Application of Raman spectroscopy for understanding the mineralogical composition of ancient copper slags (Timna, Israel)

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Prehistoric slags (Late Bronze Age to early Iron Age, ca. 1300 – 1000 BC) from copper metallurgy were sampled at the archaeological site no.2 in Timna, Israel. A classical combination of analytical methods for this kind of samples (optical and scanning electron microscopy, X-ray diffraction analysis, and electron microprobe analysis) was complemented with Raman microspectroscopy. Raman microspectroscopy is a strong tool for phase or mineral identification in general, and when coupled with the methods for determination of the chemical composition such as electron probe microanalysis, it provides a comprehensive phase description of the sample. Slags are generally composed of both crystalline and amorphous glass-like phases and include metals, intermetallic compounds and alloys, sulfides, oxides, silicates, silicate glasses and carbonaceous fuel residues. With the exception of pure metals and their respective alloys, all these phases can be theoretically analyzed using Raman microspectroscopy. However, laser-induced fluorescence can become a major issue, owing to a presence of many different metallic elements. Selection of appropriate laser excitation wavelength can reduce the amount of fluorescence. Using Raman microspectroscopy it was possible to identify major silicate phases such as olivine (fayalite) and clinopyroxene (hedenbergite). Using this technique the crystallinity of iron oxides was identified and magnetite and hematite were differentiated. Despite the fact that Cu sulphides have simple Raman spectra with only few diagnostic bands, digenite and chalcopyrite were confirmed in the Timna slags. This study was supported by the Czech Science Foundation project (GAČR 19-18513S). The sampling campaign was carried out in the framework of Erasmus+ Mobility exchange programme between Charles University, Prague, Czech Republic (CUNI) and Hebrew University in Jerusalem, Israel (HUJI).