

NON-DESTRUCTIVE CHARACTERIZATION OF PALLASITES BY MICRO X-RAY FLUORESCENCE ANALYSIS.

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Introduction: Pallasite meteorites are stony-iron meteorites that predominantly consist of large, rounded to angular, forsteritic olivine grains embedded in a matrix of FeNi metal [1–3]. Pallasites provide rare insights into dunitic mantles of differentiated planetary bodies of the early solar system. However, the enigmatic juxtaposition of olivine in FeNi metal matrix has resulted in a still ongoing debate about whether they represent the core–mantle boundaries of differentiated planetesimals (e.g., [4]), are the result of a catastrophic impact that formed a ‘pallasite planetesimal’ (e.g., [5]), or whether they sample the shallow mantle of a planetesimal that suffered from non-catastrophic impact and injection of impactor-derived FeNi metal (e.g., [6,7]). Many pallasites such as Brenham, Brahin, Esquel, Imilac, Sericho, or Seymchan are large stones of hundreds of kilograms that provide substantial sample surfaces to be studied. The substantial sample size as well as the large grain size of typical olivine crystals, of kamacite and taenite domains of the matrix, and of volumetrically less abundant phases such as sulfides or chromites make pallasites ideally suited to test the potential of micro X-ray fluorescence (μXRF) analysis for correlated studies of large-scale textures and chemical compositions (cf. [8]).

Micro X-ray fluorescence: μXRF analysis combines the advantages of conventional XRF analysis typically used to determine bulk compositions with the advantages of energy dispersive X-ray spectroscopy performed in scanning electron microscopy to determine chemical compositions of individual phases. State-of-the-art μXRF spectrometers can focus a high-energy X-ray beam to spot sizes of about 20 μm via a polycapillary lens, which allows non-destructive, spatially resolved, quantitative analysis of major, minor, and trace elements of atomic number ≥6 (carbon) from solids, powders, or liquids at tens of micrometers spatial resolution. Typical detection limits of μXRF are between 10 and 100 μg/g for most elements of interest in standard-free quantification based on a fundamental-parameter approach, but they may be lowered to <10 μg/g if suitable reference materials are used for a type calibration (e.g., [9]).

Non-destructive characterization of pallasites by μXRF: As part of an ongoing project that tests the potential of μXRF analysis for non-destructive characterization, classification, and geochemical–mineralogical investigation of various meteorite types, we characterize pallasites in the meteorite collections of Museum für Naturkunde Berlin and Mineralogische Staatssammlung München by μXRF analysis using a Bruker M4 TORNADO PLUS μXRF spectrometer. To this end, we obtain element distribution maps over large sample areas (often >100 cm²) as shown in Fig. 1. We then obtain mode and compositions of individual phases, and possibly bulk chemical compositions, from the element distribution maps. Compositions of individual phases are furthermore obtained by μXRF spot measurements, from which also quantitative diffusion profiles spanning tens of millimeters in length can be obtained. To test accuracy and reproducibility of the obtained data and to establish typical detection limits of the method, we compare standard-free quantification against a type-calibrated μXRF quantification routine based on suitable reference materials (e.g., Springwater and San Carlos olivine; FeNi metal alloys; sulfides etc.). The different data acquisition approaches will be compared against results from independent techniques such as electron microprobe analysis or (laser-ablation) inductively coupled plasma mass spectrometry.

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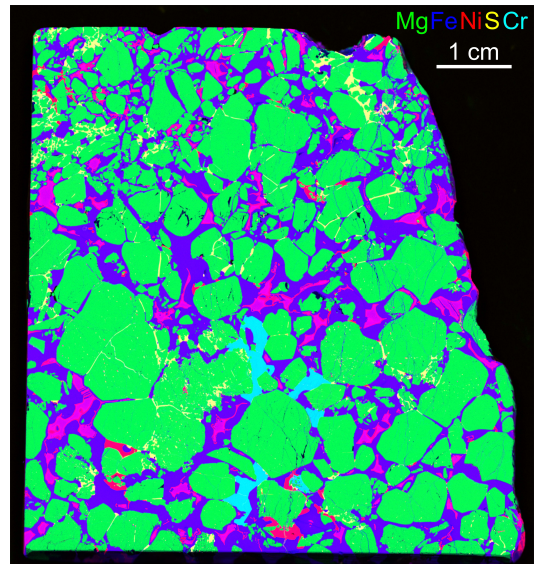


Fig. 1 μXRF element distribution map with 20 μm pixel resolution obtained from a slab of the Seymchan main-group pallasite.