
Raman spectroscopy as a tool for discrimination of sulfates in exobiology: In-situ and laboratory studies

Filip Košek^{*1}, Adam Culka¹, and Jan Jehlička¹

¹Institute of Geochemistry, Mineralogy and Mineral Resources, Faculty of Science, Charles University – Albertov 6, 128 00 Prague, Czech Republic

Abstract

Various anhydrous, monohydrated and polyhydrated sulfates are widespread secondary or evaporite minerals on Earth. Furthermore, sulfate deposits have been detected in many Martian regions [1], and there are speculations about the presence of certain sulfates on the icy surface of moon Europa [2]. Sulfates are often considered as evidence of liquid water since water-containing ones require aqueous conditions to form. They also play an important role as indicators of past and present geochemical conditions not only on Earth but also on Mars. The study of the composition of sulfates, or mere identification of specific phases, can help to estimate if conditions can be favorable or unfavorable for life. Therefore, the need for progressive methods of detection has arisen.

Raman spectroscopy has been already proposed as an analytical technique for near-future exploration missions targeting Mars (ExoMars, Mars 2020) due to the advantages and relative simplicity of this method. Sulfates, due to their crystal structure, usually provides distinctive Raman spectra across various structural types and chemical compositions. Furthermore, Raman spectroscopy is sensitive to the change in the water content, allowing discrimination of actual hydration states within certain sulfate groups (e.g. Fe-, Mg-, or Al-sulfates) [3].

In our research, we take advantage of Raman spectroscopy, both in laboratory and on-site, to identify and characterize sulfates that form in various environments, especially in sulfide-weathering areas (e.g. melanterite, copiapite, or jarosite) and at burning coal heaps (e.g. alunogen, godovikovite, or sabieite). The latter also represents an example of a high-temperature environment similar to fumaroles on volcanoes (itself considered as a promising exobiological analog) and provides a unique opportunity to study changes in hydration states of sulfates directly in the field. Presented results show advantages of deployment of miniature hand-held Raman instruments and benchtop Raman microscopes, as well as their comparison, for the characterization of sulfates from real geological settings. In general, sulfate phases are detectable by Raman spectroscopy under unfavorable in-situ conditions even using miniaturized Raman instruments although specific challenges may arise, especially when analyzing complex mineral aggregates.

References

Carter, J., Poulet, F., Bibring, J. P., Mangold, N., and Murchie, S. (2013) Hydrous minerals on Mars as seen by the CRISM and OMEGA imaging spectrometers: Updated global view. *J. Geophys. Res.-Planet* 118: 831-858.

^{*}Speaker

Shirley, J. H., Dalton III, J. B., Prockter, L. M., and Kamp, L. W. (2010) Europa's ridged plains and smooth low albedo plains: Distinctive compositions and compositional gradients at the leading side–trailing side boundary. *Icarus* 210: 358-384.

Košek, F., Culka, A., and Jehlička, J. (2018) Raman spectroscopic study of six synthetic anhydrous sulfates relevant to the mineralogy of fumaroles. *J. Raman Spectrosc.* 49: 1205-1216.