COMPARISON OF CHEMICAL ZONING OF EUCRITE AND MARTIAN MICRO-ZIRCON


1Natural History Museum Vienna, Burgring 7, 1010 Vienna, Austria; julia.walterroszjar@nhm-wien.ac.at. 2Department of Earth Sciences, Western University, 1151 Richmond Street N, London, ON Canada. 3Institut für Mineralogie und Kristallographie, Universität Wien, Althanstraße 14, 1090 Vienna, Austria. 4Royal Ontario Museum, 100 Queen’s Park, Toronto, Canada M5S 2C6

Introduction: Zircon occurs as an accessory phase in various types of meteorites with typical grain sizes ranging from 2-30 µm. Occurrence, abundances, and sizes of zircon crystals are however highly diverse among distinct groups of meteorites, which is due to highly variable bulk-rock Zr concentrations, ranging from <1 to >800 µg/g. The prime sources of extraterrestrial zircon are differentiated meteorites and rocks, i.e., Lunar rocks, samples of the howardite-eucrite-diogenite (HED) suite of rocks – with basaltic eucrites in particular, and mesosiderites (see [1], and refs. therein). Rare examples of Martian zircon occur either as a primary phase, i.e., in the unique regolith breccia Northwest Africa (NWA) 7533 and paired samples [2], or as a secondary, launch-generated, phase observed in the highly shock-metamorphosed shergottite NWA 5298 [3]. This study addresses the chemical and structural characteristics of meteoritic zircon, investigated on a high spatial resolution, which is relevant for unravelling their formation conditions, secondary alteration, such as induced by thermal and shock metamorphism, and for the interpretation of chronological data in particular.

Material and Methods: A comprehensive structural and chemical characterization has been done using electron microscopy, including SEM-CL, EPMA and EBSD investigations, as well as Raman spectroscopy. Following instruments have been used: a JEOL JSM 6610-LV SEM equipped with a Gatan MonoCL system, a JEOL JXA 8530 F EPMA, a Hitachi SU-6600 FEG-SEM, equipped with Oxford-EBSD and CL detectors, and a Horiba LabRam HR Evolution spectrometer. Investigated samples included the Martian regolith breccias NWA 7906 and NWA 7475, paired with NWA 7533 [2], and the basaltic eucrites Camel Donga, Cachari, NWA 1000, NWA 4523, Hammadah al Hamra (HaH) 286, Jonzac, and Dhofar 182 that exhibit varying degrees of shock- and thermal metamorphism.

Results and Discussion: Similar to terrestrial zircon, meteoritic zircon grains are enriched in incompatible elements, with heavy rare earth elements (HREE) in particular, that become concentrated in the residual melts during magma cooling and were incorporated in late-stage crystallization phases, such as zircon and Ca-phosphates (i.e., apatite and merrillite [1,4]). Zircon grains from all investigated basaltic eucrite samples are 4-50 µm in size and subhedral to irregular in shape. They mainly occur within silicate-rich mesostasis areas, in interstices or along interfaces between larger silicates and/or oxides such as ilmenite, and in apparent equilibrium with the surrounding igneous mineral assemblages. Planar growth banding and sector zoning, i.e., textures similar to that of terrestrial high-temperature zircon grains, are observed in some grains. In HaH 286 a unique zircon aggregate of ~5 µm grains appears to be recrystallized to form a ~80 µm skeletal grain in a mineral assemblage with pyroxene, porous Ca-phosphate, and ilmenite. In the Martian samples, zircon grains are 5-40 µm in size and occur either as single grains or multiple grains intergrown with baddeleyite within evolved igneous clasts and in the silicate matrix, in agreement with [2]. Highly crystalline igneous grains are preserved with either planar growth bands or virtually no zoning. In addition, porosity on a sub-µm scale has been observed in some Martian zircon grains, as indicated by deficient EPMA analysis totals, and in agreement with low CL and variable Raman signals within the grains restricted to these areas and of non-magmatic origin. Raman spectroscopic data also indicate a moderate- to strong structural disorder for most grains in both Martian and eucrite samples. Broadening and red-shifting of the monitored prominent, antisymmetric ν3(SiO2) stretching band (i.e., located at ~1008 cm⁻¹ in undamaged zircon) indicate radiation damage that is assigned to the alpha decay of trace actinides (U and Th) and their instable daughter nuclei. Note that a certain degree of structural recovery is observed for most zircon grains among the basaltic eucrite suite, but also in the Martian samples, that is likely induced by thermal annealing, consistent with the petrographic observations of these samples. These findings are in agreement with observed variable P, U, Th, and REE concentrations within the grains and chemical zoning as seen in CL imaging. The EBSD data quality, i.e., the diffraction signal strength, is spatially correlated with crystallinity shown by CL and Raman data, indicating (1) successful indexing using terrestrial standards, and (2) survival of the primary, pre-launch-generated structural and chemical zoning of the grains. This is a first step in comparing planetary petrogenesis using early-formed micro-zircon.