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Larvikite as a Lunar Analogue: Combining Raman Spectroscopy and XRF for In Situ Mineralogy Investigations

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It is clear that a number of planned future lunar exploration missions will require rapid and reliable *in situ* characterisation of geological materials to support scientific investigations and potential *in situ* resource utilisation (ISRU) activities, particularly the identification of oxygen-bearing silicates and Fe–Ti-rich mineral phases.¹ In this context, a number of analogue field campaigns and portable analytical instrument development programmes are focused on simulating the operational constraints expected during planetary surface exploration.² Among the techniques considered for future handheld instrumentation, Raman spectroscopy and X-ray fluorescence (XRF) are highly complementary: Raman spectroscopy provides molecular and crystallographic information for mineral phase identification, whereas XRF constrains elemental composition and spatial distributions, particularly for major and minor elements such as Fe, Ti, Ca, Mg, Al, Na, and K. The combined use of both techniques therefore improves the interpretation of complex geological materials compared with single-technique approaches.³ The optimum acquisition of such combined compositional information requires detailed investigation and planning, and the results of several such studies are presented here.

In this study, a larvikite section from Norway was investigated using combined Raman spectroscopy and XRF analysis to evaluate multimodal spectroscopic approaches for planetary analogue characterisation within the PANGAEA framework. Larvikite is a feldspar-rich intrusive igneous rock widely recognised as a terrestrial analogue for lunar rocks. Its composition presents similarities with both anorthositic highland rocks and basaltic materials observed on the Moon. Larvikite is dominated by ternary feldspars associated with mafic and accessory minerals including titanite, magnetite, ilmenite, amphibole, apatite, zircon, and locally olivine, several of which are directly relevant to lunar exploration.⁴ Raman spectroscopy enabled the identification of major silicate phases despite the complexity of perthitic feldspar intergrowths, while XRF constrained associated elemental compositions and spatial distributions. The combined approach highlights the potential of coupled Raman–XRF analyses for the rapid and non-destructive characterisation of complex planetary analogue materials, with the help of unsupervised multivariate data treatment.

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References

1. M. Smith, D. Craig, N. Herrmann, et al., in *IEEE Aerospace Conference Proceedings*, **2020** (March).
2. F. Sauro, S.J. Payler, M. Massironi, et al., *Acta Astronautica*, **2023**, 204, 222.
3. A. Moral, C. Pérez, L. Seoane, et al., *Journal of Raman Spectroscopy*, **2025**, 11, 1368.
4. P. Buelens, V. Debaille, S. Decrée, N. Coint, E. Mansur, *Lithos*, **2024**, 484, 107743.