

A CRYSTALLOGRAPHIC ANALYSIS OF NORTHWEST AFRICA 8159: CRYSTALLIZATION AND IMPACT CONDITIONS

L. V. Forman^{1,2} and G. K. Benedix^{1,2}, ¹Space Science and Technology Centre, School of Earth & Planetary Sciences, Curtin University, GPO Box U1987, Perth, WA, Australia, email: lucy.forman@curtin.edu.au ² Western Australian Museum, Locked Bag 49, Welshpool DC, WA, 6986.

Introduction: The study of martian meteorites has provided a deeper understanding of volcanism on Mars. The small number of samples analyzed have begun to answer large-scale questions pertaining to the geological history of the martian surface. Here, we investigate a basaltic shergottite meteorite from the early Amazonian [1] - one of only two currently known martian meteorites that crystallized at this time [1,2]. Shergottites sample a suite of different lithologies, formation ages, ejection ages and volcanic settings [3], therefore careful consideration of each sub-type is critical to building a wider understanding of martian volcanism as a function of both formation age and location.

North-West Africa (NWA) 8159 is the only shergottite classified as an augite basalt [1, 4]. It likely crystallized from an evolved melt at 2.37 ± 0.25 Ga based on Sm-Nd analyses [1], which is much older than the majority of the shergottite group (typically <600 Ma in formation age) [1]. We investigate the crystallization conditions of this early Amazonian rock, and what implications that has for the environment in which it formed.

The aim of this initial crystallographic examination is to qualify and quantify any crystallographic textures. These may be used as an indicator for emplacement of the rock, for example in a fast-moving flow or in a cumulate setting. We will also investigate any shock-induced micro- and nano-structures within apatites as an indicator of conditions during impact, and comparisons between apatite grains proximal and distal to the melt vein will also be conducted.

Methods & Materials: A 1-inch round epoxy thick section of NWA 8159 (supplied by UNM) was polished for 4 hours using a Vibromet polisher with colloidal silica solution to obtain a reflective surface, and subsequently coated with a ~5 nm carbon coat. Backscatter electron (BSE) and energy dispersive spectrometry (EDS) images were collected at 20 KeV accelerating voltage on the TESCAN TIMA scanning electron microscope (SEM) at the John de Laeter centre (JDLC) at Curtin University. All crystallographic information was then collected using the electron backscatter diffraction (EBSD) on the TESCAN MIRA3 SEM using Oxford Instruments' Symmetry CMOS detector. Large area maps were created based on crystallographic information obtained at a step size of 1 micrometre. Data were processed using AZtecCrystal software, and noise reduction was performed as per common protocol [e.g. 5, 6]. Grains were identified based on a 10° misorientation threshold. Phase, crystallographic orientation and crystal-plastic deformation maps were collected or deduced based on Kikuchi bands recorded by the detector.

Results: Preliminary results from earlier large-area mapping demonstrates that much of the sample is crystalline with very little amorphous material present as discovered in prior studies [e.g. 8]. Mineralogy of the large area map is broken down as follows; clinopyroxene 48%; plagioclase feldspar 36%; magnetite 8%; olivine 3%; ~5% attributed to the Ca-rich veins, and other minor phases such as apatite [9].

Crystallographic analysis of this data showed a weak alignment of the <010> axis across the plagioclase grains, whereby the orientation of this axis formed a weak cluster. This axis is typically the shortest crystallographic axis in plagioclase. There is no alignment of the other two axis. Apatites are present across the surface of the exposed sample, and will be further investigated prior to the meeting.

Discussion: The presence of an alignment in the <010> axis indicates that a consistent force was applied during the final phase of crystallization of this rock. The lack of alignment in the other two axes suggest this texture was not formed by flow (as in [7]), but rather by a compressive force, such as gravity or impact, whereby the shortest axis of the grains will stack parallel to the direction of the force being applied (e.g. [5]). The limited amount of maskelynite within this sample would indicate this was aligned during crystallization and is therefore interpreted as a gravitational settling texture. This is in agreement with earlier studies, where the groundmass was used to infer a surface lava flow, or shallow sill origin as we find here.

Conclusions and further work: The crystallographic alignment of the plagioclase grains examined thus far indicate a settling texture is present. We aim to examine crystallographic properties not only of the plagioclase laths, but also the fine-grained groundmass ahead of the meeting. We will also investigate the apatites across the sample using EBSD and atom probe techniques to compliment the EBSD analyses already performed.

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