SHOCK METAMORPHISM OF A MARTIAN BASALT, NWA 14672

R.H. Hewins[1](hewins@scarletmail.rutgers.edu), H. Leroux[2], S. Pont[1], J.-P. Lorand[1], V. Malarewicz[1], O. Beyssac[1], and B. Zanda[1,]. [1]IMPMC, Sorbonne Univ., MNHN, UPMC Paris 06, UMR CNRS 7590, 75005 Paris, [2]Univ. Lille, CNRS, INRAE, Centrale Lille, UMR 8207 - UMET - Unité Matériaux et Transformations, F-59000 Lille.

Résumé NWA 14672 est une shergottite olivine-phyrique ferroane, avec des compositions minérales semblables à celles des shergottites basaltiques. Elle possède de la maskelynite très vésiculaire, et de la coesite coexistant avec du quartz. Il n'y a pas de veines de choc, mais deux types de mésostases, l'une avec des dendrites d'olivine dans du verre riche en Fe, l'autre avec des barres de plagioclase avec d'autres minéraux. Nous l'interprétons comme une roche qui a subi un degré élevé de fusion par choc.

Introduction: Martian meteoritesare available for thorough study in our labs and complement the information on the geology of Mars from space missions. Impacr breccias are rare in the meteorite collection: only NWA 7034 paired with NWA 7355, with a record back to 4.45 Gyr, is available [1,2]. The main basaltic group, the shergottites, consists of three geochemical groups, depleted, neutral and enriched, each with poikilitic, olivine- phyriric and basaltic textural types [3]. NWA 14672 is an unusual shergottite with a crystallization history confused by extensive impact melting.

Shergottite Type: NWA 14672 is an olivine-phyric shergottite. Olivine (Fo_{53-15}) is irregular in form, with highly ferroan outer mantles. The contacts between core and mantle are sharp or gradational. Pyroxene (a continuum of augite, sub-calcic augite, and pigeonite) is anhedral and patchy with several 'cores' within a ferroan pigeonite mantle (Fig.1); an infiltration/ reaction relationship appears possible. Feldspar (An_{68-50}) occurs as smooth, maskelynite-like regions.

Olivine and pyroxene core compositions are more ferroan than in other olivine-phyric shergottites but there is slight overlap with NWA 8686 [4] and NWA1068 [5]. A better match for the pyroxene core compositions is found in basaltic shergottites though NWA 14672 pyroxene is more ferroan than most. The best match is to Los Angeles [6] and NWA 7320 [7]. Thus NWA 14672, the most ferroan olivine-phyric shergottite found so far, resembles the basaltic shergottites, and might be a basaltic shergottite liquid that scavenged xeno- or auto-crysts.

Complex And Fine-Grained Regions: The meteorite is unusual in having highly vesicular maskelynite, and fine-grained material occurring as interstitial patches, schlieren, teardrops and globules (Fig. 1). There are two main types, with either feather/swallowtail ferroan olivine dendrites in glass, or feldspar bars intergrown with other phases. In the glass, Fe sulfide forms globules with intergrown magnetite.

Within fine-grained regions (especially barred plagioclase) there are fine granular or dendritic aggregates of a single mineral. We show ilmenite aggregates in Fig. 3 within barred plagioclase and adjacent to a pyroxene aggregate (close-up, Fig. 4). Large olivine grains adjacent to fine-grained material have coarse dendritic or granular overgrowths (Fig. 5,6). Pyroxene and olivine grown on aggregates become interstitial to plagioclase bars (Fig. 3-6).

Formation conditions: Vesicles are observed in a minority of shergottites, e.g. NWA 5298 [8], those considered the more shocked examples. The Raman spectra of silica grains in NWA 14672 indicate the presence of coesite, silica glass, and quartz. Raman spectra for maskelynite showed both ~490 and ~510 cm^{-1} peaks characteristic of plagioclase.

Maskelynite is ubiquitous in shergottites and is now largely interpreted as melted plagioclase [e.g. 9] due to evidence of flow and the presence of dendritic (barred) plagioclase. Stöffler et al. [10] argued that Shergotty maskelynite was formed at ~30 GPa. Fritz et al. [11] have measured the Raman spectra of SNC feldspar that experienced shock deformation and showed peak broadening, disappearance of the plagioclase 510 cm^{-1} peak when isotropic maskelynite has formed. Above 45 GPa, ALHA 77005 feldspar first produced vesiculated glass with a very broad ~500 cm^{-1} peak and then crystallized plagioclase with both ~490 and ~510 cm^{-1} peaks). In view of the presence of coesite, glass, and abundant vesicles, we consider our feldspar with the Raman spectrum of plagioclase not to be unshocked plagioclase, but recovered or crystallized after a strong shock, >45 GPa [11], but we still call it maskelynite.

Conclusion: The meteorite lacks discrete shock melt veins but appears to have experienced extensive melting, partly congruent (maskelynite) and partly eutectic. The presence of granulated or dendritic aggregates of ilmenite, pyroxene, and olivine, and pervasive vesiculated maskelynite is a characteristic of the most highly shocked shergottites.

References: [1] Humayun et al. (2013) *Nature 503*, 53-56. [2] Hewins et al. (2017) *MAPS* 52, 89-124. [3] Udry et al. (2020) *JGR JE006523*. [4] Nicklas et al. (2022) *LPS* #1402. [5] Barrat et al., (2002) *GCA 66*, 3505. [6] Rubin et al. (2000) *Geology 28*, 1011. [7] Udry et al., (2017) *GCA 204*, 1-18. [8] Hui et al. (2011) *MAPS 46*, 1313. [9] Chen and El Goresy (2010)

EPSL 179, 489-502. [10] Stöffler et al. (1986) 50: 889. [11] Fritz et al. (2005) *Antarct. Meteorite Res. 18*, 96-116.

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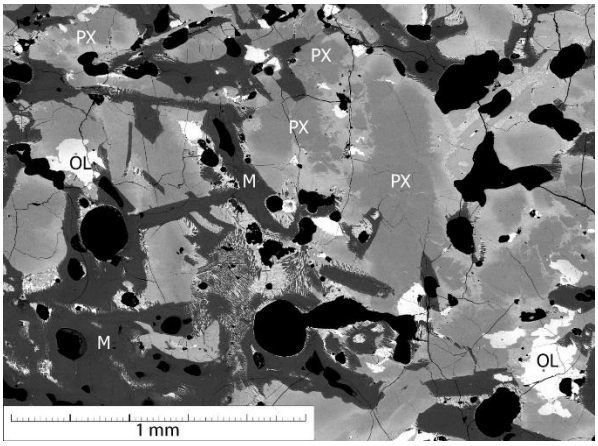

Fig. 1. Maskelynite (M) with vesicles, patchy pyroxene.

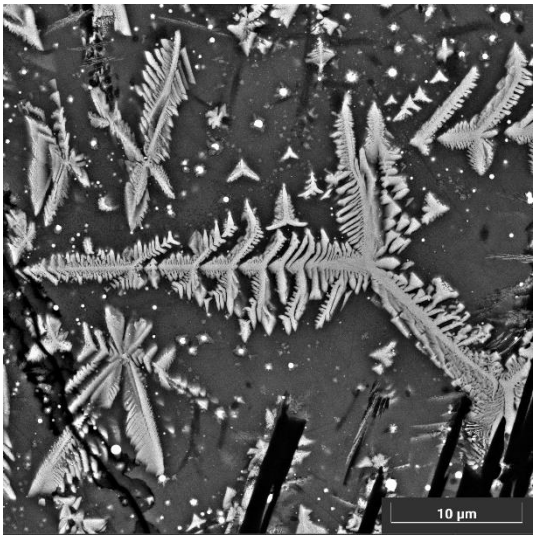

Fig. 2. Dendritic olivine in glass.

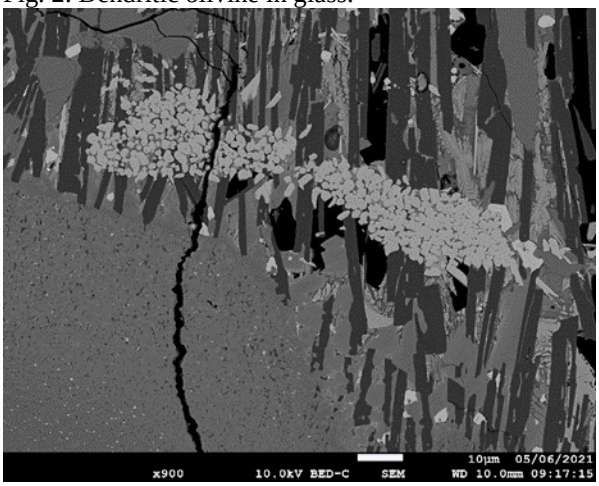

Fig.3. Granular ilmenite aggregate in barred feldspar.

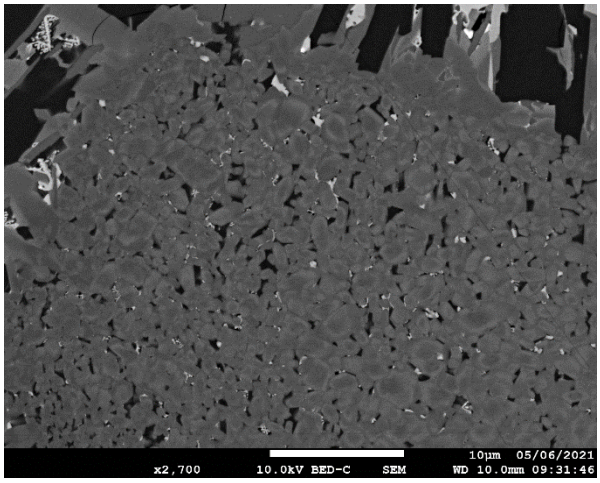

Fig. 4. Granular pyroxene aggregate (from Fig. 3).

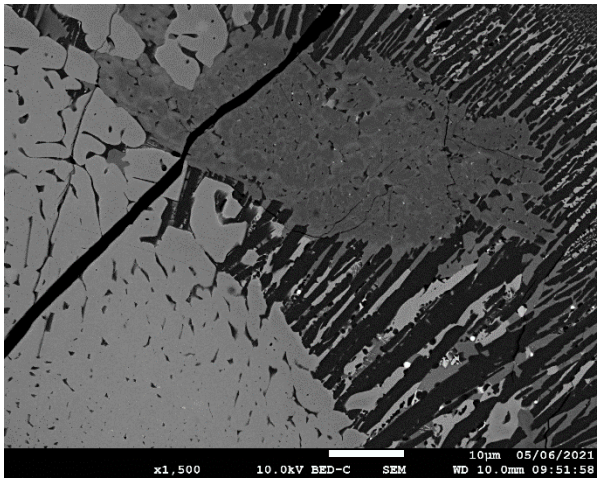

Fig. 5. Granular olivine, granular pyroxene, bars.

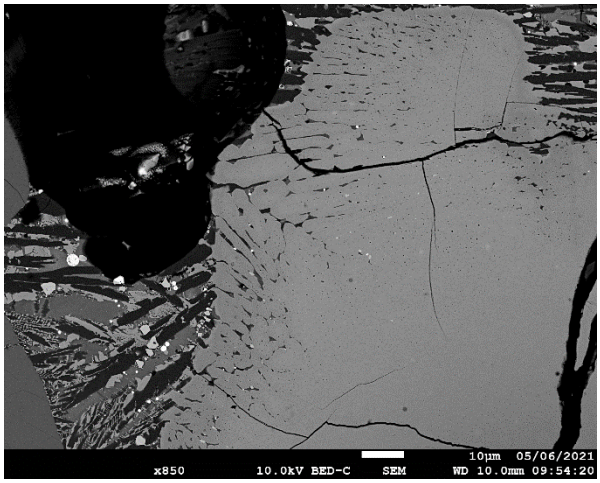

Fig. 6. Dendritic olivine overgrowths.