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# Destructive versus non-destructive methods for geochemical analyses of ceramic artifacts: comparison of portable XRF and ICP-MS data on Bronze Age ceramics from Failaka Island (Kuwait) and Bahrain

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The study of bi-phase (i.e. matrix and clasts) geochemical composition of ceramic artifacts is a very powerful tool in fingerprinting the raw materials used by ancient manufacturers (clay sources, tempering materials, coloring agents, etc.), as well as in understanding the physical parameters of the manufacturing techniques. Reliable datasets often require the deployment of destructive techniques that will irremediably damage the artifact. Recent advances in portable X-ray fluorescence instrumentation (pXRF) allow for quick measurements of a range of chemical elements that not too long ago were available only through complicated and often destructive means of analytical chemistry (instrumental neutron activation analysis – INAA, inductively coupled plasma mass spectrometry – ICP-MS, direct coupled plasma-optical emission spectroscopy – DCP-OES etc.).

In this contribution we present a comparison of datasets acquired by means of pXRF, DCP-OES, and ICP-MS on Bronze Age ceramics from Failaka Island (Kuwait) and Bahrain. The samples chosen for this study are fine grained, with very well sorted mineral components, and lack any visible organic material fragments. The sample preparation for ICP-MS and DCP-OES analyses was carried out on powdered samples, by using $LiBO_2$ flux fusion and Ge (for the DCP-OES) and In (for ICP-MS) were used as internal standards. The measurements were calibrated against certified reference materials ranging from shales to rhyolites (SGR-1, SDo-1, JA-2, and JR-1) and performed at Univerity of South Florida's Center for Geochemical Analyses. The analytical errors for major elements was smaller than 5 %, while for selected trace elements the error was usually smaller than 3 %. The same set of elements was measured on the same samples at University of South Florida's Anthropology Department using a pXRF device equipped with obsidian filter. Each sample was measured three times and the values were averaged. Two certified reference materials (NIST-612 glass and MACS-3 pressed powder) were also measured to check for accuracy and precision.

Our preliminary data shows that most of the major and trace elemental data acquired by both methods are consistent. Some transition metals (e.g. Y, Fe, and Mn) yielded overall lower values when measured with pXRF device (ranging from 27 to 60 % difference), while Ni and Ba showed systematically higher values (20 to 53 %). If samples are chosen properly for pXRF measurements (i.e. thoroughly cleaned, fine grained, well sorted) and the device is properly calibrated, the results are comparable with DCP-OES and ICP-MS data, thus being suitable to use for geochemical fingerprinting