

PHD PROPOSAL FOR THE DOCTORAL SCHOOL « Ecologie, Géosciences, Agronomie, ALimentation »

GENERAL INFORMATION

Thesis title: Hydrated silica formation conditions on Earth and Mars, and interactions with organic matter
Acronym: PALEOSILICA
Disciplinary field 1: Geosciences
Three keywords: hydrated silica, organic matter, Earth and Mars
Research unit : LPG UMR6112 et PIIM UMR7345
Name of the thesis director HDR (Habilitation thesis to supervise research) required: Benjamin Rondeau Email address of the thesis director: benjamin.rondeau@univ-nantes.fr Name of the thesis co-supervisor 1 (if applicable): Vassilissa Vinogradoff Email address of the thesis co-supervisor 1 (if applicable): vassilissa.vinogradoff@univ-amu.fr
Thesis grant (funding origin and amount): PALEOSILICA (projet ANR ANR-20-CE49-0013), 170964 €
Contact(s) (mailing address and E-mail): Sophie Huguet, LPG, 2 rue de la Houssinière, BP92208, 44322 Nantes cedex 3. sophie.huguet@univ-nantes.fr , +33(0) 2 51 12 53 15
Recruitment process: Recruitment process depends on thesis funding. To select the corresponding recruitment process, please visit the EGAAL website here . This information is needed for proposal publication. <input type="checkbox"/> Doctoral school contest <input checked="" type="checkbox"/> Interview <input type="checkbox"/> Other (indicate) :

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SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

Socio-economic and scientific context:

The re-assessment of geological conditions for alteration minerals formation is one of the research axes at Laboratoire de Planétologie et Géodynamique (LPG), a joint research unit of Nantes University, Angers University and CNRS. This axe is investigated by hyperspectral analysis on Earth and Mars, through field study, and experimental modelling in the laboratory. These works are part of spatial missions, specifically those related to Mars in which LPG is involved (Pathfinder, MarsExpress, Mars Reconnaissance Orbiter, Curiosity and Perseverance). The laboratory Physique des Interactions Ioniques et Moléculaires (PIIM), in particular the ASTRO team, a joint research unit of Aix-Marseille Université and CNRS, developed an expertise in organic matter synthesis and reactivity under interstellar and planetary conditions, its analysis using high tech chemistry techniques, and its interaction with minerals during aqueous alteration.

Assumptions and questions:

Opal is a hydrated silica mineral that forms at rather low temperature, between 0 and 200°C, and low depth, between 0 and a few kilometers, in aqueous environment. Hence it records the conditions at surface and subsurface. However, its physico-chemical formation conditions are rather poorly constrained, as well as its mechanisms of interaction with organic matter. This is even more pronounced on Mars where outcrops are much less documented. In this context, we propose this PhD program that aims to better constrain opal formation conditions and its potential for organic matter sequestration. As a consequence, this project aims to better constrain the geological conditions that prevailed on Mars.

The main steps of the thesis and scientific procedure:

- * First year: bibliographic study on hydrated silica genesis conditions on Earth and Mars, and its properties of interaction with organic matter. Theoretical and practical courses on techniques of mineral and organic matter characterization, as well as mineral synthesis. Starting of measurements on natural samples. Starting of alteration experiments in the lab.
- * Second year: characterization of organic matter, solid matter and solution resulting of alteration experiments.
- * Third year: comparison of experimental data with those observed on natural samples on both Mars and Earth. Writing of the PhD manuscript.

This program is susceptible to evolve as a function of experimental results. Results and their interpretation will be published in peer-reviewed journals of international audience and communicated in national and international congresses.

Methodological and technical approaches considered:

Dissolution processes of primary minerals will be characterized by means of mineral surface observation (AFM, VSI) and measurement of silica concentration in dissolution fluids (ICPMS). Resulting precipitates will be characterized by TEM, SEM, infrared and Raman spectroscopies. An other aspect of the work will be to characterize the co-precipitation of organic matter with amorphous silica (SEM, mass spectroscopy). Organic matter will be analyzed using GC-MS (soluble phase) and Pyrolysis-GC-MS (solid phase). Additional techniques such as XRD and elemental analysis will be used if necessary.

Scientific and technical skills required by the candidate

- * Background in Earth Sciences or organic chemistry, with a pronounced interest for experimental work and characterization techniques of organic and mineral matter.
- * Practical and technical skills in characterization techniques of organic and mineral matter are encouraged.

THESIS SUPERVISION¹

Unit name: Laboratoire de Planétologie et Géodynamique, UMR6112	Team name: Earth
Unit director name: Antoine MOCQUET	Team director name: Éric BEUCLER & Olivier BOURGEOIS
Mailing address of the unit director: dir.umr6112@univ-nantes.fr	Mailing address of the team director: eric.beucler@univ-nantes.fr, olivier.bourgeois@univ-nantes.fr
Thesis director Surname, first name: RONDEAU Benjamin Position: Professor-Assistant Obtained date of the HDR (Habilitation thesis to supervise research): June 2016 Employer: University of Nantes Doctoral school affiliation: EGAAL Rate of thesis supervision in the present project (%): 50% Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 50% Number of current thesis supervisions/co-supervisions: 1	
Thesis co-supervisor 1: Surname, first name: VINOGRADOFF Vassilissa Position: Researcher Habilitation thesis to supervise research <input type="checkbox"/> yes <input checked="" type="checkbox"/> no If yes, date diploma received: Employer: CNRS, laboratoire Physique des Interactions Ioniques et Moléculaires Doctoral school affiliation: ED Sciences chimiques 250 Rate of thesis supervision in the present project (%): 50% Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 0 Number of current thesis supervisions/co-supervisions: 0	
Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years) <i>Please provide the following information for <u>each</u> PhD students supervised</i> Surname, first name: CHAUVIRE Boris	

¹ In EGAAL Doctoral School, if only one scientist in thesis supervision = 100% of supervision rate; if 2 people involved in thesis supervision = from 50% to 70% of supervision rate for the director; if 3 people involved in thesis supervision = 40% / 30% / 30% of supervision rate distribution among supervisors.

Date of PhD beginning and PhD defence: October 2012-December 2015

Thesis supervision: Nicolas Mangold

Professional status and location: Isterre, Grenoble

Contract profile (post-doc, fixed-term, permanent): post-doc

List of publications from the thesis work:

*Chauviré B., Rondeau B., Alexandre A., Chamard-Bois S., La C., Mazzero F. (2019) Pedogenic origin of precious opals from Wegel Tena (Ethiopia): evidences from trace elements and oxygen isotope. **Applied Geochemistry**, vol. 101, pp. 127-139. DOI : 10.1016/j.apgeochem.2018.12.028*

*Chauviré B., Rondeau B., Mazzero F., Ayalew D. (2017) Precious opal deposit at Wegel Tena, Ethiopia: formation via successive pedogenesis events. **The Canadian Mineralogist**, vol. 55, pp.701-723. DOI: 10.3749/canmin.1700010*

*Chauviré B., Rondeau B., Mangold N. (2017) Near-infrared signature of opal and chalcedony as a proxy for their structure and formation conditions. **European Journal of Mineralogy**, vol. 29, pp.409-421. DOI : 10.1127/ejm/2017/0029-2614*

Surname, first name: PINEAU Maxime

Date of PhD beginning and PhD defence: September 2017-November 2020

Thesis supervision: Benjamin Rondeau

Professional status and location: LPG

Contract profile (post-doc, fixed-term, permanent): research engineer

List of publications from the thesis work:

*Pineau M., le Deit L., Chauviré B., Carter J., Rondeau B., Mangold N. (2020) Toward the geological significance of hydrated silica detected by near infrared spectroscopy on Mars based on terrestrial reference samples. **Icarus**, 137, <https://doi.org/10.1016/j.icarus.2020.113706>*

Five main recent publications of the supervisors on thesis subject:

*Pan L., Carter J., Quantin-Nataf C., Pineau M., Chauviré B., Mangold N., Le Deit L., Rondeau B., Chevrier V. (2021) Voluminous silica precipitated from martian waters during late-stage aqueous alteration. **Journal of Planetary Sciences**, accepté.*

*Chauviré B., Houadria M., Donini A., Berger B.T., Rondeau B., Kritsky G., Lhuissier P. (2020) Arthropod entombment in weathering-formed opal: new horizons for recording life in rocks. **Scientific Reports**, 10, 10575. <https://doi.org/10.1038/s41598-020-67412-9>. <https://rdcu.be/b5o7N>*

*Pineau M., le Deit L., Chauviré B., Carter J., Rondeau B., Mangold N. (2020) Toward the geological significance of hydrated silica detected by near infrared spectroscopy on Mars based on terrestrial reference samples. **Icarus**, 137, <https://doi.org/10.1016/j.icarus.2020.113706>*

*Chauviré B., Rondeau B., Alexandre A., Chamard-Bois S., La C., Mazzero F. (2019) Pedogenic origin of precious opals from Wegel Tena (Ethiopia): evidences from trace elements and oxygen isotope. **Applied Geochemistry**, vol. 101, pp. 127-139. DOI : 10.1016/j.apgeochem.2018.12.028*

Rapin W., *Chauviré B.*, Gabriel T.S.J., McAdam A.C., Ehlmann B.L., Hardgrove C., Meslin P.-Y., **Rondeau B.**, Dehouck E., Franz H.B., Mangold N., Chipera S.J., Wiens RC., Frydenvang J., Schröder S. (2018) In situ analysis of opal in Gale crater, Mars. *Journal of Geophysical Research – Planets*, vol. 123, pp. 1955-1972. DOI: 10.1029/2017JE005483

Chauviré B., **Rondeau B.**, Mazzero F., Ayalew D. (2017) Precious opal deposit at Wegel Tena, Ethiopia: formation via successive pedogenesis events. *The Canadian Mineralogist*, vol. 55, pp.701-723. DOI: 10.3749/canmin.1700010

Vinogradoff, V., Le Guillou, C., Bernard, S., Viennet, J. C., Jaber, M., & Remusat, L. (2020). Influence of phyllosilicates on the hydrothermal alteration of organic matter in asteroids: Experimental perspectives. *Geochimica et Cosmochimica Acta*, 269, 150-166.

Vinogradoff, V., Remusat, L., McLain, H. L., Aponte, J. C., Bernard, S., Danger, G., ... & Jaber, M. (2020). Impact of phyllosilicates on amino acid formation under asteroidal conditions. *ACS Earth and Space Chemistry*, 4(8), 1398-1407

THESIS FUNDING

Origin(s) of the thesis funding: PALEOSILICA, projet ANR-20-CE49-0013, 2021-2024.

Gross monthly salary: 1768.55€, awaiting information on the impact of the LPR law on the salary of doctoral students.

Thesis funding state : Acquired

Funding beginning date/Funding ending date: 1st October 2021 / 36 months

Date: 7 april 2021

Name, signature of unit director:

Antoine MOCQUET

Name, signature of team director:

Eric BEUCLER

Name, signature of thesis project director:

Benjamin RONDEAU