Raman spectroscopic identification of evaporitic minerals and biomarkers using miniaturised portable devices

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Raman spectroscopy for exobiological applications

It is advocated that in the frame of forthcoming probes planned within future exobiological missions on Mars, Raman spectroscopy will play an important role. It is planned to use this non-destructive tool to identify both minerals and potential organic compounds – possible biomarkers of preexisting life. In this work, minerals from four groups (halides, sulphates, carbonates and borates), examples of pigments known from bacteria, as well as selected osmotic biochemicals (betaine, ectoine), were investigated to estimate the potential of miniaturised spectrometers to work under complex Earth conditions to detect these compounds. Raman spectra were obtained outdoors using a portable Raman spectrometer (DeltaNu, Inspector Raman, excitation 785 nm). Collection specimens and reference compounds were investigated, as well as white evaporitic crusts from two dry evaporitic lakes (Bristol Lake, Owens Lake, California, U.S.A.) and saltern evaporation ponds (Eilat, Israel).

Results

Generally speaking, excellent identificaton of minerals and associated biomaterials through their Raman band positions was achieved on mineralogical specimens from collections. Good results were obtained using the portable spectrometer outdoors on native white evaporitic crusts under ambient atmospheric conditions. Shielding of the measurement area against insolation was nevertheless necessary. Although the recording of weaker Raman features was sometimes problematic, this did not compromise the precise identification of the mineral concerned. Raman spectra of investigated pigments and halophile osmotic compounds obtained permit their reliable identification as well.

Chalcophile element systematics in the North West Lau backarc basin

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The Lau Backarc Basin hosts numerous individual spreading centers, including the 70 km-long Northwest Lau Spreading Center (NWLSC) located ~500km west of the northern Tonga Arc volcanic front. Submarine volcanic glasses with from 9 to 2 wt.% MgO (49-62 wt.% SiO_2) were recovered from the NWLSC. These samples show no evidence of a subducted slab component. There is no indication of S loss by degassing. Fractional crystallization of olivine and clinopyroxene drives the liquid to high FeO* with decreasing MgO until the appearance of magnetite on the liquidus at ~4 wt.% MgO. S parallels FeO* but the S levels are initially below those of sulfide-saturated MORB, indicating undersaturation in sulfide. Consequently Cu, Se and Ag also initially increase with decreasing MgO. The apogee in Cu, Ag and Se contents, attributable to sulfide saturation, is at ~5.5 wt% MgO, notably earlier than the maximum in FeO* and S. Because S simply tracks FeO* at sulfide saturation, the Cu-Ag-Se trend reveals the onset of sulfide saturation better than S itself. The behaviour of Cu, Se and Ag in the basaltic to andesitic suite from the NWLSC is intermediate between MORB and oxidised backarc basin magmas; it contrasts with that from the Pual Ridge back arc basin by reaching sulfide saturation prior to the onset of magnetite fractionation. Therefore, chalcophile elements in the NWLSC are removed by continuous pyrrhotite fractionation whereas the more oxidised Pual Ridge magma fractionates to very high chalcophile element abundances before massive precipitation of Cu-Ag (and Au) sulfide at the magnetite crisis.

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