

PPS021-P01

Room:Convention Hall

Time:May 23 16:15-18:45

Trace element imaging and semi-quantitative analysis of meteorites by Laser ablation ICP-MS

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Introduction

So far, electron microprobe has been used to study two dimensional distributions of elements in earth and planetary samples. However, the sensitivity of the method is insufficient for trace elements analysis. Furthermore, though synchrotron radiation X-ray fluorescence imaging has high sensitivity, micro-XRF imaging of trace heavy elements is still difficult to perform. In this study, LA-ICP-MS method was adopted to analyze two dimensional distributions of trace heavy elements in meteorites. This method is highly sensitive and is suitable for the analysis of meteorites, because it allows the analysis of two dimensional distribution of trace elements up to 72 elements. In this study, LA-ICP-MS was applied to obtain semi quantitative information of the trace elements and to reveal correlation of the elemental distribution in the sample.

Experiment

Analyzed samples were stony meteorite (NWA2086), iron meteorites (Sikhote-Alin, Gibeon, Odessa, Henbury, Nantan) and stony-iron meteorite (Fukang Pallasite). The LA instrument used in this study was a UP-213 Universal Platform (New Wave Research, USA), coupled to an Agilent 7500s ICP-MS instrument (Agilent Technologies, USA). Semi-quantitative analysis was performed based on the external standard glass sample NIST 612. The imaging was obtained by combination of the line scans on fixed area.

Results and Discussion

Our LA-ICP-MS imaging of the stony meteorite successfully revealed the distribution of the platinum Group elements (Os, Ir, Pt), rare earth elements (La, Ce, Sm, Eu) and other heavy elements accumulated in CAI (Calcium-Aluminium rich Inclusion). A correlation of siderophile elements (Ni, Co and also) are observed in a matrix part of the meteorite. On the other hand, in iron meteorites and stony-iron meteorite, a local correlations of elements in Fe-rich regions was observed though uniform distributions were observed for other elements. Semi-quantitative analysis of rare earth elements were successfully carried out and revealed a distribution pattern of the rare-earth elements in the sample, demonstrating a potential ability of quantitative two dimensional imaging of trace elements in the samples. In conclusion, the LA-ICP-MS imaging can provide elemental distribution of light and heavy elements in ppm level, which could not be obtained by using any other analytical methods. We believe that the LA-ICP-MS imaging will become a powerful analytical tool in earth and planetary sciences.

Keywords: ICP-MS, imaging, semi-quantitative analysis

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Carbon-XANES spectroscopic comparison of Q-gas rich and depleted fractions from Allende meteorite

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Introduction:

Although the planetary noble gases enriched in the heavy noble gases, Q gases, have been frequently studied, phase Q itself is yet to be identified. Matsuda et al. (2010) has reported that TEM observations did not show clear difference between Q-rich- and depleted- carbonaceous materials, while the Raman spectroscopic differences were observed between the two. They concluded that release of Q gases is not accompanied by mass loss but resulted from rearrangement of carbon structure during removal of Q (oxidation). Our previous study has revealed that the physically separated Q-rich density fraction may be rich in diamond-related sp^3 carbon. Thus, the release of Q gases and/or phase Q could be related to carbon functional group chemistry rather than carbonaceous morphology. This study focuses on the XANES analyses of Q-rich- and depleted- materials from Allende meteorite to refine carbon chemistry that is likely associated to the release of Q gases. Moreover, Q-rich fractions obtained via the suspension and physical separation from Allende, respectively, are analyzed for comparison.

Experimental:

An Allende meteorite was treated with HF-HCl for preparing an acid resistant carbonaceous residue. During the removal of elemental S from the residue with CS₂, One-seventh of the total fraction of the residue suspended in the supernatant was recovered (AMD3). The rest of the fraction (AMD1), which is rich in Q gases, was further treated with Na₂Cr₂O₇ to remove Q gases, yielding the oxidized residue, AMD2. Apart from AMD samples, a Q-rich floating fraction (G1), was obtained by the freeze-thaw disaggregation of Allende meteorite in stainless beaker. All the samples were embedded in sulfur and ultramicrotomed. Carbon-XANES of these samples was conducted using STXM at Beam line 5.3.2, at the Advanced Light Source, Lawrence Berkeley National Laboratory.

Results and discussion:

In C-XANES spectra of AMD1 and 2, aromatic and aliphatic carbons are much lower in AMD2 than those in AMD1. Carbonyl carbon is slightly higher in AMD2 than that in AMD1. On the other hand, the peak intensities of 1s- σ^* exciton derived from graphene, are not changed between AMD1 and 2. The differences in molecular features between AMD1 and 2 may not be directly reflected by phase Q, but more likely indicate the changes in major organic macromolecule by oxidation. Nonetheless, the depletion of aliphatic and production of carbonyls probably influence the structural rearrangement related with the release of Q-gases. No quantitative change of 1s- σ^* exciton intensity before and after oxidation indicates that phase Q is unlikely related to graphene.

Only one clear difference between C-XANES spectra of AMD1 and 3 is a peak at 287.43 eV in AMD 3 is remarkably developed compared to AMD1. A peak around at this energy is generally assigned to aliphatic carbon, or alternatively, another sp^3 carbon such as -C-CF of fluorinated diamond (Yu et al. 2003). The peak may have an important relation to Q-richness, since noble gas concentrations in AMD3 are 2-4 times higher than those of AMD1 (Amari et al. 2003).

G1 showed a quite different C-XANES spectrum from those of AMD1 and 3. While aromatic carbon is low, two unidentified peaks are detected. One of the two peaks is possibly derived from diamonds or their related compounds. Such spectral features are very similar to those in the Q-rich density fraction. Additionally, C-XANES spectra of different regions of G1 are heterogeneous. These spectra are not exactly the same as those of individual density fractions in our previous study. It may be because the individual density fractions show more detailed spectral features that were covered in bulk fractions, or might have been partially contaminated with Teflon beaker used in the past treatment by Matsuda et al. (1999). To summarize, it is further suggested that some sp^3 carbon may be related to the release of Q gases and/or phase Q.

Keywords: meteorite, chondrite, Q, carbonaceous matter, XANES, noble gas

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Infrared and raman spectroscopic analyses of the chondritic organic matter shot into silica aerogel by impact experiment

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Introduction:It has been suggested that sources of the prebiotic organic molecules were delivered to the early earth by meteorites, comets, and cosmic dusts (Exogenous delivery) (Chyba and Sagan, 1992). It is important to unravel the compositions and structures of organic matter in the small primitive bodies for better understanding the origin and chemical evolution of the prebiotic molecules in space. Although indigenous organic matter in meteorites and cosmic dusts has been known to be well preserved, some could be heated and lost during atmospheric entry or exposed to contamination from terrestrial materials. In order to collect the astromaterials without these problems, the cosmic dust collection with ultralow-density silica aerogel placed on International Space Station is planned (TANPOPO mission). However, the possible alteration of organic matter by impact heating upon aerogel capture is an unsolved issue. In this study, the high velocity impact experiment of meteorite powders was conducted for the purpose to evaluate the possible alteration of organic molecular compositions of meteorites before and after the impact.

Experimental:One hundred micron-sized Murchison meteorite powders were shot into silica aerogel by the impact velocity of 4km/s, using the two-stage light gas gun at Space Plasma Laboratory, ISAS, JAXA. The meteorite particles penetrated into the aerogel were carefully picked up by tungsten needle and fine brush, sandwiched with two Al plates, and hand-pressed. For comparison, non-shot Murchison meteorite powders were prepared on the Al plates as well. These shot- and non-shot- Murchison samples were analyzed by micro-FTIR (JASCO, FTIR-620) and micro-Raman spectrometers, respectively. In addition, infra-red imaging of the shot Murchison particles was conducted by the high brilliance micro-FTIR (Bruker, IFS120HR), BL43IR, Spring-8. Step size is 10 micro metre, mode of measurement is reflection, wavenumber resolution is 4cm^{-1} .

Results and discussion:In the micro-FTIR spectra of the three shot Murchison particles, the peaks assigned to aliphatic carbon ($3000, 2900, 2880\text{cm}^{-1}$), aromatic carbon (1600cm^{-1}), and SiO (1100cm^{-1}) were identified. The infra-red imaging detected the local regions where aliphatic and aromatic carbons and SiO are abundant, respectively, from the particles. The distributions of aliphatic and aromatic carbons were very similar, but not completely overlapped. One of the two SiO-rich regions was almost consistent with the organic-rich region while another was not. In general, aliphatic carbon in carbonaceous chondrites has been known to be depleted by heating (Yabuta et al.2005). Detection of aliphatic carbon from the shot Murchison particles in this study implies that organic matter in the particles is not highly altered by the impact velocity of 4km/s.

In the Raman spectra of the three shot Murchison particles, from which organics were identified by micro-FTIR, D- ($\sim 1350\text{cm}^{-1}$) and G- ($\sim 1580\text{cm}^{-1}$) bands were detected. The peak positions and widths of D- and G-bands for the shot Murchison particles were similar to those for the non-shot- Murchison particles. Thus, again, it is unlikely that organic matter in Murchison particles is altered by the impact experiment. The G-band positions and widths for the shot Murchison particles were similar to those for insoluble organic matter from Murchison meteorite (Busemann et al. 2007). However, their D-band positions and widths were different, which is probably due to the difference of analytical conditions. Organics were not detected from the other four particles by infrared nor Raman. This may be because the volatile components in meteorites were partially vaporized or moved due to the impact heating. Further investigation will be necessary to improve the feasibility of the cosmic dust analyses collected in TANPOPO mission.

Keywords: meteorite, cosmic dust, impact heating, infrared spectroscopy, Raman spectroscopy, TANPOPO mission

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U-Pb Dating and D/H Ratio of Phosphates in the Martian Meteorite ALH84001.

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The presence of water on Mars has been revealed by observations using spacecrafts, and elemental and isotopic analyses of Martian meteorites. In previous SIMS analyses of hydrogen, phosphate minerals containing OH group, for example an apatite($\text{Ca}_5(\text{PO}_4)_3[\text{OH}, \text{F}, \text{Cl}]$) and a whitlockite($\text{Ca}_9[\text{Mg}, \text{Fe}^{2+}](\text{PO}_4)_6\text{PO}_3\text{OH}$) were used. There are many studies that measured D/H ratios from the OH group in phosphates [1], [2]. Phosphate minerals are enriched in Uranium and U-Pb dating has been made in many studies [3]. We have measured U-Pb ages, D/H ratios and amounts of water of phosphates in the Martian meteorite, ALH84001 with a NanoSIMS. The goal of this study is to observe a secular variation of D/H ratios by Martian meteorites. Phosphate minerals in a thin section were detected by SEM-EDS and it was coated with gold films before the NanoSIMS measurement. For U-Pb dating by SIMS, primary O^- ions with a beam intensity of 10nA were used. Several points were measured in single grains of a phosphate mineral in a spot diameter of about 10 micrometer. The apatite produced from Prairie Lake called PRAP whose age was known [4] was used as a standard. This phosphate mineral crystallized about 4 billion years ago according to the U-Pb, Pb-Pb system. The age obtained in this study was consistent with those of the previous studies [3] within the experimental error. For D/H ratio measurements, primary O^- ions with a beam intensity of 1 nA were used. The spot size was about 3 micrometer. D/H ratios in a number of phosphate grains were measured. Surface water contamination could be negligibly small after the baking of the sample over night at 80 deg C under a high vacuum about 10^{-7} torr. The standard apatite for water measurement was driven from Morocco and some other places. The water of the Morocco apatite was extracted by heating at 1200 deg C for an hour in a vacuum line, and the abundance was measured by a manometric method. Observed D/H ratios of ALH 84001 tended to show a mixing line between the martian heavy hydrogen and terrestrial light hydrogen. Even though it is difficult to estimate the martian end-members, the data distribution suggests that the D/H ratio is at least higher than 3000 permil. The amount of water was found to be very small. This result shows a little heavier than previous results [5]. In previous studies, U-Pb age was obtained by spot analysis of several phosphate minerals. In this study it is possible to determine the age of an individual phosphate grain with several spots. We have measured the D/H ratio of the same grain. The data reflect the water on Mars at 4.0 Ga. At the poster session I will discuss the meaning of the U-Pb age and the D/H ratio.

[1] Leshin L. A. et al.(2000) *Geophys Res. Lett.* **27** 2017-2020, [2] Greenwood J. P. et al.(2008) *Geophys Res. Lett.* **35** L05203, [3] Terada K. et al.(2003) *Meteoritics&Planet.Sci.* **38** 1697-1703, [4] Sano Y. et al.(1999) *Chem. Geol.* **153**, 171-179, [5] Sugiura N. and Hoshino M. (2000) *Meteorol. Planet. Sci* **35**, 373-380.

Keywords: martian meteorite, alh84001, U-Pb dating, D/H ratio, phosphate

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Mineralogical characterization and formation process of shock-induced melt veins in the Efremovka CV3 chondrite

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An understanding of shock effects is important to bring out the impact history of the solar system. A shock-induced melt vein is one of the typical textures caused by impact; the vein is considered to be formed by rapid shear melting and be solidified along the shearing plane in extremely short times. Mineralogy of the shock-induced melt veins have been well studied in highly shocked ordinary chondrites so far, while there are few studies of carbonaceous chondrites which are usually considered to have been experienced relatively weak shock metamorphism.

Efremovka, grouped as a CV3 carbonaceous chondrite, is known to be experienced a strong shock metamorphism classified with a shock stage of S4. Although the previous studies on Efremovka mainly focused on the chemical/isotopic properties, the detailed mineralogical and petrographic characteristics remain to be known. We made a SEM observation of the Efremovka thin sections with a total area of about 200 mm², and found distinguish veins or puddles including spherical globules of Fe-Ni metal, Fe-sulfide in the matrix. In order to clear whether these objects have been actually experienced melting or not, and to clear its formation process, we undertook a mineralogical study regarding on the veins (tentatively called "melt vein") compared with the other area of the matrix (called "normal matrix") using transmission electron microscopy (TEM) and synchrotron radiation X-ray diffraction (SR-XRD).

The veins are often observed near chondrule-matrix boundaries, and sometimes penetrate into the adjacent chondrules or matrices. For site-specific samplings, the melt veins and the normal matrix were lifted up from the thin section and were trimmed to feasible shapes for SR-XRD and TEM experiments using a focused ion beam (FIB) technique. The SR-XRD and TEM experiments show the clear differences between the melt veins and the normal matrix, especially as to the constituent olivines. The unit cell volume data from SR-XRD and the TEM-EDX analyses consistently indicate that the olivine of the melt veins (Fo₇₃) is poorer in Fe contents than that of the normal matrix (Fo₄₅). A clear difference is also seen in the grain size; the olivine size in the melt veins is significantly larger (~300 nm) than that in normal matrix (~100 nm). Moreover, appearances of lattice defects in the olivines is different; from TEM observation, dislocation densities in the melt vein's olivines are much lower than those in normal matrix in spite of the evidence of the heavy shock impact.

These results indicate that the melt veins have certainly experienced a different formation process from that of normal matrix, which are apparently affected by melting and quenching processes. During these processes, olivine in the veins grew larger in size and become poorer in Fe contents than those in original matrix. On the other hand, as for most parts of Efremovka matrix escaping from melting, the shock wave effect can be found in compaction of matrix and high dense dislocations in the constituent minerals. The present study reveals that chemical and mineralogical disproportions are caused by melting and quenching process. Such shock-induced process may be one of the factors generating a diversity of meteorites.

Keywords: carbonaceous chondrite, melt vein, shock metamorphism, Efremovka, TEM, SR-XRD

Heterogeneity of chemical and mineral compositions of Bensour meteorite (LL6) in relation to Hayabusa sample analysis.

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The Hayabusa spacecraft returned to the earth last June. "Hayabusa" succeeded in observation of the asteroid Itokawa, and samples on the surface of Itokawa were recovered. Asteroids are considered to have information when they were formed in the early stage of the solar system, and it is expected that the clue to the information can be obtained by analyzing their samples. However, the maximum size of the sample particles recovered by "Hayabusa" is the order of 100 micro meters, and most of them are smaller than ten micro meters [1]. The chemical composition and mineral composition obtained from these small particles doesn't represent the material on the Itokawa surface. Then, it is necessary to examine how the chemical composition and the mineral composition change compared with the bulk when the sample becomes smaller in connection to the texture of meteorites.

It is proposed that the surface material of Itokawa is similar to LL5 or LL6 ordinary chondrite based on the infrared spectroscopic observation by "Hayabusa" [2]. In this study, heterogeneity of the chemical and mineral compositions was quantitatively examined by obtaining elemental mapping of the Bensour meteorite (LL6 chondrite). 13 elements (Al, Ca, Cr, Fe, K, Mg, Mn, Na, Ni, P, S, Si, Ti) were measured for two areas of about 4mmx4mm in a polished thin section, and elemental maps (images of 1024x1024 pixels) were obtained. In addition, mineral maps were made from the obtained elemental maps. The minerals contained in those ranges were olivine, Ca-poor pyroxene, Ca-rich pyroxene, plagioclase, apatite, whitlockite, taenite, kamacite, and chromite.

The elemental and mineral maps were divided into smaller areas by four, sixteen, and so on in the images. The standard deviations of the characteristic X-ray intensities of the elements and of the mineral modes were calculated as a function of the number of the division. The characteristic X-ray intensities and the mineral modes and changes of their standard deviations by increasing the number of the division were not greatly different among the two measured areas. This indicates that these areas roughly represent an average feature of this meteorite. The standard deviation of the characteristic X-ray intensity normalized its intensity increases with increasing the number of the division. The normalized standard deviations at the same number of the division for elements of low abundances, such as P, Ni and Cr, are larger than those of elements with high abundances, such as Si and Mg. This is due to the concentration of the elements with low abundances in specific accessory minerals, such as Ca phosphates, taenite, chromite for P, Ni and Cr, respectively, which are distributed locally. On the other hand, there is a different group of elements with low abundances, such as K, Mn and Ti. These normalized standard deviations are relatively small. These elements are included as minor elements in major minerals, such as plagioclase of K and pyroxenes for Mn and Ti. Based on the present study, if the Hayabusa sample is an LL6 chondrite, we can quantitatively expect deviations of the element and mineral compositions obtained from limited size of the sample by preliminary examination.

We are grateful to Dr. T. Fagan of Waseda University for providing the polished thin section of the Bensour meteorite.

[1] Nakamura T. et al. (2011) abstract in 42nd LPSC. [2] Abe M. et al. Science, 312, 1334-1338. [3] Tsuchiyama A. et al. (2011) abstract in this conference.

Keywords: Hayabusa, chondrite meteorite, composition

Conditions of aqueous alteration of C-type asteroids estimated from oxygen isotope ratios of carbonate in CM chondrites

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CM chondrites have undergone prevailed aqueous alteration that changed mineralogical and isotope signatures of water-bearing C-type asteroids (Zolensky and McSween, 1998; Clayton and Mayeda 1984). In the present study, we studied a CM chondrite GRA06172 that has never been studied in detail in order to estimate the degree and the conditions of aqueous alteration occurred on a meteorite parent body. A polished section was observed by a SEM/EDS and analyzed by an EPMA/ WDS. A small piece (200 microns in size) of matrix was analyzed by synchrotron radiation X-ray diffraction to identify minerals, since matrix minerals are too small to identify by using a scanning electron microscope.

SEM observations suggest that approximately half of the meteorite consists of primary rocks (Metzler et al., 1992) where chondrules were mantled by thick fine-grained rims and aggregates of PCPs occur on the rims. The other half is clastic matrix that was produced by fragmentation of the primary rock. This observation indicates that the meteorite is a breccia. Mesostasis glasses in both type-I and ?II chondrules are aqueously altered but most of anhydrous silicates such as olivine and low- and high-Ca pyroxenes are unaltered.

The results of the X-ray diffraction analysis indicate that matrix is composed mainly of serpentine and tochilinite, which suggests that matrix has undergone aqueous alteration. The presence of tochilinite limits the temperature experienced by this meteorite to be lower than 245C. (Gooding and Zolensky, 1992). In addition, sharp diffraction peaks from low-Ca pyroxene were detected. This indicates that some of anhydrous silicates survived aqueous alteration.

The EPMA analysis suggests that most of matrix composition fall within the area enclosed by composition PCP and two serpentine compositions on a Si-Mg-Fe ternary diagram as was reported in the McSween (1986). The average matrix composition changes with progressive alteration (McSween, 1986) and suggests that the degree of aqueous alteration experienced by GRA06172 is similar to or even higher than that for Murchison.

In addition, the mineralogical alteration index defined by Browning (1995) (when the number of oxygen of serpentine is nine, the index is calculated by $2 - (\text{Fe}3 + / (2 - \text{Si}))$) is approximately 0.65, which indicates that the meteorite altered to a degree higher than Murchison (1.57). Based on the CM chondrite classification scheme (CM2.6-2.0) defined by Rubin (2007), the average value of FeO/SiO₂ in PCP (2.8) and mineralogical and other characteristics of the meteorite suggest that it is classified to CM2.5 that is the same as Murchison. These results suggest that the extent aqueous alteration on GRA06172 is intermediate similar to or slightly higher Murchison, although small gaps are present between estimations from different models (i. e., McSween, 1986 vs Rubin, 2007).

There are many carbonate with sizes up to 100 microns in the matrix. Oxygen isotope analysis of the carbonate and co-existing serpentine is in progress using SIMS at Tohoku University (CAMECA ims-6F) so as to estimate water temperature and water / rock ratio during aqueous alteration.

Keywords: carbonatious chondrite, aqueous alteration, oxigen isotope

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Al-Mg isotope distribution in Type B CAI: partial melting and chronology

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Introduction: Oxygen isotopic compositions are heterogeneously distributed within and between minerals in coarse-grained CAIs, suggesting crystallization from different generations of melt. These minerals often plot on a straight line or multiple lines on an Al-Mg isochron diagram. From petrographic and O isotopic study, these CAIs have experienced at least two partial melting events (e.g., Simon et al., 2005; Itoh et al., 2009). In the present study, we report preliminary results of Al-Mg isotopic measurements of spinel and melilite in Golfball and TS34 to estimate the reset for Al-Mg isotope system of the multiple melting events of each melt.

Results and discussion: Al-Mg isotope analyses were performed with a Cameca ims-1270 SIMS instrument at Hokkaido University. These analytical procedures are described in detail elsewhere.

Two isochrons are defined by the Al-Mg data for these CAIs. For Golfball, the gehlenitic core melilite and rim melilite yield different initial $^{26}\text{Al}/^{27}\text{Al}$ ratios of 4.9 (8) and 1.9 (12) $\times 10^{-5}$, respectively. The age difference between the two isochrons is calculated to be about 1 My. For TS34, the spinel (through the origin) and the mantle melilite yield different initial $^{26}\text{Al}/^{27}\text{Al}$ ratios of 5.5 (4) and 4.5 (6) $\times 10^{-5}$, respectively. The age difference between the two isochrons is calculated to be about 0.2 My. These results are consistent with the multiple crystallization history by the results of petrographic study.

Keywords: SIMS, Al-Mg isotope, CAI, oxygen

Noise analysis of SCAPS-II ion imager

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A solid-state ion imager SCAPS has been proposed and demonstrated two-dimensional isotope ratio imaging with permil precision coupled with a stigmatic SIMS. The SCAPS system can measure high ion flux with an accuracy of the statistical error. However, the readout speed currently optimized at 0.05 frames/s is not sufficient for the time-critical applications. In order to realize real-time readout without loss of quantitative capability, high sensitivity is needed to overcome the read noise. The output signal fluctuation from SCAPS caused by 1 incident ion (i.e., conversion gain) was 30 micro V/ion pixel, whereas the read noise was 85 micro V. We evaluated newly designed ion imager SCAPS-II with higher conversion gain and noise reduction mechanism to achieve high-sensitivity corresponding to real-time readout.

The SCAPS-II has 504x504 pixel 7 x 7 micron in size with 65% fill factor. Improvement of the conversion gain can be achieved to reduce the pixel capacitance according to the relationship of $Q = CV$ where Q is the accumulated charge, C is the capacitance, V is the output voltage. The pixel capacitance of SCAPS-II is designed to 3.5fF, which is 4 times smaller than SCAPS (14fF). In order to increase dynamic range on the image detection, the conditional reset function was incorporated.

We also incorporated noise-reducing mechanism by multiple signal sampling using a switched capacitor (SC) integrator. The analog signal of pixel is sampled for multiple times as a difference voltage between pixel signal and a reference voltage via capacitor. The voltage is integrated in analog memory consisting of an amplifier with a feedback capacitor. The multiple sampling circuits are installed into each column totally 504 units and sample the signal of pixels in a row containing 504 pixels selected by a row selection pulse at the same time. This function realizes 16 times sampling for one pixel signal at 10 frames/s and 12.5 frames/s with 1 time sampling. The 2-line analog buffer output the integrated signal to read faster twice.

The conversion gain for ion was evaluated using a SIMS instruments (Cameca ims-1270). The imager is installed in a vacuum chamber and cooled at 173K to achieve long integration time by reducing thermally generated dark current. In order to decrease the noises including fixed pattern noise, nondestructive readout correlated double sampling is used to subtract a dark frame from a signal frame obtained without pixel reset. The incident ion number is counted by Faraday cup attached to the SIMS instrument. The saturation level of signal is about 5×10^3 ions/pixel. The noise is increasing statistically until the noise floor becomes dominant. The conversion gain of SCAPS-II was estimated to be 150 micro V/ion, which is 5 times larger than SCAPS. The noise using multiple-sampling method is not decrease along the slope-1/2 line. In order to investigate the noise source, the different sampling sequence called frame-averaging method is applied. The frame averaging sequence samples the pixels signal once every frame rates and averaging the frames while the multiple-sampling method samples multiple times in tens of micro sec order. The frame-averaging method takes long time for sampling but the noise reduction efficiency is higher than multiple-sampling method under 50 micro V. However the noise source is not clarified yet, the possible noise source is the 1/f noise of the MOS transistor because the difference between multiple-sampling method and frame-averaging method is the required time in sampling.

The capability of single ion detection is evaluated with the combination of multiple-sampling method and frame-averaging method. The frame ratio is 3.5 frames/s, therefore, it takes 14.4 seconds to obtain the ion image. The histogram of imager output of ion incident region shows the peak around 150 micro V. Considering the conversion gain of 150 micro V/ion, this peak indicates single ion signal.

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Hydrothermal alteration experiments of amorphous silicates: effect of organic-inorganic interaction.

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Most of carbonaceous chondrites with primitive chemical compositions have experienced aqueous alteration in their parent bodies. In order to understand the formation of minerals during the aqueous alteration process, we have previously carried out hydrothermal alteration experiments using Fe-free amorphous silicates with CI chondritic composition [1]. That study showed that saponite, serpentine, calcite and a relatively small amount of aragonite are formed from amorphous silicates and de-ionized water. This study focuses on the organic-inorganic interaction upon aqueous alteration of chondrites, since carbonaceous chondrite contains large amounts of organic compounds (~2%) [2] that could have been involved to formation of some minerals, such as carbonates.

The glass of the system, $\text{SiO}_2\text{-MgO-Al}_2\text{O}_3\text{-CaO-Na}_2\text{O}$, with the CI chondrite chemical composition was used. Three major elements, Fe, Ni and S, were excluded from the system for simplicity to avoid the change of the redox states. The glass sample was ground to make micron-scale powders. Two kinds of amino acids, glycine and alanine, were used as the analogue of whole organic matter in the carbonaceous chondrites. The ratio of alanine to glycine is 2.56:1.00, based on that in the GRA95229 which is weakly altered CR chondrite [3]. Silicates (100 mg), amino acids (23 mg) and de-ionized water (0.1 or 0.5 ml) were placed in Teflon vessels so that water to rock mass ratios were 1.0 and 5.0, sealed with stainless jacket, and were heated in an electric furnace at 150°C for 1, 2, 4 and 8 weeks under water saturated vapor pressures (approximately 3.0 bars). After heating experiments, vessels were rapidly cooled to room temperature in water. Solid products were recovered from solutions and dried in vacuum at room temperature. Parts (~80 mg) of solid materials were extracted with hot Milli-Q water for 24 hrs. The water extracts were analyzed with high-performance liquid chromatography (HPLC) to quantify the concentrations of amino acids. Solid products were analyzed with powder X-ray diffractometer (XRD).

In the XRD patterns of all the samples obtained from the hydrothermal experiments with different heating times, two major phyllosilicates, serpentine and saponite were identified. Aragonite, minor phase in CM chondrite, was also formed in all the experiments. However, calcite was not formed. The concentrations of alanine and glycine decreased with increasing time of heating, which is consistent with the trend of amino acid concentrations in aqueous-altered carbonaceous chondrites. On the other hand, the ratio of alanine to glycine decreased with increasing time of heating. This is a reverse trend to that of carbonaceous chondrites.

[1] Noguchi et al. (2011) 42th LPSC, abstract #1789

[2] Pizzarello et al. (2006) Meteorites and the Early Solar System II. 625-651

[3] Martians et al. (2007) Meteoritics and Planetary Science 42, 2125-2136

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