INVESTIGATING THE IMPACT FLUX OF THE EARLY SOLAR SYSTEM THROUGH THE ANALYSIS OF HEDs AND MESOSIDERITES

I. Kouvatsis[1] and J. A. Cartwright[1], [1]Department of Geological Sciences, University of Alabama, Tuscaloosa, AL 35487, USA. E-mail: ikouvatsis@crimson.ua.edu

Introduction: Hypervelocity collisions and impacts are important Solar System processes that result in deformation effects in rocks and minerals such as brecciation, formation of melt pockets and/or veins, and high-pressure and high-temperature polymorphs [1, 2]. These features are preserved as shock metamorphic effects in many meteorites [3]. The analysis of the materials, particularly melt clasts created by these collisions is important, as they can act as markers for impact timing and impact flux on planetary bodies. Of particular interest is the asteroid (4) Vesta, the largest and one of the very few differentiated asteroids remaining from the early Solar System [4]. Vesta is also the likely parent body for the howardite, eucrite, diogenite (HED) meteorite clan. Howardites are polymict breccias that contain eucritic and diogenetic material and are believed to come from the vestan surface. Eucrites are thought to have crystallized as lavas on Vesta's surface or in shallow dikes and plutons and can be classified based on their petrology as either basaltic or cumulate rocks, with basaltic eucrites further subdivided by their geochemistry [5]. Diogenites are coarse-grained cumulates traditionally believed to have originated from a plutonic layer deep in the crust. Both eucrites and howardites contain melt clasts, that often exhibit striking textural appearances and compositional variability (e.g. [6]), that likely formed through impact processes. This means that they provide a snapshot of the timings and conditions of bombardment on the vestan surface [6]. Another potentially-related meteorite group for consideration are mesosiderites, which are stony-iron meteorites composed of roughly equal proportions of silicates and Fe-Ni metal [7]. Many previous studies have suggested a relationship between the mesosiderites and the HEDs (e.g. [8]). Their geochemical characteristics imply a formation process with contributions from crust and core materials, and it has been proposed that mesosiderite formation requires a catastrophic distruption of at least one differentiatied asteroid [9]. For example, Haba et al. [9] proposed that mesosiderites can be explained by a hit-and-run collision on Vesta 4,525.4 million years ago (Ma), and also caused the formation of a thick crust observed by NASA's Dawn mission [9].

In previous work, Cartwright et al. [6] reported on howardite samples and revealed evidence for an extended period of bombardment on the vestan surface. While this work continues [10], in this study we continue to investigate eucrite materials [11] and expand into considering mesosiderites. These samples will be investigated using standard petrographic techniques, to locate suitable phases and clasts to be considered for chronometric analysis. We will use a combined approach of uranium-lead (U-Pb) techniques with argon-argon ($^{40}Ar/^{39}Ar$) techniques to determine crystallisation and resetting ages of targeted clasts. Disturbances due to thermal and shock metamorphism processes can lead to total- or partial-loss of ^{40}Ar, resetting the decay clock. Three goals could be achieved by combining U-Pb and $^{40}Ar/^{39}Ar$ chronometry: i) constrain the crystallization history of various clasts using U-Pb; ii) constrain the history and extent of impacts by measuring disturbances in the $^{40}Ar/^{39}Ar$ system; and iii) determine the possible relationship between mesosiderites and HEDs by comparing their chronological histories.

Sample Preparation & Methods: Two mesosiderites, Vaca Muerta and Estherville, and eucrites Northwest Africa (NWA) 8564 and Serra Pelada were prepared, mounted and polished to reveal a flat surface. Following standard microscopic observations and imagery of the samples within the Cartwright Cosmochemistry Lab (CCL) at the University of Alabama (UA), we used the ThermoFisher Apreo field-emission scanning electron microscope (FE-SEM) at the Alabama Analytical Research Center (AARC) at UA, for general high-resolution imaging purposes, to create energy-dispersive X-ray spectroscopy (EDS) elemental maps and to locate and examine clasts for U-Pb and Ar-Ar chronometry studies. U-Pb geochronology measurements will be conducted in Summer 2021 using the CAMECA IMS 1280 ion microprobe, which uses a focused ion beam to sample in situ targeted areas, in the NORDSIM laboratory (PI: Prof. M. Whitehouse) located in the Department of Geosciences at the Swedish Museum of Natural History in Stockholm, Sweden. Subsequent $^{40}Ar/^{39}Ar$ analyses will be performed in the Group 18 Laboratory (PI: Prof. K. V. Hodges) Arizona State University.

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