Confocal Raman Imaging in Geosciences

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Description of geological materials may require detailed knowledge of their compositional properties on the nanometer scale, leading to a growing demand for analytical methods that provide information in addition to techniques routinely applied in geosciences. Confocal Raman microscopy provides insights regarding chemical variation and distribution, structural information, or material stress at high spatial resolution without inflicting damage or using invasive techniques such as staining. This technique is a tool that provides information complimentary to data obtained by electron microprobe (EMP), energy dispersive X-ray analysis (EDX), or secondary ion mass spectrometry (SIMS). In addition to the quantitative and semi-quantitative elemental and/or isotopic data acquired by these techniques, confocal Raman microscopy contributes to the visualization of spatial molecular information over a defined sample area. Furthermore, considering that most geo-materials are transparent from the NUV to the VIS and NIR to some degree, this information can be obtained threedimensionally due to the confocal set-up of the microscopes.

The power of Raman imaging stems from the highly detailed chemical information revealed by molecular vibrational spectra. Due to Raman spectroscopy being an inelastic light scattering process, acquisition of Raman spectra may be the time-limiting factor in Raman imaging. By combining an ultrahigh throughput confocal microscope with an extremely sensitive spectroscopy system, the integration time for the acquisition of Raman spectra can be reduced to few milliseconds. This short integration time enables the acquisition of arrays of thousands of complete Raman spectra within minutes. In addition, the confocal setup reduces unwanted background signals, enhances contrast and provides depth information for translucent materials. The images are evaluated from the two dimensional array of the collected Raman spectra by isolating spectral characteristics such as peak intensity, width, position, etc. Differences in chemical composition can be analyzed with a resolution down to ~200 nm.

This contribution aims to outline the key features required for confocal Raman microscopy and demonstrate the capabilities with examples from a variety of geological samples.