XRF ANALYSIS OF STONY METEORITES USING AN ELEMENTAL ANALYZER AND A PORTABLE XRS. Kyeong Ja Kim[1,2], Ire Choi[3], Seung Ryeol Lee[4], Eung Seok Yi[5], Han Woo Choi[6], [1]Space Science and Astrobiology Division, Ames Research Center, NASA, Moffett Field, CA94035, USA. [2]Planetary Geology Deptartment, Geological Research Division, Korea Institute of Geosciences & Mineral Resources, Dajeon, 305-350, Republic of Korea (kjkim@kigam.re.kr).

Introduction: An active X-ray spectrometer (AXS) has been considered as one of science payloads for the SELENE-2 rover [1], which is under development as a pre-project phase for the second Japanese lunar mission. An AXS consist of two components: an X-ray spectrometer and an X-ray generator [2]. X-ray spectrometer is generally used for elemental analysis for both laboratory usage and industrial as well as medical applications. Recently, a portable AXS is more frequently used for *in situ* analysis for geological and industrial areas to identify the composition of both natural rocks and man-made materials. Most cases, a portable AXS is made of an X-ray detector and an X-ray tube. In the case of planetary usage, X-ray generators have been used with a radioisotope [3-8]. For the SELENE-2 rover's AXS, an X-ray generator is used instead of radioisotopes. In order to avoid nuclear materials, a pyroelectrical crystal is used to generate X-rays for the AXS for the SELENE-2 rover [2]. Thus, using the commercially available components: X-ray generator (Cool-X) and X-ray spectrometer by AMPTEK, Inc, we investigated a preliminary study of elemental analysis for stony meteorites.

Meteorites are divided into three groups based on their compositions. Rocky materials are stony meteorites, metallic meteorites are iron meteorites, and there is a mixture of these two groups as stony-iron meteorites. It is known that 94.7% of all meteorites are stony meteorites [9]. Most meteorites contain some iron and based on the degree of iron content, stony meteorites are divided into several subgroups. Most meteorites are originated from asteroids. Stony meteorites are either chondrites or achondrites. The chondrites are divided into many different groups based on the petrologic types. The petrologic types (type 1 through type 7) are categorized with their alterations such as aqueous alteration and thermal metamorphism [10]. Type 1~2 and Type 3~7 are associated with aqueous alteration and thermal metamorphism, respectively.

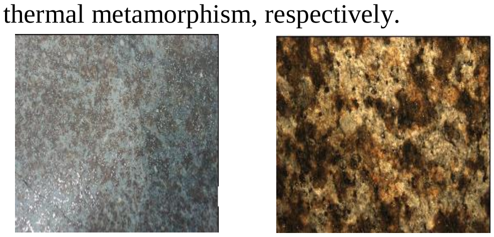

Fig. 1. A real image and microscopic image of a stony meteorite sample (Zag) of this study.

Methodology: There are many stony meteorites are commercially available and we carefully chose 11 meteorites which are large enough for our experimental settings of *in situ* XRS analysis. This means targets should be as large as 3 cm and flat. For this study, we aimed to characterise XRF analysis of stony meteorites using a portable AXS and other XRF system: an XRF microscope analyser, XGT7000V. We compared XRF spectra for both cases and tried to characterize the trend of stony meteorites with respect to the elemental compositions among these 11 meteorites (Figure 1).

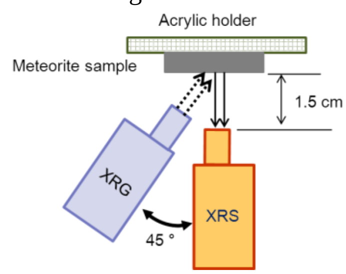

Fig. 2. Experimental setup of an AXS system of this study.

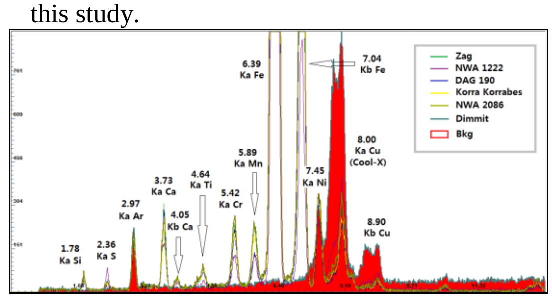

Fig. 3. An XRF spectrum of Zag and 4 other meteors obtained by an AXS of this study. Red regions are due to either background or originated by the XRG.

For the calibration of X-ray energy spectrum, we used X-ray source, Fe-55. Figure 2 shows the experimental setup for this study. The AXS system is located inside of a large shielding box, which is automatically controlled by an electronic system to meet the requirement of the nuclear safety regulation law of Korea. Figure 3 and 4 show an XRF spectrum of Zag and other 4 samples for an AXS and Zag sample for XGT7000V, respectivly. It can be noticed that the number of elemental peaks are similar between these two XRS instruments. For the Zag sample, Si, S, Ca, Cr, Mn, Fe, Ni, Ti are detected. The red regions of the XRF spectrum in Figure 3 are associated with the shielding materials of Fe and Pb as well as the XRG.

Results: Using XGT-7000V, we are able to obtain elemental mass (%) of the 11 stony meteorite samples. Si, S, Ca, Cr, Mn, Fe, Ni, and O (%) are plotted in Figure 5. This figure distinctively demonstrates each meteorite with respect to the elemental abundance. It can be found that NWA (Northwest African)-1222 has the highest S content and lowest Fe content among these meteorites. Also, this NWA-1222 has the highest Si content. With this respect, we clearly see that with this approach we are able to quantitatively visualize the meteorite composition and their types easily.

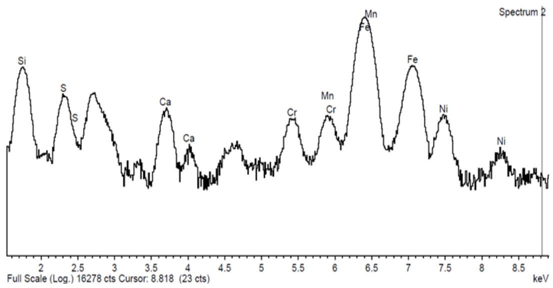

Fig. 4. An XRF spectrum of Zag sample obtained by XGT7000V.

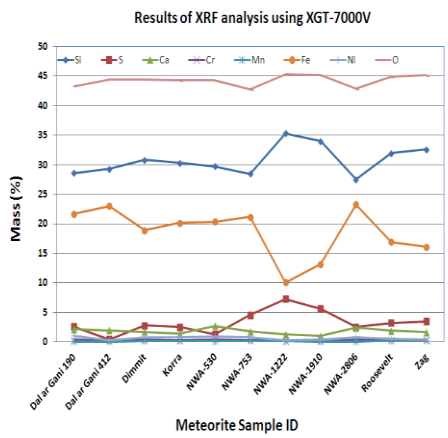

Fig. 5. Results of elemental analysis of the eleven stony meteorites of this study obtained by XRG-7000V.

The results of this study show that NWA-1222 contains high sulphur content as it contains ferroan alabandite. The XRF elemental analysis of Fe, S, Si of NWA-1222 is consistent with the class description. Not only the NWA-1222 but also other meteorites are also classified using the XRF elemental analysis shown in Figure 6. In the case of NWA-2906, it is known that it mostly contains plagioclase and exsolved Ca-pyroxene; plagioclase; pyroxene, etc [11]. The mineralogical characteristics of NWA-2906 are well represented in the Figure 6. The variety of NWA meteorites is clearly seen in Figure 6 and both NWA-1910 and NWA-1222 as the classification of ensatite, they are plotted in the lowest right corner of the curve representing high Si, low Fe, and low Ca in their elemental abundance features.

Further elemental data obtained by XGT-7000V X-ray scanner will be studied to compare our prospective data analysis using the portable AXS. The concept and method of XRF analysis between the two instruments are similar and therefore it is beneficial to do instrumental cross checking toward obtaining an absolute abundance of the AXS with the result of XGT-7000V.

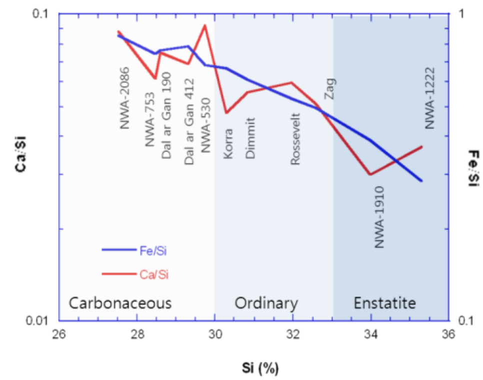

Fig. 6. Results of the elemental ratios of Ca/Si and Fe/Si as a function of Si (%) for chondrite samples.

Conclusions: *In situ* elemental analysis for eleven stony meteorites using both a portable AXS system and an X-ray scanner, XGT-7000V was investigated. It was confirmed that the meteorite associated with the least abundance for both Fe and Ca was found to be NWA-1222. The NWA-1222 sample was also found to have the largest amount of S among the eleven stony meteorites.

This study confirmed that the total number of peak identifications of elements of the meteorites samples is similar for both instruments. This study demonstrates that elemental ratios of XRF data are useful in not only the classification but also characterization of meteorites.

This approach with a portable AXS can be used for planetary application toward surface rock analysis. Further analysis of a cross-checking for a portable AXS using other XRF instrument is encouraged as well as development of the method quantification to obtain absolute elemental abundance of unknown samples using a portable AXS.

Acknowledgements: This project was supported by the KIGAM's Basic Project (14-3612) funded by the Ministry of Science, ICT and Future Planning of Korea.

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