PhD position @ CRPG, Université de Lorraine (Nancy, France)

Origin of aubrites and their parent bodie(s): petrological, geochemical and cosmochemical study

Context / funding: This PhD is part of the IMPAcToR (Aubrite meteorites: relicts of a large protoplanet Mercury?) project led by Camille Cartier, funded by the ANR for the period 2025-2029. This project aims at unraveling the link between aubrites meteorites, planet Mercury, and E-type asteroids through a multi-disciplinary approach. IMPAcToR brings together a team of 8 researchers from various disciplines, working at CRPG or other French research institutes, who will all interact with the student. This PhD is an analytical and geochemical modeling project, but bridges could be established with the other parts of the ANR project, particularly the experimental and the dating parts. In addition to the PhD student, the project includes the internships of two Master 2 students.

Supervisors: Camille Cartier (CRPG, Université de Lorraine), François Faure (CRPG, Université de Lorraine)

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Contact Camille Cartier for more information about the ANR IMPAcToR project and/or PhD logistical details.

Keywords: Cosmochemistry, Planetary Science, Meteorites, Igneous Petrology, Geochemical Modeling

Expected start date and duration: 3 years starting October 2025

Location: This PhD will be hosted at CRPG (Nancy) and will include missions in France and abroad.

Application deadline: Applications will be accepted until May 23, 2025.

Application process: Candidates should contact the two supervisors with a cover letter and a CV.

Desired profile: Candidates should be in the final year of a Master's degree, in Geosciences or Planetary Science. Candidates should be highly motivated by the study of meteorites and early solar system Science, with advanced knowledge in igneous petrology and geochemistry, background in cosmochemistry, an excellent level of written expression, and a sense of initiative. Knowledge of low oxygen fugacity environments and/or reduced meteorites is a plus, as well as experience with one or several of the numerous methods that will be used.

Summary: Mercury stands out as an exception in our solar system, characterized by its unique lithologies formed in an ultra-reducing, sulfur-rich environment (Cartier and Wood, 2019). Despite being the smallest planet, Mercury has the proportionally largest core (Charlier and Namur, 2019). Thus, a long-standing hypothesis suggests that Mercury originally possessed a much larger rocky mantle, largely destroyed in giant impact(s). However, due to a lack of constraints, this scenario has never been confirmed, and the origin of Mercury remains an elusive and controversial topic. Aubrites, rare achondrites whose mineralogy is particularly close to that of Mercury, are known to originate from E-type asteroids, small "rubble piles" located in the innermost asteroid belt (Keil, 2010). The ANR IMPAcToR project aims to evaluate the original hypothesis that aubrites are remnants of the shallow

mantle/crust of a large proto-Mercury, pulverized by giant impact(s), and of which a small fraction of the debris would have been implanted in the asteroid belt (Cartier et al., 2022). The objective of the doctoral project is to exhaustively characterize the petrography, chemical compositions and some isotopic compositions of a unique collection of aubrites and potentially related meteorites, in order to reconstruct the geological history of their parent body(ies). Approximately 35 meteorites will be studied, some of which will be studied for the first time. The student will carry out the first complete in situ geochemical study of aubrites (trace elements in all phases of all samples will be studied by LA-ICPMS and SIMS). Particular attention will be paid to vitrophyre clasts (Fogel, 2005; Keil et al., 2011), very rare objects containing igneous glass. Preliminary work has led to the discovery of several vitrophyre clasts (Lacheux et al., 2024). The data will be used to test, by geochemical modeling, the equilibrium relationships between the different phases and to trace the thermodynamic conditions of these equilibria, in order to resolve the controversial origin of metal and sulfide grains in aubrites, and to evaluate the nature of their parent body, in particular its size. We will also measure the H, C and N contents of the glasses by SIMS, in order to provide constraints on the controversial volatile element contents of aubrites (Piani et al., 2020; Peterson et al., 2023). The analyses will be complemented by a textural study of the aubrites. In particular, the characterization of dendrites in glassy objects will allow the thermal history of vitrophyre clasts to be deduced, whether or not they are of volcanic origin (Keil et al. 2011). In addition, some aubrites exhibit pegmatitic textures with centimeter-sized enstatite crystals containing thousands of vesicles and inclusions of silicates/sulfides/metals whose origin is unknown (Lorenz et al., 2020; Wilbur et al., 2022). The objective will be to understand whether these inclusions form early, during the crystallization of aubrites, or later, during impact processes. Finally, aubrites are extremely brecciated meteorites that contain clasts and dust of exogeneous materials, and whose highly reduced nature makes them very sensitive to terrestrial oxidation. Oxygen isotopic compositions will be measured in situ by SIMS. All data will be integrated with literature data to construct a petrological model of aubrite formation in their parent body(ies) and to decipher the properties of the latter.

Methods: SEM-EDS, EPMA, LA-ICPMS, SIMS, Raman Spectroscopy, X-ray tomography, petrological/geochemical modeling.

References:

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