Ecole Doctorale EDSIS - Contrats doctoral 2023

Deformation microstructures in chronometric minerals (monazite, zircon) subjected to natural and laser shock loading.

Key words:

Mineralogy; Physic; Planetology; Impacts; Laser shock; Deformation; Nanoscale; Electron Microscopy; Atom Probe Tomography

Abstract:

Since their formation, the Earth and the other planets or bodies of the solar system, such as the moon or Mars in particular (see the recent images of the surface of Mars taken by the Perseverance Supercam cameras), have been subjected to a continuous bombardment of solid bodies (asteroids) from space. When these objects hit the surface of the planets they form structures called impact craters. On Earth, few impact craters are accurately dated due to the lack of geochronometers giving usable ages to link impacts and geological events (*Jourdan et al., 2012*). As a result, fundamental questions about the possible link between impact events, changes in the geosphere and biosphere, and the origin of life, all of which rely on precise acquisitions of impact conditions and times, remain debated (*Moser et al., 2019*). During an impact, rocks and minerals undergo specific transformations, which traces in the residual structures are complex to decipher, even at the nanoscale (*Fougerouse et al., 2021; Seydoux-Guillaume et al., 2022*), although they constitute key evidence for identifying impact structures (*French and Koeberl, 2010*). However, little is known about the behavior of minerals in response to such impacts. This thesis aims to provide insight into the (mineralogical and physical) behavior of 'chronometer' minerals (monazite, zircon) to simultaneously characterize (P, T) and date impact events. The objective will be to account for (1) the residual structures resulting from extremely rapid deformations under shock conditions, by combining laser shock experiments and comparison with natural samples formed under impact conditions, (2) possible disturbances of the chronometers, which may distort the measurement of time, and (3) the mechanisms at play in these shocked minerals, both experimentally and naturally. For this purpose, an approach on the nanometric scale, combining Transmission Electron Microscopy (TEM) and Tomographic Atomic Probe (TAP), will be implemented, the latter allowing access to information hidden on a less fine scale, even micrometric (*Seydoux-Guillaume et al., 2019*).

[Fougerouse et al. (2021). doi.org/10.1016/j.gca.2021.08.025. French and Koeberl (2010). doi.org/10.1016/j.eartscirev.2009.10.009. Jourdan et al. (2012). 10.2113/gselements.8.1.49. Moser et al. (2019). doi.org/10.1038/s41561-019-0380-0. Schmieder M. and Kring D. A. (2020) Astrobiology 20(1), 91–141. Seydoux-Guillaume et al. (2019). doi.org/10.1016/j.gsf.2018.09.004. Seydoux-Guillaume et al. (2022). doi.org/10.1016/j.epsl.2022.117727]

Supervision team:

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Context of the project:

This thesis follows a MiTi-CNRS project (Nanotempo) and is part of the ANR DENSE (2022-2026 - Dense structures on the nanoscale; led by R. STOIAN, LabHC) which proposes an innovative technique to create new high-density materials up to new crystal structures (hard materials, minerals).

Working environment:

The PhD student will be located at the LGL-TPE (@Saint-Etienne) but with close interactions with the Georges Friedel Laboratory (LGF) of the Ecole des Mines de Saint-Etienne (EMSE), the LabHC (Saint-Etienne) and Pprime institute (Poitiers). Equipment available locally: MEB-FEG of UJM (JEOL JSM IT800 with EDS-EBSD-CL) and EMSE (Zeiss Supra 55vp EDS-EBSD), FIB (FEI Helios 600 i, Manutech), MET of UJM (JEOL NeoARM200F Cold FEG corrected (Cs) of the latest generation, equipped with ADF/ABF, EDS detectors and an electron energy loss spectrometer (EELS) and integrated at Clym (https://www.clym.fr/fr/node/336).

Profile required:

Student with a Master 2 research degree (or engineering school) in geosciences with a strong background in mineral physics and analytical techniques (electron microscopy in particular), or in materials physics with the same analytical and experimental background and with a curiosity for the Earth and Universe sciences.

Application: Interested candidates should send a CV + a cover letter + 2 referee contacts, before **April 15, 2023** in a single pdf file by email to anne.magali.seydoux@univ-st-etienne.fr