AN XRF STUDY OF METEORITES. K.C. Daviau[1,2], R.G. Mayne[1], and A.J. Ehlmann[1]. [1] Department of Geology, TCU Box 298830, Texas Christian University, Fort Worth, TX 76109, [2] Department of Physics, Bard College, P.O. Box 5000, Annandale-on-Hudson, NY 12504-5000

Introduction: Meteorites from the Oscar E. Monnig collection at TCU were scanned with a Bruker Tracer-III SD XRF machine in order to begin creating a library of XRF spectra for different groups of meteorites. The Monnig collection contains over 1700 different meteorites hailing from nearly all of the classification groups known today. Over a ten week period this study examined 122 chondritic and achondritic samples, looking at the x-ray spectra for a total of eight groups. Table 1 shows which groups were studied along with the number of samples from each examined.

Procedure: The Bruker Tracer-III SD XRF was run at a voltage of 40.00 and a current of 3.00 amps. No vacuum was used. Each sample was placed on the machine, which remained in a stationary upright position, and scanned for a 60 second interval.

Most selected meteorites had at least one smooth, flat surface, preferably polished. When such polished surfaces were not available, the flattest, most even surface on the sample was used. Since rough surfaces can affect the results of an XRF study we were careful not to scan such faces, as we wanted all of our spectra to be directly comparable.

Each meteorite was scanned a minimum of five times. After each scan the position of the sample was altered in order to achieve an representative analysis of the entire surface. The raw spectra were then transferred to the accompanying software, ARTAX 7. Using ARTAX 7, the area under the peak was calculated. These areas were averaged to find one value per element per sample.

Results: The elements identified by the XRF which appear to be most useful in distinguishing meteorite groups are manganese (Mn), silicon (Si), and magnesium (Mg) (Figure 1). Within the chondritic meteorites iron (Fe) also differed noticeably between groups. For the achondrites, titanium (Ti), calcium (Ca) and aluminum (Al) varied as well.

The XRF was also able to recognize a-typical meteorites which were not obvious by usual examination. For instance, two Diogenites, NWA 1648 and NWA 2824, consistently plotted with the Eucrites, no matter which elements were considered. These mete-
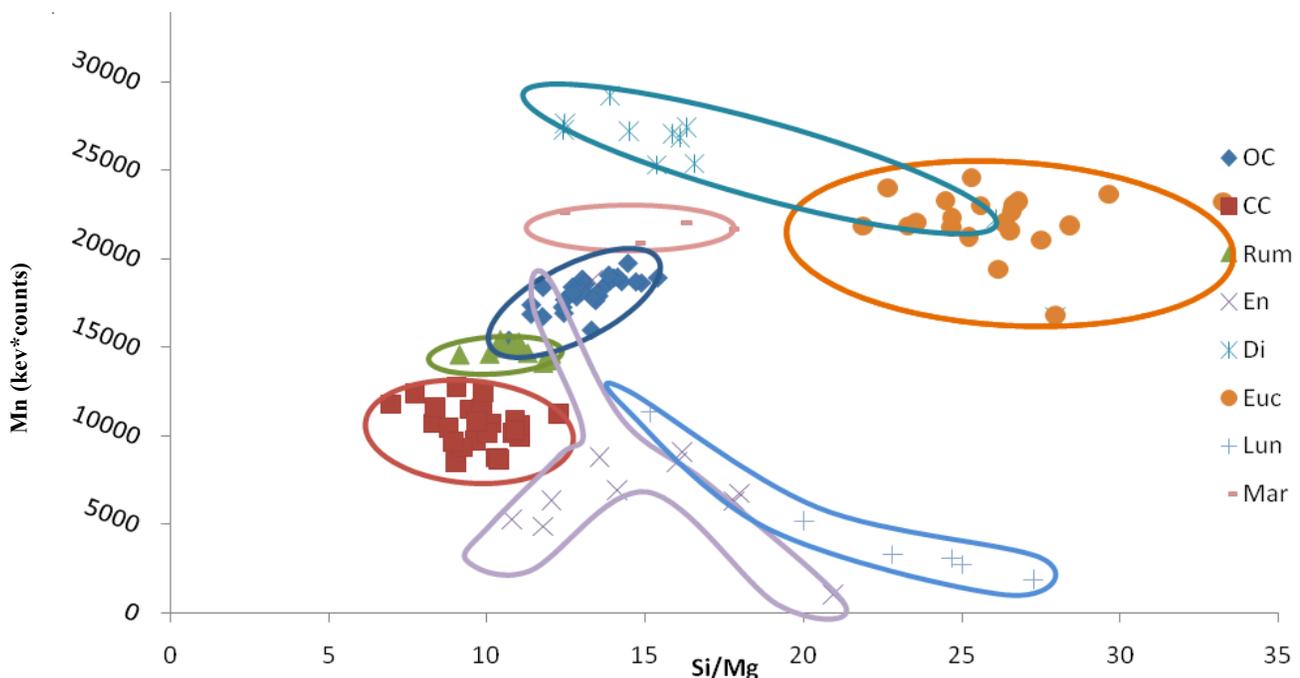
Figure 1. A graph of Si/Mg vs Mn for each group of meteorites examined
Key: OC=ordinary chondrite, CC=carbonaceous chondrite, Rum=rumurutiite,
En=enstatite chondrite, Di=diogenite, Euc=eucrite, Lun=lunar, Mar=martian

orites were investigated further and it was found that NWA 1648 is a polymict breccia containing several cumulate eucrite and basaltic eucrite clasts [1]. NWA 2824 is also unique in that it is described as being a "Eucrite-like sample" [2]. The first of the two graphs in Figure 2 demonstrates the eucrite-like characteristics
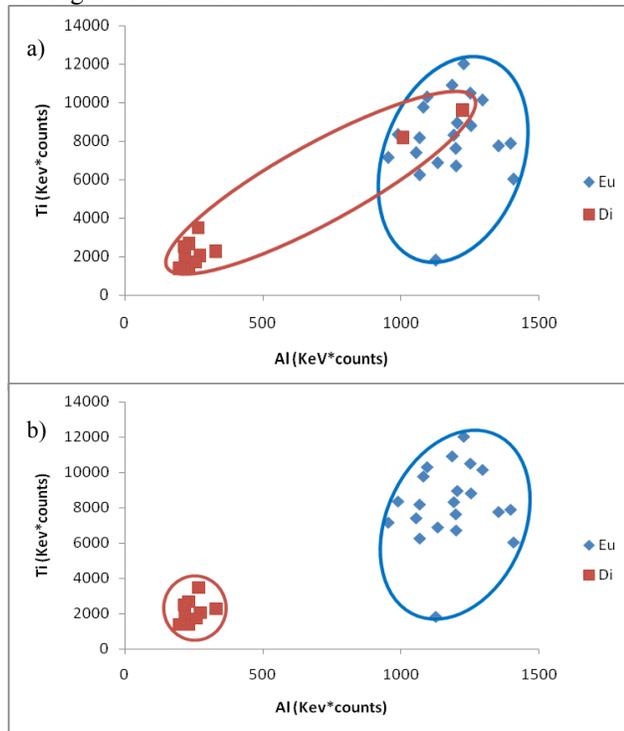
Figure 2. Plots of Al vs Ti for Eucrites (blue) and Diogenites (red). a) when NWA 1648 and NWA 2824 are included and b) when the two abnormal diogenites are left out.

that the XRF identified in these two samples. The second graph shows how distinct the eucrite and diogenite groups are when NWA 1648 and NWA 2824 are not considered.

Final Thoughts: The XRF has already proven useful to the field of meteoritics and has the potential to continue doing so. It has been used frequently at TCU to identify meteorites from "meteorwrongs".

An XRF library of meteorites could take this tentative identification process a step further. Depending on the spectra of the rock it may be possible to not only determine whether it is a meteorite but to also give some idea of what group it may belong to. Although it cannot take the place of the more sophisticated, in depth analysis, the XRF may be a quick and simple way to see roughly what type of meteorite you are looking at.

In a related study, iron meteorites were also examined with the XRF in order to see if the height of the nickel (Ni) peak in the spectra corresponds to the percentage of nickel in the sample. A clear, linear trend line has been found establishing a solid relationship between these two values [3].

As was seen with NWA 1648 and NWA 2824, the XRF can also reveal unusual qualities in rocks. For instance, the controversial rock Lavina has been examined with the XRF and, based on the trend line from the iron study, the resulting spectra support the hypothesis that this is not a meteorite [4].

References:
[1] Meteoritical Bulletin Database: http://www.lpi.usra.edu/meteor/metbull.php [2] Bunch, T.E, et. al. (2009) *Meteoritics & Planet. Sci., 44,* A45 [3] Mayne R.G. et al. (2011)) *Meteoritics & Planet. Sci., 46,* A150 [4] Nishiizumi K. and Caffee M.W. (2011) *Meteoritics & Planet. Sci., 46,* A177.