THE ANOMALOUS DIOGENITE NORTHWEST AFRICA 12973.

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Introduction: Diogenites are a relatively abundant type of achondrite meteorites, with in total 524 individuals (i.e., with distinct names), but only 12 observed falls [1]. They are petrologically highly diverse, including dunitic, harzburgitic, and noritic lithologies, in addition to the more traditional orthopyroxenites [e.g., 2,3]. Diogenites are petrogenetically associated with mafic magmatism in the lower crust of the parent body of the howardite–eucrite–diogenite (HED) meteorites [3]. Six of the 524 individuals are classified as "anomalous diogenite", including Northwest Africa 12973 (NWA 12973) for which we report here detailed observations using a multi-method approach. Found in Tunisia in January 2019, NWA 12973 was classified by A. Irving and P. Carpenter [1]. It shows a protogranular texture, with prominent triple grain junctions, and is mainly composed of orthopyroxene, with small amounts of other phases, including olivine, clinopyroxene, V-bearing chromite, and troilite, plus minor secondary calcium sulfate and barite [1]. It shows typical petrographic and geochemical characteristics of diogenites but was classified as an "anomalous diogenite" due to the presence of a vesiculated "layer" (up to 1.5 cm in thickness) on some of the fragments (Fig. 1) of the about 1.5 kg that were recovered.

Material & Methods: Four polished sections were prepared from two fragments of NWA 12973, one of them showing both lithologies, i.e., the normal diogenite (the "host") and the vesicular lithology, allowing to investigate the contact zone (Fig. 1). Petrographic observations and chemical composition of the components were performed using optical microscope, energy-dispersive micro X-ray fluorescence (µXRF) Bruker M4 Tornado at the VUB (Belgium), and a JEOL JXA-8530-F field emission gun electron microprobe (EPMA) at the NHMV (Austria). Additionally, trace element abundances were measured at the UGent (Belgium) by using a set-up consisting of an Analyte G2 laser ablation system coupled to an Agilent Technologies 8800 tandem ICP-MS instrument.

Results: The vesicular lithology contains generally lower S and higher Ca amounts, in addition to showing a finer grain size than the host diogenite. The host consists of low-Ca pyroxene ($Wo_3En_{75}Fs_{22}$), with olivine ribbons (Fa_{26}) and chromite (with up to 0.5 wt.% V). The vesicular lithology mostly consists of a low-Ca pyroxene matrix ($Wo_4En_{73}Fs_{23}$), with locally Ca pyroxene ($Wo_{43}En_{46}Fs_{11}$) and olivine grains (Fa_{28}), with tiny chromite grains spread in the whole portion of the meteorite. Minor kamacite and troilite grains occur in both lithologies, but kamacite has a slightly higher Ni content in the vesicular lithology than in the host.

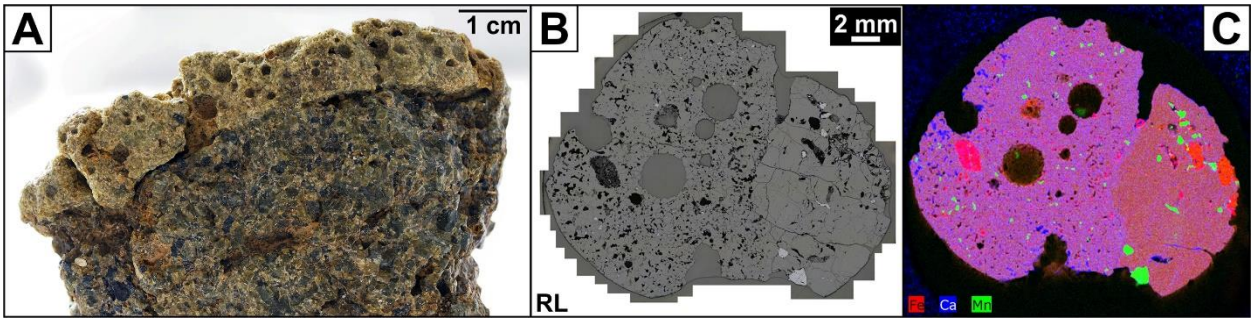

Fig. 1. A) Main mass of NWA 12973 showing the two lithologies (photo credit: V. Jacques). B) Reflected light mosaic and (C) µXRF map of section NHMV-O1969 showing the contact zone.

Discussion: Based on our observations, we envision the following formation scenario: 1) crystallization of olivine in the mantle of the parent body; 2) peritectic reaction along olivine margins once embedded in a pyroxenic melt (in the lower crust); 3) local melting by adiabatic decompression (triggered by an impact event?), with peak temperature lower than the melting point of olivine (based on the presence of round relics); 4) injection of melt in a (pre-existing) crack in the host (no in situ melting based on the observed sharp contact); 5) slow cooling of the melt with fractional crystallization, but faster cooling relative to the host, resulting in finer-grained pyroxene matrix; 6) final excavation (from the lower crust) and ejection following an impact event. LA-ICP-MS and geothermobarometric works are in progress and will provide further constraints on the here suggested scenario.

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References: [1] Meteoritical Bulletin Database [www.lpi.usra.edu/meteor/metbull.php], accessed on June 3rd, 2021. [2] Mittlefehldt D. W. (2015) *Geochemistry* 75(2):155–183. [3] Shearer et al. (2010) *GCA* 74:4865–4880.