Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-01 Room:102A Time:May 20 09:00-09:15

Particle Transport and Thermal Processing during FU Orionis Events in the Solar Nebula

BOSS, Alan[1]*, Conel Alexander[1], Morris Podolak[2]

[1]DTM - Carnegie Institution, [2]Tel Aviv University

Solar-type young stars undergo ~100-year-long FU Orionis outbursts roughly every ~ 0.01 Myr during their early evolution. Such outbursts are thought to be caused by rapid mass accretion by the protostar during phases when the disk is marginally gravitationally unstable (MGU). We study here the trajectories of particles embedded in the solar nebula during a MGU phase of disk evolution. These trajectories have profound cosmochemical consequences, ranging from large-scale outward transport of refractory grains, such as the calcium, aluminum-rich inclusions (CAIs) found in Comet Wild 2 by the Stardust Mission, to an explanation for a CAI found in Allende whose variations in oxygen isotopes imply repeated passages both inward and outward in the disk, to time scales (~ 10 yr) for sublimation of CAIs similar to those inferred for a Leoville CAI, as well as for the transport and mixing of ices throughout the nebula.

Keywords: CAIs, solar nebula, FU Orionis, thermal processing, WL rims, transport

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-02 Room:102A Time:May 20 09:15-09:30

Nature, origins and thermal processing of carbonaceous material in chondritic meteorites

BREARLEY, Adrian[1*]

[1]Dept. Earth Planet. Sci., Univ, New Mexico

We have been studying the distribution of carbonaceous material in situ in carbonaceous chondrites using energy filtered transmission electron microscopy. Extensive studies of carbonaceous materials in carbonaceous chondrites have provided a wealth of information about the types of compounds that are present as well as their isotopic composition. We now know that a significant proportion of the organic material in these meteorites is present as an insoluble organic material that has some similarities to terrestrial kerogen. However, significant questions still remain as to the exact location of this material within chondritic meteorites are still unanswered. For example, although the organic material is known to be concentred in the fine-grained matrix of chondritic meteorites, the associations of this material with the mineralogic constituents of matrix have, until recently been unknown. Using energy filtered TEM, we have studied the distribution of carbonaceous material in CM and CR carbonaceous chondrites.

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-03 Room:102A Time:May 20 09:30-09:45

CALCIUM-ALUMINIUM INCLUSION IN THE KABA METEORITE AND ITS APPLICATION TO ASTROMINERALOGY

GUCSIK, Arnold[1*], NISHIDO, Hirotsugu[2], NINAGAWA, kiyotaka[3], Szaniszlo Berczi[4], Szabolcs Nagy[4], Peter Abraham[5], Ildiko Gyollai[6], Akira Tsuchiyama[1], Irakli Simonia[7], Peter Rozsa[8], Daniel Apai[9], Krisztian Mihalyi[8], Mihaly Nagy[10], Jozsef Posta[11]

[1]Department of Earth and Planetary Sciences, Graduate School of Science, Osaka University,, [2]Research Institute of Natural Sciences, Okayama University of Science, Okayama, Japan, [3]Department of Applied Physics, Okayama University of Science, Okayama, Japa, [4]Institute of Physics, Department of Material Physics, Eotvos University, Budapest, Hungary, [5]Konkoly Observatory of Hungarian Academy of Sciences, Budapest, [6]Department of Lithospheric Research Center for Earth Sciences, University of Vienna, Austria, [7]Graduate Studies of Ilia State University, Tbilisi, Georgia, [8]University of Debrecen, Debrecen, Hungary, [9]Lunar and Planetary Laboratory, Department of Planetary Sciences, The Arizona University, [10]Reformed College of Debrecen, Debrecen, Hungary, [11]Debrecen University, Dept Chemistry

CAI of the Kaba meteorire has a complex texture and consists of spinel, anorthite and augite (fassaite), where spinel grains (up to 10 micron in size) are surrounded by anorthite and augite grains. CAIs are observed and maximum 1.8-2.0 mm in size. The composition of anorthite is An95.6Ab4.4Or0. Augite has a composition of En45.5-55.1Wo44.0-53.9Fs0.6-0.9.

The age of Kaba ? as determined from Mn-Cr dating ? is thought to be between 4,562 and 4,563 Ma (Hua et al. 2005). It is instructive to attempt to place the formation and properties of Kaba in the context of protoplanetary disk evolution as observed around other stars. Any such comparison relies on the zero points of the astronomical and cosmochemical timescales, i.e. the time of the protostellar collapse and the time of the CAI formation. While these zero points are likely to be slightly shifted, detailed comparisons of protoplanetary disk evolution and events in the proto-solar nebula suggest that they could not differ by more than 1 Myr, if the proto-solar nebula was a typical disk (Pascucci & Tachibana 2010). Consistent with the above description we assume that CAIs have formed at the time of or very shortly after the protostellar collapse.

In contrast, the younger disks in Cha I and Taurus frequently display disks with flaring geometry (disk opening angle increasing with radius, see e.g., Sz?cs et al. 2010, Ciesla and Dullemond 2010). These disks also commonly display sharp and prominent crystalline silicate peaks, revealing the presence of sub-micron-sized forsterite and enstatite grains (e.g. Apai et al. 2005) with a few disks showing amorphous silicate emission features. The observed evolution of the small, initially amorphous dust grains into larger, crystalline grains is poorly understood, but it is often thought that grain-grain collisions and destructive planetesimals collisions will replenish and gradually replace the dust population. In this context, Kaba grains could provide an insight into the dust population of a disk halfway between a young protoplanetary disk and a debris disk: if so, a substantial amount of the building blocks of Kaba may have been recycled material from previous generation of small bodies. Furthermore, a systematic Micro-Raman spectral study (as future work) of an interaction between the organic compounds and CAIs in Kaba meteorite can provide us better understanding of the evolution of organic matter in the early Solar System.

References

Apai D., Pascucci I., Bouwman J., Natta A., Henning Th. and Dullemond C.P. 2005: The Onset of Planet Formation in Brown Dwarf Disks. Science 310: 834-836.

Ciesla F.J. and Dullemond C.P. 2010: Evolution of Protoplanetary Disk Structures. In Protoplanetary Dust: Astrophysical and Cosmochemical Perspectives, Eds.: Apai D. and Lauretta D.S., Cambridge University Press, p. 66-96.

Hua X., Huss G. R., Tachibana S. and Sharp T. G. 2005: Oxygen, silicon, and Mn-Cr isotopes of fayalite in the Kaba oxidized CV3 chondrite: Constraints for its formation history. Geochimica et Cosmochimica Acta 69: 1333-1348.

Pascucci I. and Tachibana Sh. 2010: The Clearing of Protoplanetary Disks and of the Protosolar Nebula. In Protoplanetary Dust: Astrophysical and Cosmochemical Perspectives, Eds.: Apai D. and Lauretta D.S., Cambridge University Press, p. 263-298

Sz?cs L., Apai D., Pascucci I. and Dullemond C.P. 2010: Stellar-mass-dependent Disk Structure in Coeval Planet-forming Disks. The Astrophysical Journal 720: 1668-1673.

Keywords: meteorite, Early Solar System, CAI, astromineralogy

PPS06-04 Room:102A Time:May 20 09:45-10:00

Sample return from near-Earth C-type asteroid

TACHIBANA, Shogo[1*], Hayabusa-2 sampler team[1]

[1]Dept. Earth Planet. Sci., Univ. Tokyo

Several sample return missions from primitive undifferentiated asteroids, such as Hayabusa-2, Osiris-REx, and MarcoPolo-R, have been planned to obtain samples without any terrestrial contamination but with geological information. The target asteroids for the future missions are near-Earth C-type or related asteroids, from which rocks potentially keeping the interactions between minerals, ice and organic matter in the protosolar disk intact are expected to be sampled. In this talk, primary scientific goals of sample return missions from near-Earth primitive asteroids will be discussed.

Keywords: sample return, near-Earth C-type asteroid

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-05 Room:102A Time:May 20 10:00-10:15

Spectroscopic observations of asteroid 21 Lutetia over the 3-micrometer region by AKARI satellite

OKAMURA, Natsuko[1]*, HASEGAWA, Sunao[2], Hiroi Takahiro[3], OOTSUBO, Takafumi[4], Thomas G. Mueller[5], Fumihiko Usui[2], SUGITA, Seiji[1]

[1]University of Tokyo, [2]ISAS/JAXA, [3]Brown University, [4]Tohoku University, [5]Max-Planck Institute

M-type asteroids have been interpreted to be fragments of the metallic cores of differentiated asteroids based on high albedos (0.15-0.25) and red-sloped featureless spectra. However, two of them, 55 Pandora and 92 Undina, were found to have the evidence of hydrated materials (i.e., strong 3-micrometer absorption bands). Because hydration usually occurs by aqueous alteration of minerals in asteroids, the presence of hydrated materials on M-type asteroids contradicts the interpretation of M-type asteroids as disrupted cores of differentiated bodies. However, if water was present long enough to metamorphose high-temperature anhydrous minerals, hydrated minerals may be formed on differentiated bodies.

Asteroid 21 Lutetia is categorized as a typical M-type asteroid. While the reflectance spectrum of the surface of 21 Lutetia was initially found to have 3-micrometer absorption, a recent observation showed a very shallow or no 3-micrometer absorption band. Thus, the presence of 3-micrometer absorption bands of 21 Lutetia is still unclear. The spectrum of 21 Lutetia over the 3-micrometer region needs to be observed. However, the spectra in the wavelength region between 2.6 and 2.8 micrometers cannot be easily observed with ground-based telescopes because of the strong absorption of H2O in the telluric atmosphere. Thus, observation in space, which is not affected by the telluric absorption, is extremely useful for obtaining data in the wavelength region including 2.6-2.8 micrometers. The purpose of this study is to investigate whether the 3-micrometer absorption exits in the spectrum of 21 Lutetia obtained by the Japanese infrared satellite AKARI.

AKARI, the first Japanese satellite for infrared astronomy, was launched on 2006 February 21 UT. A grism spectrograph with the 1'x 1' aperture was used for obtaining the reflectance spectra of the asteroids between 2.5 and 5 micrometer with a spectral resolution of 0.097 micrometer/pix. 21 Lutetia was observed in twice as shown on 2008 September 2 UT. These data are processed through the IRC Spectroscopy Toolkit for Phase 3 data (version 20090211) with the new spectral responsively (version 20110301).

Two observational data (IDs 1520157 and 1520158) and their average spectrum seem flat between 2.6 and 3.6 micrometer, especially over the 3-micrometer band range. Acquisition of the spectral portion over the wavelength range from 2.6-2.8 micrometer, where ground-based telescopic observation is extremely difficult, has become possible using AKARI. We compare our spectra with those of previous studies. The spectrum 1520157 is analogous to the 2007 and 2008 spectra in Fig. 1 of [1] over the range of 2.85-3.50 micrometer within 10% difference. Both of them are blue-sloped in the range of 2.85-2.9 micrometer and a little red-sloped beyond 3.3 micrometer. The spectrum 1520158 is analogous to the 2003 spectrum in Fig. 1 of [1] over the 2.85-3.50 micrometer range within 5%. Both spectra exhibit a shallow absorption band at 3.2 micrometer and a feature around 3.5 micrometer. Additionally, the spectra 1520157 and 1520158 are analogous to the 2007 and 2008 spectra in Fig. A5 of [2] over the 2.85-3.50 micrometer range within 5% and 10%, respectively.

We investigated whether the presence of 3-micrometer absorption band of 21 Lutetia. If the lowest reflectance and error in observation over the wavelength range from 2.55-2.60 micrometer is higher than the highest reflectance and error in observation over the wavelength range of 2.70-2.80 micrometer, we consider that absorption band exists. As a result, the reflectance spectrum has a very shallow or no obvious absorption band around 3-micrometer. Such observation of 3-micrometer band will help us understand the nature of M-type asteroids.

[1] Rivkin A. S. et al. (2011) Icarus, 216, 62-68. [2] Vernazza P. et al. (2011) Icarus, 216, 650-659.

Keywords: AKARI, asteroid, 21 Lutetia, hydrated mineral, thermal history

PPS06-06 Room:102A Time:May 20 10:45-11:00

Formation of H_2O and its isotopologues on interstellar grains

OBA, Yasuhiro[1*], WATANABE, Naoki[1], HAMA, Tetsuya[1], KUWAHATA, Kazuaki[1], HIDAKA, Hiroshi[1], KOUCHI, Akira[1]

[1]Institute of Low Temperature Science, Hokkaido University

Solid H_2O is the most abundant component in icy grain mantles in molecular clouds. Since the observed abundance of solid H_2O in molecular clouds cannot be explained only by gas-phase synthesis, it has been considered that solid H_2O is produced on the surface of interstellar grains. Tielens and Hagen (1982) proposed that solid H_2O is produced by hydrogenation of O, O_2, or O_3. Since then, the formation of H_2O through those reactions has been experimentally demonstrated to occur by several research groups (e.g. Miyauchi et al. 2008; Ioppolo et al. 2008).

In addition to these hydrogenation processes, reactions of hydroxyl radicals (OH) with H_2 have been accepted as an important route to H_2O formation in dense molecular clouds where the UV field is very weak. Under those conditions, it is unlikely that the reaction thermally occurs due to the significant barrier of about 2000 K; the reaction should proceed through quantum tunneling if it really occurs in dense clouds. However, it has not been experimentally demonstrated so far.

In this presentation, we will show experimental results on the formation of H_2O and its isotopologues (HDO and D_2O) by the reaction of OH/OD with H_2/HD/D_2 at 10 K, and discuss its astrophysical implications.

Keywords: water, deuterium enrichment, molecular cloud, surface reaction, tunneling reaction, isotope effect

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-07 Room:102A Time:May 20 11:00-11:15

D-H exchange kinetics between organic solids and water: Implications for D/H content in chondritic organic matter

KEBUKAWA, Yoko[1]*, CODY, George[1]

[1]Carnegie Institution of Washington

The high deuterium enrichment in insoluble organic matter (IOM) in chondrites has largely been attributed to small molecule chemistry prior to IOM, in the results of ion-molecule interactions at low temperature ($<$˜200 K) interstellar medium (ISM) [1]. A possible synthesis scenario of IOM formation has been proposed using highly deuterated interstellar formaldehyde [2]. However, even among the highest D enriched IOM has significantly lower (by a factor of ˜2) D content compared with ISM molecules [3]. While water in the solar system is much depleted in D [4]. Thus, D-H exchange between D enriched IOM precursor and D depleted water could have occurred during and/or after the formation of IOM. Here we report D-H exchange kinetics obtained using laboratory synthesized organic polymers, in order to evaluate the D-H exchange between D enriched organic polymers and D depleted water.

Our recent study revealed that insoluble organic matter (IOM) in primitive chondritic meteorites is predominantly derived from the polymerization of interstellar formaldehyde with incorporation of ammonia, evidenced by molecular spectroscopic characters [2,5]. In addition, montmorillonite (clay mineral) was shown to enhance the yield of the formaldehyde polymer. We used laboratory synthesized D enriched formaldehyde polymer (D-FormPoly) as a starting material of D-H exchange experiments. The polymers were incubated in H_2O at 150^{o}C, 200^{o}C and 250^{o}C for 1 hour up to 504 hours (21 days) in sealed glass tubes. Fourier transform infrared (FTIR) spectra of D-FormPoly were collected after the incubations. We use a peak area ratio of an aliphatic C-H stretching band at 2985-2835 cm^{-1} and an aliphatic C-D stretching band at 2250-2055 cm^{-1} as an indicator of D-H exchange.

The D-H exchange rates were faster in the higher incubation temperatures. Several kinetic rate laws were considered for these D-H exchange profiles, e.g., n-order reaction and diffusion. Three-dimensional diffusion was found to be the best fit among the rate laws tested. The apparent reaction rate constants were obtained by the fitting curves with a combination of three-dimensional diffusion equations [6]. Then the apparent activation energy and the frequency factor are obtained by the apparent rate constants and the temperature with the Arrhenius equation.

Using obtained kinetic expressions, D-H exchange profiles can be estimated for a certain time and temperature, based on the assumption that the kinetic rate low is invariance. Compared with aliphatic C-H loss profiles which is obtained by Murchison IOM [7], D-H exchange occurs faster than aliphatic loss in lower temperature range ($<$˜200^{o}C). This result suggests that D in highly D enriched IOM precursor could exchange with H in D depleted water without significant molecular structure change in low temperature aqueous alteration process.

The diffusion controlled D-H exchange is consistent with the fact that organic nano-globules have higher D/H values compared with fluffy IOM [8]. Because the D-H exchange rate depends on the grain size, therefore final D/H values depends on the grain size.

Acknowledgments: We gratefully acknowledge support from NASA Astrobiology and Origins of the Solar System programs.

References: [1] Robert F. and Epstein S. (1982) GCA, 46, 81-95. [2] Cody G. D. et al. (2011) PNAS, 108, 19171-19176. [3] Alexander C. M. O'D. et al. (2010) GCA, 74, 4417-4437. [4] Hartogh P. et al. (2011) Nature, 478, 218-220. [5] Kebukawa Y. et al. (2010) Meteoritics & Planet. Sci., 45, A103. [6] Crank J. (1970) In Mathematics of Diffusion. [7] Kebukawa Y. et al. (2010) Meteoritics & Planet. Sci., 45, 99-113. [8] Nakamura-Messenger K. et al. (2006) Science, 314, 1439-1442.

Keywords: Insoluble organic matter, Chondrite, Isotopic compositions, Kinetics, FTIR

PPS06-08 Room:102A Time:May 20 11:15-11:30

Finding of Nitrogen-rich Organic Material in Antarctic Ultracarbonaceous Micrometeorite

YABUTA, Hikaru[1*], ITOH, Shoichi[2], NOGUCHI, Takaaki[3], SAKAMOTO, Naoya[4], HASHIGUCHI, Minako[2], Ken-ichi Abe[2], Shin'ichi Tsujimoto[3], A. L. D. Kilcoyne[5], Ayako Okubo[6], OKAZAKI, Ryuji[7], TACHIBANA, Shogo[6], TERADA, Kentaro[8], NAKAMURA, Tomoki[9], NAGAHARA, Hiroko[6]

[1]Department of Earth and Space Science, Osaka University, [2]Department of Natural History Sciences, Hokkaido University, [3]College of Science, Ibaraki University, [4]Creative Research Initiative, Hokkaido University, [5]Advanced Light Source, Lawrence Berkeley National Laboratory, [6]Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, [7]Department of Earth and Planetary Sciences, Kyushu University, [8]Division of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, [9]Department of Earth and Planetary Materials Sciences, Faculty of Science, Tohoku University

Introduction:

Ultracarbonaceous micrometeorites (UCMMs), first discovered by Nakamura et al. (2005) [1], are unique extraterrestrial materials that represent large sizes of high carbon contents. The mineralogical and isotopic investigations of UCMMs by [2] have revealed the association of extreme D-rich organic matter with both crystalline and amorphous silicates, which appears to be compatible to cometary origin. However, there have been only two UCMMs reported so far, and little has been known about the nature of UCMMs. In this study, for an UCMM, which was found in ˜200 MMs collected in 250 kg of the surface snow near the Dome Fuji Station, Antarctica, we have carried out the systematic studies applying isotope microscopy, focused ion beam (FIB) extraction, scanning transmission X-ray microscopy (STXM) and transmission electron microscopy (TEM) observation to study the origin and formation of UCMMs.

Experimental:

A polished thick section of a UCMM was used in this study. Isotope imaging of the UCMM was performed by a Hokudai isotope microscope system (Cameca ims-1270 SIMS with SCAPS). A Cs+ primary beam in an aperture illumination mode was used to achieve uniform secondary ion emission from a sample area. The normal incident electron gun was used to compensate for sample charging. A tungsten strap was deposited on the surface of the UCMM, and an FIB section with ˜100 nm thickness was extracted from the UCMM by a JIB-4501 FIB-SEM microscope at Ibaraki Univ. C-, N-, and O- X-ray absorption near edge structure (XANES) spectra of the FIB section were acquired using STXM at the beamline 5.3.2.2., Advanced Light Source, Lawrence Berkeley National Laboratory.

Results and discussion:

The 12C14N and 32S distributions in carbonaceous matters from the UCMM show that the carbonaceous matter has the heterogeneously-distributed N- and S-rich signatures relative to the surrounding epoxy. The isotope-ratio images for hydrogen, carbon and nitrogen of the FIB section show that there is no significant difference in isotopic compositions of the UCMM from those of epoxy within analytical uncertainties (dD = ˜ +100 per mil with a error of plus or minus 300 per mil, d13C = ˜ 0 per mil with a error of plus or minus 70 per mil, d15N = ˜ +100 per mil with a error of plus or minus 110 per mil).

A STXM carbon map shows that organic carbon is distributed all over the FIB section. Using a nitrogen map, organic N-rich and poor regions are identified, respectively. N-XANES spectra of N-rich regions exhibit intense peaks of imine, nitrile, and amide, while that of N-poor region shows a less characteristic spectrum. Aromatic C=C are likely assigned to pyridine in the N-rich regions, while that in the N-poor region is similar to those of typical chondritic and/or IDP organics [3].

The N-rich regions within a large range of the UCMM with a sufficient S/N has not been generally observed in chondritic organic matter and IDPs. It is noted that the N-XANES spectral patterns of the N-rich regions are very similar to those observed from the three samples of Comet 81P/Wild 2 dust particles, one of which was an organic globule [4, 5]. Nitrogen isotopic composition of the Comet Wild 2 organic globule is indistinguishable from terrestrial values [4], which is consistent to that in this study. In addition, that the N-rich and N-poor regions co-exist with a sharp boundary within the particle is intriguing. This may indicate that there exists more than one precursor for extraterrestrial organic matter. Further studies on the possible relationships of the UCMM with IDPs and meteorites from the comprehensive perspectives of mineralogy, isotope, and organic chemistry will be expected.

References:

[1] Nakamura et al. (2005) Meteor. Planet. Sci. 40, A110. [2] Duprat et al. (2010) Science, 328, 742. [3] Cody et al. (2011)

PNAS doi : 10.1073/pnas. 1015913108. [4] De Gregorio et al. (2010) GCA, 74, 4454. [5] De Gregorio et al. (2011) Meteor. Planet. Sci. 46, 1376.

Keywords: Ultracarbonaceous Micrometeorite, Organic matter, XANES, SIMS, FIB

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-09 Room:102A Time:May 20 11:30-12:00

Hydrogen isotopic composition of the water in CR chondrites

BONAL, LYDIE[1*], C.M.O'D Alexander[2], G.R. Huss[3], Quirico E.[1], P. Beck[1]

[1]Institut de Planetologie et d'Astrophysique de Grenoble, [2]Carnegie Institution of Washington, [3]HIGP - University of Hawaii

Many chondrites experienced aqueous alteration, as revealed by the presence of phyllosilicates that are often associated with carbonates, magnetite, sulfides, and sulfates. The timing and duration of the alteration has been constrained by Mn-Cr dating of carbonates; physical constraints on the alteration (e.g. temperature) have been assessed through O isotopes of individual components [e.g., 1]. These data suggest that the alteration of chondrites took place over extended periods of time, and probably occurred almost entirely in asteroidal rather than nebular settings [e.g., 2]. However, our understanding of the conditions of alteration remains imperfect. For example, the origin, composition, and evolution of the fluids during alteration remain poorly constrained. The modification induced by the fluids on the pristine characteristics of the original constituents of the chondrites is only partially understood. In addition to allowing a better understanding of asteroidal alteration, the isotopic composition of asteroidal water is a key parameter to better understand the asteroid-comet continuum and is an important input in nebular models [e.g., 3].

Aqueously altered chondrites are composed of two main hydrogen (H) bearing phases: organics and hydrated minerals. Phyllosilicates and silicates in some aqueously meteorites are enriched in deuterium (D)relative to SMOW [e.g., 4,5], but the enrichments are smaller than in the respective organics [6]. An interstellar origin was attributed to the asteroidal water based on its D enrichment [4]. However, different hypothesis must be tested. Were the D enrichments in water inherited from the molecular cloud or nebula, or do they represent a later signature produced through some secondary reprocessing?

CR chondrites are considered to be the most primitive chondrites in our collections. The thermal and aqueous alteration experienced by QUE 99177, MET 00426, EET 92042, GRA 95229, Renazzo and Al Rais CR chondrites was assessed through multi-technique characterization (Raman, IR, EPMA, SIMS) of the carbonaceous matter and hydrated mineral phases in them. Each of the chondrites escaped long duration thermal metamorphism and experienced some fluid circulation [7, 8]. In particular, the extent of aqueous alteration experienced by QUE 99177 and MET 00426 may have been previously underestimated. The H isotopic compositions of the altering fluids were measured in situ, by SIMS, in fine-grained phyllosilicates and individual coarse-grained hydrated silicates. The main observations are that (i) the water is systematically enriched in D in each CR chondrite (up to dDwater = 1980permil); (ii) the isotopic composition of the water is characterized by highly variable D-enrichment at the micrometer scale; (iii) there is no clear trend observed in the isotopic composition of the water (maximum D-enrichment, range of variation) along the aqueous alteration sequence in the studied CR chondrites.

The high variability of the isotopic composition of the water/OH in CR chondrites is most easily reconciled with a secondary origin of the D-enrichments than with the presence of preserved pristine D-rich ices. Chondrites and comets may have sampled different water reservoirs. The water present in the CR chondrites probably formed in the inner Solar System [7, 8].

[1] Clayton and Mayeda (1999) GCA 63, 2089. [2] Brearley (2006) MESSII, 584. [3] Drouart et al. (1999) Icarus 140, 139. [4] Deloule and Robert (1995) GCA 59, 4695. [5] Grossman et al. (2000) MPS 37, 49. [6] Alexander et al. (2010) GCA 74, 4417. [7] Bonal et al. (2011) LPSC #1287. [8] Bonal et al. subm. to GCA.

Keywords: water, CR chondrites, H isotopic composition

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-10 Room:102A Time:May 20 12:00-12:15

Where is all the CO in Protostellar Systems?

NUTH, Joseph[1*]

[1]NASA Goddard Space Flight Center, Code 690

The material falling into protostellar systems is a mixture of gas plus organic coated silicates and carbonaceous dust grains. CO is the most abundant molecular species after H2 and its place in protostellar nebulae has been monitored for many years. As carbon coated grains enter the high temperature regions of the inner nebula or encounter high temperature shocks, copious quantities of CO should be generated as silicates are vaporized or annealed. Similarly carbonaceous grains in the oxygen rich environment of the hot inner nebula, in lightning discharges or in nebular shocks should generate CO. Finally, carbonaceous grains incorporated into growing planetesimals should continuously emit CO, especially as radioactive heating begins to melt their interiors. If the mass of carbonaceous materials is of the same order of magnitude as the oxygen rich dust a significant increase in the concentration of CO should be observed. Where is this excess CO?

Considerable work has been done on the potential for Fischer-Tropsch type reactions to occur on grain surfaces in protostellar nebulae, starting with the work of Anders and colleagues between 1967 - 1980 (e.g. Hayatsu and Anders, 1980) and proceeding through more recent work by Llorca and Cassanova (2000) or Hill and Nuth (2003) and Nuth et al., 2008). It appears that such processes are efficient enough to remove the excess CO that should be generated during the formation of planetary systems. This implies the existence of a large-scale carbon cycle that could be converting both carbonaceous grain coatings as well as more graphitic solid grains into organic materials, thus seeding many newly formed planetary systems with the seeds of life.

References
Hayatsu R. and Anders, E., 1981, Topics in Current Chemistry, 99, 1-37.
Hill, H. G. M. and Nuth,J. A., 2003 Astrobiology 3, 291?304.
Llorca, J. and Casanova, I., 2000, Meteoritics and Planetary Science 33, 243 ?251.
Nuth, J. A., Johnson, N. M. and Manning, S. 2008, Astrophysical Journal Letters 673 L225 ? L228.

Keywords: Protostellar Nebula, Carbon Monoxide, Carbon Grain Coatings, Planetesimal Evolution, Thermal Processing

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-P01 Room:Convention Hall Time:May 20 13:45-15:15

Evaporation of icy planetesimals due to planetesimal bow shocks in a protoplanetary disk

TANAKA, Kyoko[1*], YAMAMOTO, Tetsuo[1], MIURA, Hitoshi[2], NAGASAWA, Makiko[3], NAKAMOTO, Taishi[3], TANAKA, Hidekazu[1]

[1]Institute of Low Temperature Science, Hokkaido University, [2]Department of Earth Sciences, Tohoku University, [3]Tokyo Institute of Technology

In a protoplanetary disk, planetesimals grow to planets by mutual collisions and accumulations. The gravitational interactions among the planetesimals increase eccentricities of the planetesimal orbits. When a relative velocity between the disk gas and planetesimal exceeds a sound velocity of the gas, a bow shock wave is produced on the leading side of the planetesimal.

It has been shown that heating by the planetesimal bow shocks in the nebular gas played a key role in formation of particles found in meteorites and interplanetary dust. For instance, the shock heating leads to formation of chondrules, millimeter-scale igneous silicate spheres in chondrites, by melting dust in the protoplanetary disk (e.g.,Hood 1998; Weidenschlling et al. 1998; Ciesla et al. 2004; Miura and Nakamoto 2002). Furthermore, it is possible by a planetesimal bow shock to form various types of cosmic crystals, which are fine silicate crystals observed in chondritic meteorites and interplanetary dust particles (Miura et al. 2010).

So far, the attention has mainly been paid on thermal evolutions of dust particles in the shocked region in the previous studies. However, we note a possibility that the planetesimal bow shock leads to heating and evaporation of the planetesimal itself. A similar process is found in ablation of the planetesimals penetrating through the atmosphere of a protoplanet (e.g., Podolak et al. 1988; Pollack et al. 1986). Heating and resultant evaporation by the planetesimal bow shocks will suppress growth of planetesimals. Furthermore, cooling of the vapors thus produced will form small dust particles by re-condensation. Those dust clouds in the disk may be found in the infrared spectra of the protoplanetary disks.

In the present study, we focus on the planetesimal heating and evaporation by the planetesimal bow shocks. We evaluated the surface temperature and evaporation rate of the planetesimal using a simple model of planetesimal evaporation by the planetesimal bow shock. We applied the model of the planetesimal evaporation to the formation stage of protoplanets. Our results show that the icy planetesimals evaporate efficiently in the planetary oligarchic stage (Kokubo and Ida 2002), where strong shocks are generated by the gravitational perturbations from the protoplanets. The results suggest that the growth of a protoplanet is suppressed owing to the insufficient accretion of planetesimals onto the protoplanet. There may be an influence on the chemical conposition in the asteroid region because the vicinity of asteroid belt (2-4 AU) corresponds to the region where the evaporation is effective.

References

Ciesla, F. J., Hood, L. L., and Weidenschilling, S. J. 2004, Meteorit.Planet. Sci., 39, 1809
Hood, L. L. 1998, Meteorit. Planet. Sci., 33, 97
Kokubo, E., and Ida,S. 2002, ApJ, 581, 666
Miura H., Nakamoto T, and H. Susa, 2002, Icarus 160, 258
Miura, H., K. K. Tanaka, T. Yamamoto, T. Nakamoto, J. Yamada, K. Tsukamoto, and J. Nozawa, ApJ., 2010, 719, 642
Pollack, J. B., Podolak, M., Bodenheimer, P., and Christofferson, B. 1986, Icarus, 67, 409
Podolak, M., Pollack, J., and Reynolds, R. T., 1988, Icarus, 73, 163
Weidenschilling, S. J., Marzari, F., Hood, L. L. 1998, Science, 279, 681

Keywords: protoplanetary disk, planetesimal, shock wave, evaporation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-P02 Room:Convention Hall Time:May 20 13:45-15:15

In-situ observation of DCPD crystal (010) surface dissolution during transformation into HAP in solution

CUI, Meiyun[1]*, TSUKAMOTO, Katsuo[1], MIURA, Hitoshi[1], KIMURA, Yuki[1]

[1]Graduate School of Science, Tohoku University

Biomineralization is a biological process by which living organisms make use of organic matrix, such as peptides and proteins, to control the formation of functional minerals. The mineral brushite (DCPD) has been found under pathological conditions in kidney stones, some forms of arthritis, and caries. It has been proposed that brushite is a transient precursor for phase hydroxyapatite (HAP), which is the major inorganic component of bone and dental tissues. In recent years, the transformation mechanism from DCPD to HAP has attracted many attentions. The transformation from DCPD to HAP can be divided into two processes: dissolution of DCPD and precipitation of HAP. However, many researchers considered only the effect of interfacial energy on the transformation process from DCPD to HAP in solution and there were few literatures about kinetics of dissolution of DCPD. The purpose of this study is to reveal the details of fundamental process of the dissolution and the effects of bioorganic on the dissolution during transformation. For the purpose, we carried out in situ observations of dissolution of DCPD in solution by using the following microscopes. The phase shift interferometer (PSI) was used to measure the dissolution rate of DCPD crystal. Phase contrast microscope (PCM) and atomic force microscope (AFM) will be used to observe the change of crystal surface in atomic scale, e.g., the formation and growth of etch pit during dissolution process.

Firstly, we prepared the plate-like DCPD crystal around 2 mm in size by a simple precipitation method. The (010) surface of DCPD crystal during dissolution in solution has been in situ observed by PCM, PSI and AFM under different undersaturation, pH value, and concentration of Tris(hydroxymethyl)aminomethane. The reason why we chose Tris is that it is an organic compound and a primary amine, which can be widely used in biochemistry and molecular biology.

From in situ observation by PCM, we observed the triangle, quadrilateral, and trapezoidal etch pits on the (010) crystal surface under different conditions. We found that at the case of triangle etch pit, the step velocities, of [101], [-100] and [10-1] steps on the (010) surface are different in spite that the solution condition is the same. Especially, [-100] step has the fastest step velocity, which is opposite to the former report. It was also found that the step velocities increased evidently when two or three etch pits merged. In addition, the experimental data demonstrated that the dissolution rate normal to the (010) face became slower after adding Tris in solution. Therefore, it is considered that the effect of impurity on the crystal surface during dissolution process is very important, which may further change the crystal habit. Finally, these findings are helpful for us to further understand the mechanism of biomineralization.

Keywords: Biomineralization, DCPD crystal, dissolution, in-situ observation, etch pit

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-P03 Room:Convention Hall Time:May 20 13:45-15:15

Oxygen isotopic composition as a fundamental reference marker in water-material chemical interaction.

OZIMA, Minoru[1]*, SUZUKI, Takeru[2], YAMADA, Akinori[1]

[1]Earth & Planetary Sciences, University of Tokyo, [2]Physics Department, Nagoya University

To understand the basic processes in water-material chemical interactions in nature it is common to use oxygen isotopic ratio as a reference marker. For this SMOW has been conventionally employed as a standard, but its validity as a universal reference in a whole solar system is currently in hot debate [e.g.1,2]. We urge that any cosmochemical study on water-material interaction in the early solar system (the objective of this session), either theoretical or experimental, must in the first place consider this fundamental constraint.

The latest report of GENESIS project [3,4,5] gave a convincing isotopic composition of oxygen in bulk solar wind (SW) sample collected on a concentrator. However, correction for putative isotopic fractionation between SW and the Sun is still needed to conclude the solar oxygen isotopic composition. Although a model-dependent and somehow circular argument on the fractionation process was suggested in the GENESIS report [5], a definitive examination of the isotopic fractionation is urgent. Here, we studied noble gas isotopic fractionation, and on the basis of the latter result, we discuss oxygen isotopic fractionation between SW and the Sun. Our result does not support the solar oxygen isotopic composition concluded from the GENESIS mission.

Firstly, we show that the average noble gas isotopic composition in the early solar system is represented by Q-noble gas in primitive meteorites, one of two major noble gas components (Q and SW) widely occurring in the early solar system. Next, we show that SW-noble gas was mass-dependently fractionated from Q-noble gas with a fractionation factor inversely proportional to a square root of mass ratio of isotope, namely in proportional to 1/(mi/mj)1/2, where mi and mj stand for the mass of isotope i and j. We note that the characteristic fractionation factor is the typical of a Rayleigh distillation type fractionation. If the noble gas isotopic fractionation factor concluded in this work were applied to the Genesis SW oxygen data, the corrected oxygen isotopic composition becomes much closer to the terrestrial oxygen than to those suggested in the GENESIS report [5], and therefore is contrary to a widely held view [1, 5] that the solar oxygen isotopic ratio is the same as CAI oxygen, but differs from the terrestrial oxygen. Besides the mass-dependent isotopic fractionation identified in the case of noble gas, additional mass-independent fractionation (MIF) may also be present, which we speculate attributable to the dissociation of CO in the lower solar photosphere [6,7].

[1] Clayton, R.N., *Nature* **415**, 860-861 (2002). [2] Ozima M., Podosek F.A., Higuchi T., Q.-Z. Yin, and Yamada A., *ICARUS* **186**, 562-570, 2007. [3] Heber V. et al., *Geochimica et Cosmochimica Acta* **73**, 7414-7432 (2009). [4] Heber V. et al., *Meteoritics and Planetary Science* **46**, 493-512 (2011). [5] McKeegan K.D. et al., *Science* **332**, 1528-1532 (2011). [6] Asplund M., Grevesse N. & Sauval A. J. *Annu. Rev. Astron. Astrophys.* **47**, 484-522 (2009). [7] Chakraborty S. et al., *Science* **321**, 1328-1331 (2008).

Keywords: Oxygen isotope, noble gas, Sun, solar nebula

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS06-P04 Room:Convention Hall Time:May 20 13:45-15:15

Condensation with dust/gas separation and chemical fractionation in a protoplanetary disk

NAGAHARA, Hiroko[1]*

[1]Dept. Earth Planet. Sci., The Univ. Tokyo

The inner edge of a protoplanetry disk is the region where all the solids are vaporized, where condensation/evaporation plays a critical role in chemical evolution of dynamic disk. We have investigated chemical evolution of dust and gas with a kinetic condensation model (Nagahara and Ozawa, 2008, 2009) and kinetic parameters determined by condensation/evaporation experiments by our group. The model is based on the Hertz-Knudsen equation and mass balance between solid and gas in a cooing gas. Free parameters are cooling time of the system, total pressure and gas/dust separation efficiency, which is tentatively expressed by the critical size of dust separation.

The results show that there are three regimes in terms of chemical fractionation; one is the regime where no chemical fractionation takes place due to very fine grain size of condensing dust, one where no chemical fractionation takes place due to very large dust size, and one where effective fractionation takes place depending on the cooling time scale and critical dust separation size. The cooling rate and critical size for dust separation can be regarded as the relative velocity of gas around the inner edge, thus the dynamics of gas.

We discuss the conditions to achieve chemical fractionation among chondrites.