Simulating the Effects of Thermal Fatigue on the Formation of Regolith in a Thermal Vacuum Chamber

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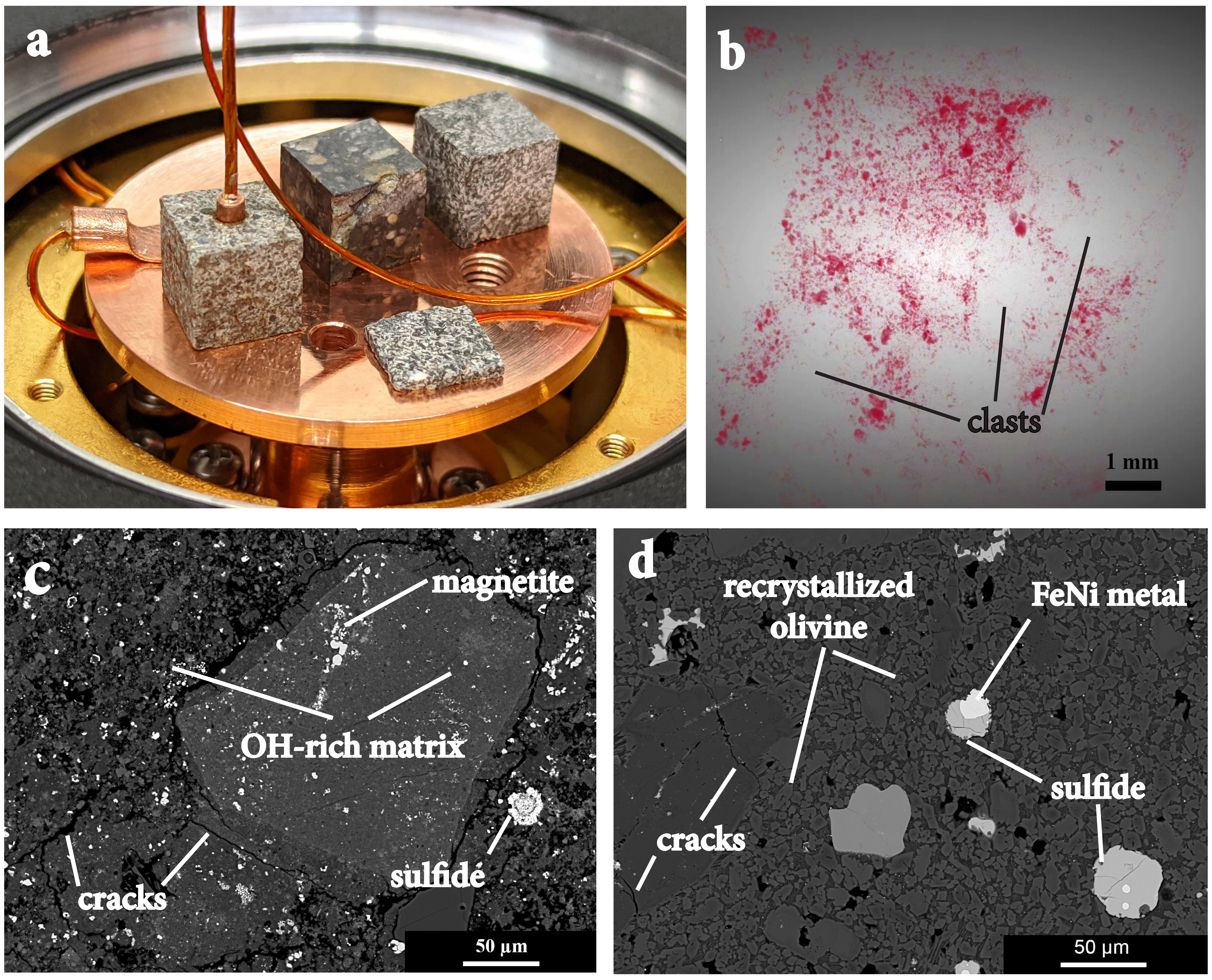
Introduction

Precious space is a research group funded by the Alexander von Humboldt foundation that aims at determining the presence, preservation and characteristics of precious planetary materials. The core competence is the understanding and characterization of regolith since it is an ubiquitous on all solar system bodies. Regolith on the surface of asteroids and the moon is subject to **diurnal temperature variations** that are able to damage the structural integrity of this material [e.g., 1,2]. This study aims to understand the effect of diurnal temperature variations on the formation of regolith on airless bodies including mineralogic aspects.

Sample Selection

Meteorites allow us to study the mineralogy and petrology of the asteroids they derive from. Since each meteorite group and their respective parent bodies have their **unique mineralogy** (e.g. Fig. 1c and d), their structural changes as they respond to temperature excursions need to be evaluated individually. For this study, we selected meteorite samples covering **different achondrite** (NWA 11273, lunar; NWA 11050, eucrite) and **chondrite groups** including carbonaceous (Allende, CV3; Murchison, CM2; Jbilet Winselwan, CM2; Tagish Lake, C2) and ordinary chondrites (Chelyabinsk, LL5; El Hammami, H5). Since certain minerals in meteorites can be altered on Earth within short timescales, the original mineralogy and texture will be rapidly lost and physical properties may change due to the weathering of e.g. metal and sulfide grains. Thus, **meteorite falls** have been chosen for the experiments where ever possible.

Experimental Setup and Samples



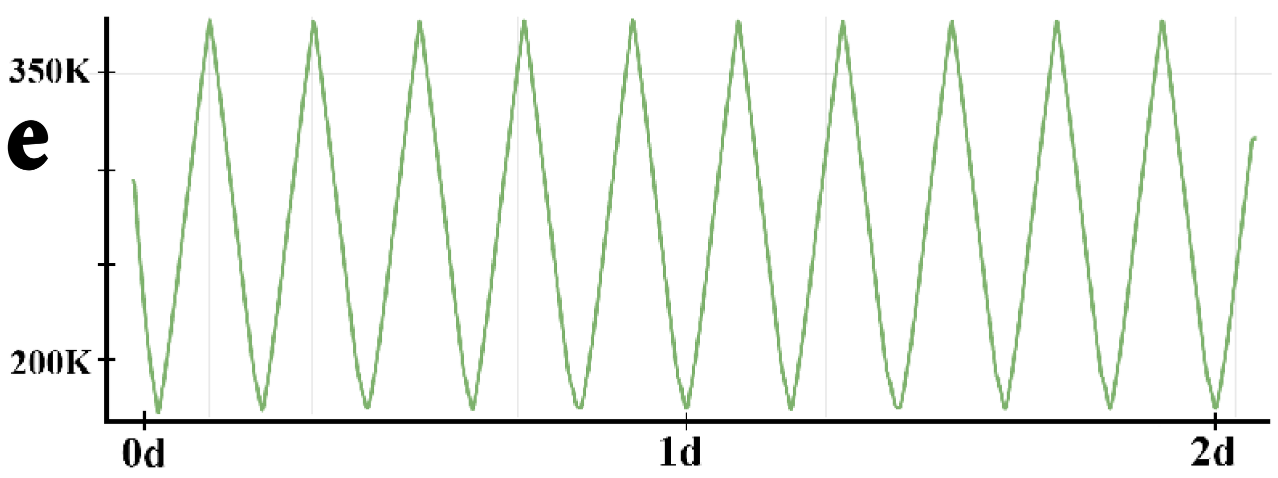


Fig 1: (a) Monitor sample located on the coldfinger with thermocouples attached to the sample and the coldfinger. (b) 2D view from a micro computed tomography (µ-CT) scan of the lunar meteorite NWA 11273 showing the structure of voids and cracks that can develop under thermal cycling around individual clasts. (c) Tagish Lake (C2) mainly consisting of OH-bearing porous phyllosilicate-rich matrix. (d) Impact melt in Chelyabinsk (LL5) with abundant metal and sulfide grains embedded into recrystallized olivine. (e) Reproducable temperature course of the monitor sample over 10 cycles covering 2 days (d).

The experimental chamber is based on an evacuated (~5×10^{-6} mbar) cryostat. A custom-made Cu-coldfinger can be cooled by liquid nitrogen to 100K and cyclically heated with a 100W cartridge heater to up to 475K covering the naturally observed surface temperatures of **Near Earth Asteroids (NEAs)** or the **Moon** (e.g. Fig. 1a, [e.g., 2]). Temperatures measured on various locations in the chamber and within a monitor sample show a well reproducible experimental setup (e.g. Fig 1a,e). Combining the observations of the **thermal cycling** experiments obtained by **scanning electron microscopy** and **µ-CT** scans allows for in-depth understanding of crack growth.

Preliminary Results

Preliminary results indicate no crack development nor propagation on the surface of thermally cycled (175K to 375K) NWA 11273 after a total of 10, 20, 50, and 100 cycles. However, cracks developed on the surface of NWA 11050 recently. Evaluation of the µ-CT scans requires exact co-registration of the analyzed volumes to allow automated crack discovery and precise determination of their dimensions and volumes. This work is ongoing.

References and Acknowledgement

[1] Molaro J. L. and Byrne S., (2012), J. Geophys. Res, 117, E10. [2] Delbo M. et al. (2014), Nature, 508(7495), 233-236. The authors are supported by a Sofja Kovalevskaja Award Project of the Alexander von Humboldt Foundation.

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