation from a denser polymorph: tetragonal, cubic or Ortho II [6, 7] to monoclinic. Peak-shock pressures in shergottites [3] imply P-T residence higher than that of the Ortho II P-T stability field [7]. TEM images show that ZrO_2 domains have many grain-boundaries, implying that interface diffusion effectively occurred thus questioning the validity of U-Pb dating results obtained by SIMS declared pristine crystallization ages [1, 2]. Application of only microRaman and EBSD studies could never reveal any reliable information on the ***origin*** of baddeleyite in any shergottite. This could only be uncovered by FIB-TEM presenting clear evidence for the mode of formation: if igneous or by phase transformation from a dense polymorph with typical inversion mosaic.

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