The Power of Comparative Planetology to Decipher the Mechanics of Surface Processes and Their Records

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Landforms, shaped by interactions between environmental fluids and geologic surfaces, encode information about hydrology, climate, and the overall environment that may be preserved over geologic timescales. Thus, understanding the mechanics of geomorphic and sedimentary processes that shape the landscapes of planets is key to deciphering their respective paleoenvironmental records. To date, the majority of mechanistic models for surface processes were derived from observations of modern Earth, where life thrives, and from scaled-down experiments. Numerical models help to probe wider parameter spaces than can be achieved on our planet, but they only contain the physical rules that they were designed to honor in the first place. However, the foreign parameter spaces spanned by other planets may lead to phenomena that we do not realize need to be included in our models – the unknown unknowns. Even Earth would have looked alien to any of us before the advent of macroscopic life, with a different atmospheric composition and different surface sedimentary dynamics for example. As a result, the applicability of existing models for surface processes is often limited to those systems that most closely resemble modern terrestrial conditions, impeding our ability to reliably decipher the environmental records of other planets and the early Earth. Flipping this paradigm, planetary bodies in our Solar System (and beyond) span a range of sizes, environments, and compositions that allow us to approach comparative planetology as a fullscale experiment, where other bodies offer a unique opportunity to develop more robust models and expand their applicability. Knowledge gained from the exploration of other planets not only contributes to our fundamental understanding of surface processes, but at times can feed back into our understanding of the Earth. In this lecture, I will illustrate how a dialogue between the Earth and planetary sciences can increase our ability to interpret the landscapes and rocks of the Solar System with three examples – the formation of large eolian ripples under the thin Martian atmosphere, the dynamics and record of unvegetated meandering rivers on the early Earth and Mars, and the alien organic sediment cycle of Saturn's moon, Titan.

Biography: Dr. Lapôtre is an Assistant Professor in Earth & Planetary Sciences at Stanford University. His research focuses on the physics behind sedimentary and geomorphic processes that shape planetary surfaces (including Earth's). Using a variety of approaches such as field and laboratory studies, in situ and remote sensing data analysis, and analog experiments and numerical modeling, his research aims to unravel what landforms and rocks tell us about past hydrology, climate, and habitability. He earned a BS in Geophysics, an MS in Environmental Science & Engineering, and an MS in Geophysical Engineering from the University of Strasbourg, France, and an MS in Planetary Science, and PhD in Geology from the California Institute of Technology. During his PhD, he was part of the team that operated NASA's Curiosity rover on Mars. Before joining Stanford in 2019, he was a John Harvard Distinguished Science Fellow at

Harvard University. He was the 2021 recipient of the American Geophysical Union Luna B. Leopold Early Career Award.