

**DESCRIPTION OF A THESIS PROJECT**  
**DOCTORAL SCHOOL “Matter, Molecules, Materials & Geosciences”**

<b>Title of the thesis:</b> Aeolian processes as morphologic agent on Pluto, a comparative study.
<b>Principal disciplinary field:</b> Planetology <b>Disciplinary field 2:</b> Geosciences
<b>Three keywords:</b> Sublimation/condensation, planetary surfaces, analogical and numerical modelling
<b>Research unit (specify if the research time is shared between several sites):</b> Laboratoire de Planétologie et Géosciences, UMR 6112
<b>Indicate if the thesis will be subjected to a labeling by one of the Graduate Programmes of Nantes University:</b> Earth and Planetary Sciences (EPS)

 **FUNDING OF THE THESIS**

<b>Origin(s) of the funding:</b> ANR SHERPAS <a href="https://web.lmd.jussieu.fr/~tbertrand/ANR_Sherpas/sherpas.html">https://web.lmd.jussieu.fr/~tbertrand/ANR_Sherpas/sherpas.html</a>
<b>Funding status:</b> acquired
<b>PhD employer:</b> Nantes Université
<b>Gross monthly salary:</b> €2100 per month
<b>Starting date:</b> 01/10/2024 <i>Funding for the thesis covers a period of 3 years starting from the date of the first registration.</i>

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## SCIENTIFIC DESCRIPTION OF THE PROJECT

### Context, objectives, methodology (1 page maximum)

It will be 10 years in 2025 since the New Horizon mission flew over Pluto, revealing surprising icy landscapes of CH<sub>4</sub> bladed terrain and plains of N<sub>2</sub>, Sputnik Planitia, at the heart of Pluto that contrasts sharply in color and appearance with Cthulhu Regio at the equator. These differences testify to the ages and processes at the origin of these highly varied terrains. Given the temperature and pressure conditions on Pluto, wind combined with sublimation could be a highly effective geomorphic agent, responsible for various bedforms such as penitents and sublimation waves. Aeolian processes on planetary surfaces are known to produce bedforms such as ripples and dunes made of loose sediment grains (e.g. sand), or rock or ice (without grain transport). On the one hand, their geometric and kinematic characteristics (e.g., shape, size, orientation, migration direction, migration velocity and growth rate) constitute geomorphic markers to constrain surface-atmosphere interactions and climate models (e.g. the dune orientation on Titan). On the other hand, from known atmospheric and surfaces conditions, scaling laws can be applied to predict aeolian bedforms characteristics for various planetary environment, assuming the processes involved are the same. While the physics behind the formation and development of loose bedforms is well understood, it is not the case for the icy bedforms for which limited quantitative information and modeling exists in the literature.

The intriguing icy bedforms observed on Pluto's N<sub>2</sub> and CH<sub>4</sub>-rich surfaces therefore constitute a new laboratory to study the processes involved. Volatile sublimation and/or condensation have been invoked to explain the CH<sub>4</sub>-rich Bladed Terrain Deposits, but the exact mechanisms remain to be modeled. Aeolian icy dunes of CH<sub>4</sub>-rich grains have been proposed for the Sputnik Planitia bedforms but the morphology of these terrains rather recalls that of "icy sublimation waves", observed on some water ice deposits on Earth and Mars. These sublimation waves, which result from an instability mechanism between the sublimation of the ice and the turbulent winds, have been modeled in 1D with the theoretical model OnDiNe, developed at LPG. This model predicts that similar waves could occur on Pluto. Condensation waves could also take place, but have not been explored or modeled yet on Mars or Pluto.

The objective of the Thesis is to understand the formation of the periodic bedforms observed on Pluto, identify the dominant mechanisms and compare to similar features elsewhere in the Solar System to analyze the universality of the processes involved. To achieve this goal, we (the PhD student and the team) will first study experimentally the influence of wind as a morphologic agent over a sublimating icy substrate in the emergence of bedforms, in order to validate scaling laws proposed for sublimation patterns on Earth and Mars. These experiments are key, because there are no extensive data on icy bedforms and therefore it remains unclear how their characteristics evolve depending on the parameters of the environment (e.g. migration velocity and characteristic time of emergence have only been observed for the case of Blue Ice Area in Antarctica). Our experiments (in a controlled environment) will fill this gap and constitute the first complete database for sublimation bedforms (experiments with condensation remain complicated to design, but we will look for solutions). Second, we will develop the analytical model OnDiNe for the formation of periodic icy bedforms. Steps of validation will be performed by using data from Antarctica and the Martian polar cap, in the continuity of previous studies at LPG. In parallel, we will map the morphology of the terrains of interests on Pluto (ridges spacing, direction, etc.), and then OnDiNe will be applied to Pluto to provide insights into the dominant processes forming the bedforms and constraints to the environmental conditions on Pluto. This will fill a comparative planetology study. Finally, we will make use of the Pluto climate models developed at LMD and LESIA by A. Falco and T. Bertrand to simulate at high spatial resolution the formation and growth of the Bladed Terrain Deposits over geological timescales.

**Scientific and technical skills required:**

- Master degree in Planetary Sciences, Geophysics or Physics/Mechanics
- Good knowledge in programming (python, matlab)
- Good knowledge in planetary sciences, geophysics, fluid dynamics
- Good level in english
- Interest in fluid dynamics,
- Interest in digital image manipulation

**Application information:**

Candidates must hold a master's degree and/or an engineering diploma with knowledge of geophysics, planetary sciences, astrophysics, fluid dynamics and/or materials physics. Experience in numerical modeling and programming is expected. Previous experience in a related subject/field will be an asset. Good oral and written communication skills in English are also required.

Applications must include a CV and covering letter, as well as the contact details of the Master 2 internship supervisor and another academic reference. Successful applicants will be interviewed. The preferred starting date for the thesis is the beginning of October 2024.

**Working environment:**

The thesis work will be carried out under the supervision of Sabrina Carpy (LPG), Gabriel Tobie (LPG) and Tanguy Bertrand (LESIA), as part of the ANR SHERPAS project, coordinated by T. Bertrand (LESIA) and in partnership with LPG and LMD. The person recruited will be attached to the Ecole doctorale 3MG (Matière, Matériaux et Géosciences) and to the Graduate Programme Earth and Planetary Sciences of Nantes Université. The candidate will work at the Laboratoire de Planétologie et Géosciences (LPG - UMR 6112), located on the UFR Sciences et Techniques campus of Nantes Université (bat. 4, 2 rue de la Houssinière, 44322 Nantes), under the supervision of the LPG Director.

The Laboratoire de Planétologie et Géosciences (LPG - UMR 6112) is a multidisciplinary research unit created in 2000 and spread over 3 sites: Nantes University, University of Angers and University of Le Mans. The LPG is a major international player in the field of Earth and Universe Sciences. The laboratory's research covers a broad spectrum of disciplines, currently divided into three themes. Its research is part of past, current and planned international space missions to the telluric and icy bodies of the solar system.

The person recruited will work mainly on the LPG's "Planets and Moons" theme, and will be required to collaborate with various teaching researchers and researchers from the LPG and partner laboratories as part of the ANR SHERPAS project. International travel is to be expected.

**Language requirements:**

- **English:**  
Good
- **French:**  
Basic

 MANAGEMENT OF THE THESIS PROJECT

*A minimum supervision percentage of 40% must be allocated to the director of the thesis. A minimum supervision percentage of 30% must be allocated to the co-directors and/or co-supervisors. For more information, please consult the internal regulation of the doctoral school.*

<p><b>Name of the home research unit:</b> Laboratoire de Planétologie et Géosciences</p>	<p><b>Name of the research team:</b> Planètes &amp; Lunes</p>
<p><b>Name of the research unit director:</b> Benoit Langlais</p>	
<p><b>Director of the thesis</b>          Name, first name: Tobie, Gabriel          Function: Directeur de recherche au CNRS          Date of obtaining HDR*: 2018          Research unit: UMR6112          Supervision percentage in the project: 40%          Number of current directions, co-directions and co-supervisions: 1          Current total thesis supervisions percentage (directions, co-directions and co-supervisions): 50%          *HDR = French Ability to Supervise a PhD</p>	
<p><b>Co-director (if applicable)</b>          Function:          Date of obtaining HDR:          Research unit (or private company):          Supervision percentage in the project:          Number of current directions, co-directions and co-supervisions:          Current total thesis supervisions percentage (directions, co-directions and co-supervisions):</p>	
<p><b>Co-supervisor 1 (if applicable)</b>          Name, first name: Carpy, Sabrina          Function: Maitresse de conférence          HDR holder: no          Research unit (or private company): UMR 6112          Supervision percentage in the project: 30%          Number of current directions, co-directions and co-supervisions: 1 (ending in july 2024)          Current total thesis supervisions percentage (directions, co-directions and co-supervisions):30%</p>	

**Co-supervisor 2**

Name, first name: Bertrand, Tanguy

Function: Astronomer

HDR holder: no

Research unit and location (or private company): LESIA

Supervision percentage in the project: 30%

Number of current directions, co-directions and co-supervisions in belonging ED: 0

Current total thesis supervisions percentage (directions, co-directions and co-supervisions):30%