From orbit to outcrop: using hands-on analogue rocks to augment planetary science education

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In planetary science we study a myriad of internal and external geological processes that are shaping the planets and moons inside the solar system. Thanks to the remote exploration by satellites we can reconstruct the geologic, climatic and possibly biologic past of these planetary bodies. Key focal points targeted by the Dutch community are planetary evolution and past and present-day habitability. Herein too, lies an important challenge for our education approach for engineering students. Their curricula are well-aligned to offer training in solving the engineering challenges of space flight and operations of spacecraft. While our students are not trained as geologists, these future space engineers and planetary scientists would benefit from developing sound geological concepts at higher learning levels that help them understand the science drivers for instruments and their potential and limitations on space missions. We believe that the development of such concepts can be supported by an 'analogue approach', which involves using materials from Earth that resemble those observed on other planetary bodies [1]. It offers learners an unparalleled opportunity to augment their textbook knowledge with first-hand, real-world observations of materials that drive scientific questions and design requirements for planetary missions.

Rock collections for teaching in the field of geoscience are often compiled and expanded over decades by the involved teaching staff. This means that existing geological collections are not aligned *a priori* to the educational needs in planetary science teaching. Afterall, collections with a relevant scope for planetary science will be strongly dependent on outcomes of past and present planetary missions.

Here we report on the development of the Planetary Analogue Rock Collection (PARC) and the first outcomes of using PARC in teaching activities. We have recently started involving hands-on materials and to study how these can contribute to a better understanding of numerical approaches and in-situ measuring strategies by space missions. Based on our initial activities and evaluations for the courses '*Physics of Planetary Interiors*' and '*Measurement Strategies for Planetary Science Missions*', we found that the assimilation of theoretical knowledge on rocks and minerals benefits from relevant examples and the use of hands-on materials. In the next steps of the project we not only aim to refine and improve our educational formats, but we will also create 'digital twins' (3D models) of selected rock examples. Aligned to this new trend [2-4] it allows us to assess the effectiveness of hands-on vs. blended-learning activities in the learning process. At the same time, we can make the collection more broadly accessible to the planetary science community at large.

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