Elemental Comparison between Sutter's Mill and Murchison

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We have used synchrotron-induced x-ray fluorescence (S-XRF) to make a model independent comparison of a Murchison fragment to Sutter's Mill 51, showing that for 34 major and trace elements, the two samples are statistically equivalent, with SM51/MUR = 1.05 ± 0.06.

In April, 2012, UC Davis participated in a consortium study to analyze meteorite fragment Sutter's Mill 51 (SM51)[1]. A fragment of the Murchison meteorite was provided for comparison and quality assurance goals[2]. They were both analyzed S-XRF[3] using 38 keV mono-energetic polarized x-rays of our x-ray 0.5 mm milli-probe at beam line 2.2 of the Stanford Synchrotron Radiation Lightsource (SSRL), SLAC. This method is fully non-destructive, requires no sample preparation beyond cleaning, is fast (a few hours for all 11 SM51/Murchison analyses), and can handle samples of large size. The same Sutter's Mill fragment was also analyzed by standard XRF at Lawrence Livermore NL (LLNL) and by High Resolution Inductively Couple Plasma- Mass Spectroscopy (HR ICP/MS) at UC Davis. The x-ray spectra were examined for elements from silicon to barium, and then tantalum through uranium. Of the 52 elements examined, 34 had statistically sound results.

In order to establish quality assurance, a comparison was made of 9 major elements and the 10 least prevalent trace elements seen by both S-XRF and HR ICP-MS. The standard deviation of the ratio for the 9 major elements, S-XRF to LLNL XRF, was 0.11, and for S-XRF to HR ICP/MS, 0.022. For the 10 least prevalent trace elements, ranging from Ta (0.02 ppm) through In, Tl, Ce, Sb, Pd, Te, Pb, Y to Sr (10.8 ppm), XRF lacked sensitivity, but the standard deviation of the ratios of S-XRF to HR ICP-MS was 0.051.

Using this technique, the comparison between the Murchison fragments with SM 51 is striking, with a ratio of 1.05 ± 0.06 for 34 elements ranging in concentrations between 22% (Fe) and 20 ppb (Ta). In summary, the results showed that the Sutter's Mill meteorite was statistically identical to a Murchison fragment.

[1] Jenniskens *et al Science* **338,** 1583 (2012), [2] P. G. Brown *et al Science* **290,** 320 (2000), [3] S.R. Barberie *et al Nucl. Instrum. Meth. Phys. Res. A*: **729,** 930 (2013).