Europlanet TA Scientific Report

PROJECT LEADER

Project number: 20-EPN2-067
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TA Facility visited: CRPG

Project Title: Hydrogen isotope compositions of matrices in unequilibrated ordinary chondrites

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database and published)

One way to study the origin of water and other volatiles which accreted onto rocky planets such as Earth during the formation of the Solar System is to study meteorites that fall from asteroids and other planetary bodies. Hydrogen isotope ratios within meteorites can be used as a tracer for the source of a body's water, and to an extent spatial and temporal information about the formation of parent bodies.

Previously, we measured the D/H ratios of bulk powders of a wide range of unequilibrated ordinary chondrites (UOCs), and found wide variations which did not fit into current H-distribution models. Using SIMS, we measured the H, D, C, and Si contents of the fine-grained matrix of 13 of these previously studied UOCs (only falls) ranging from types 3.00 – 3.9.

Preliminary results confirm the wide previously observed spread of D/H ratios between samples, including high elevations in a handful of UOCs. C/H ratios will be used to determine the D contribution within samples specific to water, however initial observations confirm contributions from both hydrated and organic components. The results from this visit will be combined with other in-situ studies carried out at the home institution to determine exactly what phases are hosting this highly D-rich material, and how these chondrites affect models of water transport in the early Solar System.

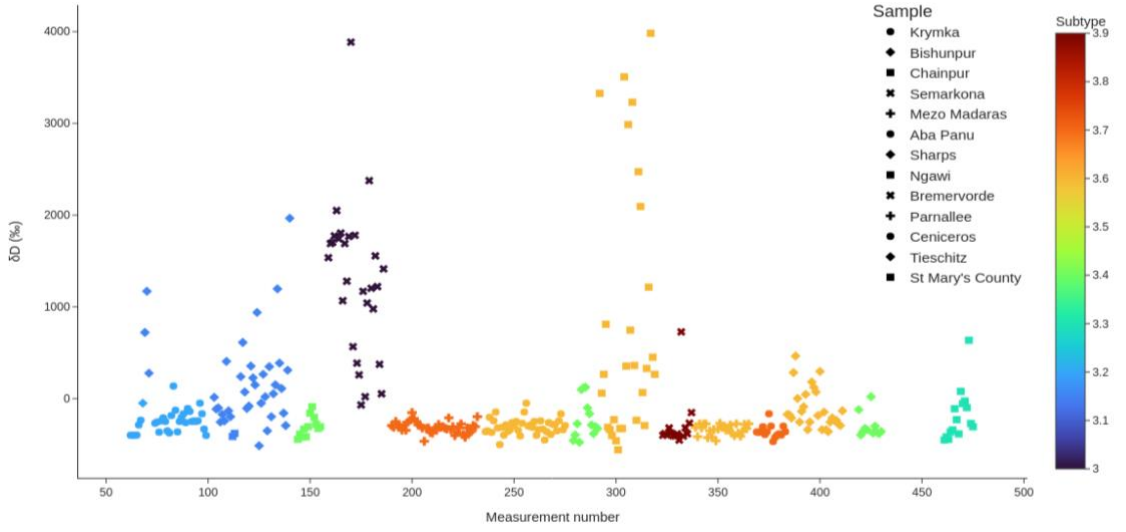
Full Scientific Report on the outcome of your TNA visit

We encourage you to add figures to your report, which should be approx. 1 page of text plus figures.

The leading model on the origin of volatile species such as water, carbon and nitrogen on Earth is through accretion from small solar system bodies (SSSBs) early in the formation of the Solar System. One way to investigate the viability of this model is to study chondritic meteorites that fall to Earth, in particular in the porous fine-grained matrix found between larger phases. Previously volatiles and organic compounds have been studied extensively in carbonaceous chondrites (CCs), despite CCs only making up less than 5% of all chondrites found. On the other hand, the most common meteorite to fall to Earth - ordinary chondrites (OCs) – have been considerably less studied, despite evidence for the presence of aqueous alteration in the most pristine unequilibrated OCs (UOCs). Previously, we studied the bulk water content and isotopic composition of a collection of 21 UOCs – 15 falls and 6 finds, ranging in petrologic subtype from 3.00 to 3.9 - which revealed both the presence of water and unusually high D/H ratios in a number of samples. These high D/H ratios are particularly unexpected as OC parents are believed to have formed in the D-poor inner Solar System. However, H-bearing organic compounds may contribute to bulk D/H ratios, and thus these ratios may not be representative of the water itself. To investigate this further we have done in-situ analysis of fine grained matrix of the 13 UOC falls from the bulk study – Semarkona, Bishunpur, St Mary's County, Chainpur, Sharps, Ngawi, Tieschitz, Parnallee, Aba Panu, Ceniceros, Mezö-Madaras, and Bremervörde. Two fall samples from the bulk study (Bo Xian and Dhajala) were excluded as their preparation was not deemed good enough to measure reliable data.

Small chips of the UOC samples were polished and pressed into indium mounts to be studied non-invasively with a combination of SEM, XRD, and EPMA to identify target regions and determine their mineralogy. Samples were then gold coated and matrix H, D, C, and Si contents measured with the IMS 1280HR2 SIMS at CRPG in Nancy. By measuring D/H and C/H ratios simultaneously and extrapolating to where C/H is equal to zero, it is possible to calculate the water specific D/H ratio of a phase.

As shown in the figure below, which shows D/H ratio against an arbitrary measurement number, significant variation in both D/H and C/H was found within and between samples. D/H ratios conformed well with previous bulk D/H measurements. As expected, Semarkona, Ngawi, and Bishunpur have the largest spread of ratios, with the highest ratios peaking around δ = +4000‰, where the bulk mean on Earth is δ = 0‰. The highest measured D/H ratio was, in fact, Ngawi – a meteorite previously classified as an LL3.6. These results suggest that this is likely a mis-classification and Ngawi may have a petrologic subtype as low as 3.00-3.2. The remaining 10 samples have much lower D/H ratios in the range of δ ~ -500 – +300‰, with clear trends between D/H and C/H ratios allowing for determination of water specific D/H ratios. A handful of measurements of non-matrix areas were taken, which had very low D/H and C/H ratios, confirming that the D-rich material is primarily in the fine-grained matrix.



A number of points, particularly relating to C/H ratios, will have to be assessed and likely excluded from the final data set. The main reasons for this are cracks/holes within samples meaning measurements are not necessarily of the matrix, and low H abundances resulting in skewed C/H ratios. In addition, prior to SIMS the samples had been carbon coated for SEM and EPMA work. Although the samples had been re-polished

to remove the coating, it is possible some C remained in cracks within the samples, which will need to be considered when assessing C/H data.

This work has shown that elevated D/H ratios are indeed present in a number of UOCs, particularly those which have undergone little-to-no alteration as part of their parent body. These D-rich areas are predominantly found in the fine-grained matrix of samples, where D contributions are seen to come from both hydrated (C-poor) and organic (C-rich) phases. Furthermore, this raises issues with current H-isotope distribution models within the Solar System.

- Give details of any publications arising/planned (include conference abstracts etc)

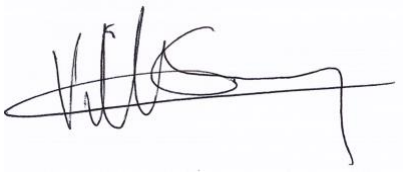
Data will be written up into a paper on in-situ measurements of D/H in the matrix of UOCs, an abstract for the Lunar and Planetary Science Conference and possibly the annual meeting of the Meteoritical Society. Potentially a second paper will be written specifically on Ngawi.

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: 7/10/22 Arrived: 9/10/22	10/10/2022	0	10	0	21/10/2022	Departed: 22/10/22 Arrived: 23/10/22

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	
Host Signature	**Johan Villeneuve, lab manager of IPF CRPG platform**  **Laurie Reisberg, CRPG Europlanet coordinator** 
Date	**27/11/2022**

- Project Leader confirmation

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YES

Project Leader Name	
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Date	**29/11/22**