CLASSIFICATION OF CHONDRITIC METEORITES USING MICRO-XRF SPECTROSCOPY

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Micro-XRF Spectroscopy: The M4 Tornado micro-XRF is an energy dispersive X-ray spectrometer developed by Bruker Instruments. Unlike traditional XRF spectrometers, which are used primarily to analyze bulk material, the M4 Tornado is designed specifically for the analysis of small sample areas. It has the same capabilities of a scanning electron microscope/ energy-dispersive spectrometer (SEM/EDS), such as point analysis, line scan, and area analysis, but is a stand-alone, desktop instrument. The M4 Tornado uses a silicon-drift detector to identify elements with an atomic number ≥ 11 (Na and heavier), making it well-suited for geological materials. The M4 Tornado uses XFlash silicon drift detector technology, which allows for rapid collection of data. Elemental distribution can be obtained with an acquisition of < 1 ms per pixel. The X-ray optics provides a ~25 µm diameter spot size, thought this can be improved, particularly in flat samples, using an oversampling strategy [1]. While flat samples allow for a somewhat better resolution, the M4 Tornado can also analyze rough surfaces. Samples up to 190 x 160 mm can be completely mapped, though larger samples can be accommodated in the vacuum chamber. No sample preparation is necessary prior to analysis, and the technique is non-destructive. The speed, resolution, and non-destructive nature of micro-XRF spectroscopy suggest that it may prove to be a valid technique for classification of meteorites.

Application to Chondrite Classification: Classification of chondritic meteorites is based on abundances of components (e.g., chondrules, CAIs, matrix, and metal), mineral chemistries (primarily of olivine and pyroxene), and petrologic type [2]. Petrologic type can often be determined through visual examination of texture [3]; however, abundances of components and mineral chemistries must be measured. Abundances are typically determined using image-analyzing software, such as Adobe or ImageJ, while electron microprobe phase analysis (EMPA) is almost exclusively used to determine mineral chemistries. The micro-XRF instrument is capable of measuring both phase abundances and mineral chemistries. Standardless quantitative analysis is accomplished using a fundamental parameter based analysis (FP), while phases are quantified by binning pixels with similar elemental intensities.

In this study, we examine the potential of micro-XRF spectroscopy as a new tool in chondrite classification. We have acquired thin sections of five L and LL ordinary chondrites whose bulk compositions [4], modal abundances [5,6], and mineral chemistries [6] have been measured in previous studies. We will compare these data to XRF-measured compositions, abundances, and chemistries in order to test the use of the micro-XRF instrument in chondrite classification.

References: [1] Wiedenbeck M. 2014. *Elements* 10:5-6. [2] Van Schmus W.R. and Wood J.A. 1967. *Geochimica Cosmochemica Acta* 31:747-765. [3] Huss G.R. et al. 2006. In *MESS II* 567-586. [4] Jarosewich E. 1990 *Meteoritics* 25:323-337. [5] Gastineau-Lyons H.K. et al. 2002. *Meteoritics and Planetary Science* 37:75-89. [6] Dunn T.L. et al. 2010 *Meteoritics and Planetary Science* 45:123-134.