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Shocked minerals in the Northwest Africa 807 meteorite: Investigating the formation conditions of the high-pressure fayalite polymorph asimowite

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Pressure and temperature conditions for shock synthesis of high-pressure (HP) polymorphs of olivine in meteorites are presumed to resemble those where these phases appear in the mantles of terrestrial planets [1], although the timescale and mechanisms of shock and static compression are different [1, 2]. Because the Fe-analogue of wadsleyite, asimowite [3], appears in shocked meteorites but is absent from equilibrium phase diagrams, its existence poses a challenge to calibration of shock pressure using static compression and to understanding of dynamic synthesis of HP olivine polymorphs. Our observations of HP phases in shock-induced melt veins (MVs) in NWA 807 [4] offer insight into the origin of Fe-rich wadsleyite and asimowite.

Eight HP phases -ringwoodite, ahrensite, wadsleyite, asimowite, majorite, albitic jadeite, lingunite and xieite- were verified by chemical analysis, EBSD and/or Raman methods. One lens-shaped MV clast (**Fig. 1**) hosts majorite ($Ca_{0.08}Mg_{2.62}Fe_{0.99}Mn_{0.08}Al_{0.40}Si_{3.75}O_{12}$) at the center, rimmed by wadsleyite ($Fa_{30.3}$), followed by ringwoodite ($Fa_{38\text{-}41}$), an extended domain of olivine ($Fa_{12.2}$), and an outer rim of ahrensite ($Fa_{51\text{-}54}$). At two locations in the MV (one shown in **Fig. 2**), we identify the third known occurence of asimowite ($Fa_{50\text{-}53}$), coexisting with ahrensite (Fa_{76}).

The HP phases in NWA 807 suggest pressures from 14 to 23 GPa and temperature heterogeneities during the shock [2]. Based on Mg_2SiO_4-Fe_2SiO_4 phase relations at 1600 ºC, we infer that asimowite (Fa_{53}) and ahrensite (Fa_{76}) represent a metastable phase coexistence within the fayalite stability field at ~8 GPa [5]. This suggests that asimowite crystallizes metastably from ahrensite during decompression, with transformation into fayalite kinetically hindered or barricaded by high activation-energy. This potentially explains why asimowite is found in meteorites despite its absence from equilibrium phase diagrams and suggests a need for rapid decompression experiments or simulations to study the kinetics of phase transformation in the olivine system.

[1] Gruetzner *et al.* (2018) *Earth Planet Sci Lett* ***482**, 236-244.* [2] Hu & Sharp (2022) *Prog Earth Planet Sci* ***9**, 1-22.* [3] Bindi *et al.* (2019) *Am Mineral* **104**, 775-778. [4] Simopoulou *et al.* (2024) *LPI Contrib. 3036, 6054*. [5] Fei *et al.* (1991) *J Geophys Res: Solid Earth* ***96**, 2157-2169.*

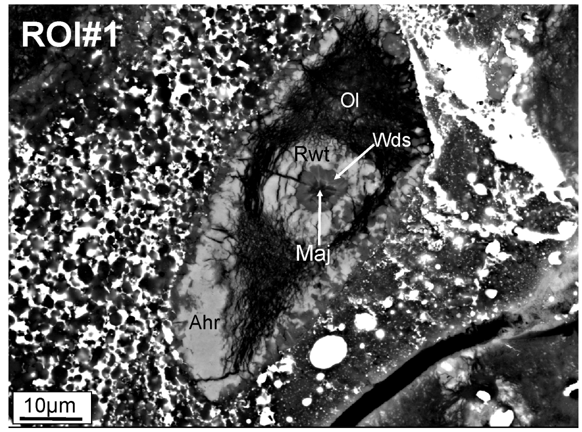

Figure 1: BSE image of the lens-shaped clast showing various HP zones (ROI#1). Ahr:ahrensite, rwt:ringwoodite, wds:wadsleyite, ol: olivine, maj: majorite garnet

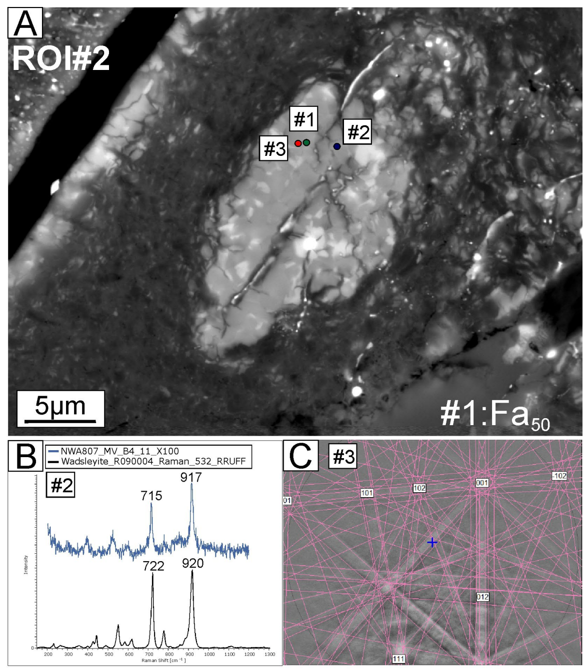

Figure 2: Wadsleyite clast containing asimowite confirmed by chemical analysis, Raman, and EBSD (ROI#2)