Proposition de thèse de doctorat

Début : 2017-2018

Titre de la thèse : Cristallisation de sels par sublimation de glace : modélisation expérimentale et applications planétologiques / Crystallization of salts by sublimation of ice: experimental modeling and applications in planetology.

Laboratoire : Laboratoire de Planétologie et Géodynamique

Equipe : Planète Terre / Mondes Glacés / Planètes Telluriques

Localisation de la thèse : Université de Nantes

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Description du sujet

Hydrated salts (such as sulfates, nitrates, chlorides, perchlorates, or carbonates) are common minerals at the surface of the Earth and there is growing evidence for their existence on several other bodies of the Solar System, such as Mars, some icy moons (Europa, Ganymede), the dwarf planet Ceres, and some comets. Because they form and remain stable under specific physical conditions, these hydrated salts have been widely used to constrain the environment of planetary surfaces. On the present-day Earth, most hydrated salts form by in-situ weathering of primary minerals or by evaporation of saline water bodies. Both processes involve chemical reactions that are generally assumed to require high water/rock ratios and temperatures above the melting point of water. By analogy, extra-terrestrial and ancient terrestrial salts have been widely interpreted as indicators of warm environments with high water-rock ratios. At the present time however, these physical conditions are seldom encountered in extra-terrestrial settings. Thus, the ubiquity of salts in the Solar System raises the question of whether these minerals can form by alternative processes, which would challenge numerous environmental interpretations proposed thus far for their formation in terrestrial and extra-terrestrial settings.

Recently, it has been suggested that hydrated salts can form also by sublimation of ice containing chemical impurities (Liu et al., 2015). This new candidate formation process implies temperatures below the melting point of water and low water vapor pressures in the atmosphere. In addition, the discovery of salts collected on a sublimation ice cliff on a terrestrial glacier suggests that they formed by sublimation as well. Crystallization through sublimation is probably of minor quantitative importance on the Earth, but may play a major role in the Solar System because many occurrences of extra-terrestrial salts described or expected thus far are located at the surface of sublimating icy bodies, where the temperature and the water vapor pressure are low.

The aim of the project is thus to assess the plausibility that hydrated salts can crystallize by sublimation of ice containing ionic impurities. For that purpose, the work will include physical, mineralogical and geochemical analyzes of the natural, terrestrial salt crystals already collected, and will aim to determine the physical conditions of their formation. In addition, laboratory experiments of salt crystallization by sublimation (experimental modeling) will be performed at the University of Bern (Switzerland), in collaboration with Antoine Pommerol. The experiments will be performed under various simulated atmospheric compositions, pressures and temperatures, and their products will be characterized with different analytical instruments: Infrared Spectroscopy, Scanning Electron Microscopy, Raman Spectroscopy, X-ray Diffraction, etc. These experiments will provide the basis for possible renewed interpretations of the environmental significance of hydrated salts on Earth and on other bodies of the Solar System.

Compétences requises

Master's degree (or equivalent) in Earth Sciences, Physics or Chemistry.
Solid knowledge in mineralogy, crystal growth; analytical and experimental skills.

Commentaires Supplémentaires

Financement prévu : contrat doctoral ministériel Indemnité : Oui
Montant mensuel envisagé : tel que prévu par le contrat doctoral ministériel (1757€ brut)