Sources and inventory of cosmic dust: From space to the Earth's surface

RAS specialist discussion meeting – 10:30 – 15:35, February 11 (UK time)

Organisers: *Matthias van Ginneken (University of Kent)*
Martin Suttle (Open University)
Penelope Wozniakiewicz (University of Kent)
Matthew Genge (Imperial College London)

ABSTRACTS

ACCRETION RATE OF ANTARCTIC MICROMETEORITES STORED IN SURFACE SNOW NEAR DOME FUJI STATION

Takaaki Noguchi (noguchi.takaaki.2i@kyoto-u.ac.jp)
Kyoto University, Japan

We have collected Antarctic micrometeorites (AMMs) preserved in snow from the surface to ~10 cm in depth near the Dome Fuji Station, Antarctica from 2003 to 2012. Because the snow accumulation rate near the Station is ~10 cm/year, the snow and the AMMs included fell within about 1 year before collection. We collected 1025 AMMs (843 unmelted, 51 scoriaceous, and 131 spherules) in the snow whose total amount was ~1.0 tons. Their average sizes were 40, 64, and 40 µm, respectively. We estimated their total weight based on the following assumptions. (1) Volumes of the AMMs and the spherules were estimated as spheres with an average diameter. (2) The densities of the unmelted AMMs and the spherules were 2 and 3 g/cm^3, respectively. The surface mass balance (SMB) at the Dome Fuji station was 27.3 ± 1.5 $kg/m^2/yr$. The accretion rate F of the AMMs were calculated as follows: F=A_E×(m_AMM⁄M_snow ×f_s), where A_E, m_AMM, Ms_now, and f_s are the surface of the Earth, total weight of the AMMs, total weight of the snow, and SMB, respectively. The obtained accretion rate for the AMMs collected near the Dome Fuji Station is 3.3 ± 0.2 × 10^3 t/yr. Rojas et al. (2021) reported 5200 +1500/−1200 t/yr using 1280 unmelted AMMs and 808 spherules with diameters ranging from 30 to 350 µm, which were collected at the Concordia Station, Antarctica. Our estimated value is smaller than their value. The smaller value may be related to the small amount of snow used in this study because large AMMs were depleted in our collection. However, these two estimated values are within the range of the accretion rates of AMMs estimated for different times from ~900 to ~3300 years ago.

THE MICROMETEORITE FLUX AT DOME C (ANTARCTICA)

Julien Rojas[1], J. Duprat [2,1], C. Engrand[1], E. Dartois[3], L. Delauche[1], M. Godard[1,3], M. Gounelle[2], J. D. Carrillo-Sánchez[4,5], P. Pokorný[4,6], J.M.C. Plane[7] (Julien.Rojas@ijclab.in2p3.fr)
[1]Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France, [2]IMPMC, CNRS-MNHN-Sorbonne Universités, UMR7590, 57 rue Cuvier, 75005 Paris, France, [3]ISMO, CNRS, Univ. Paris Saclay, Bât 520, 91405 Orsay, France, [4]Department of Physics, Catholic University of America, 620 Michigan Ave., N.E., Washington, DC 20064, USA, [5]ITM Physics Laboratory, NASA Goddard Space Flight Center, Code 675, 8800 Greenbelt Rd., Greenbelt, MD 20771, USA, [6]Astrophysics Science Division, NASA Goddard Space Flight Center, Code 667, 8800 Greenbelt Rd., Greenbelt, MD, USA, [7]School of Chemistry, Univ. of Leeds, Leeds LS2 9JT, UK

A comprehensive study has been performed with the Concordia Collection to better constrain the flux of micrometeorites falling on Earth. The unique conditions at Dome C (Antarctica) allow an accurate control on both the exposure parameter (the equivalent surface of accumulation) and the collection efficiency. The size distributions and mass fluxes of unmelted micrometeorites (uMM) and cosmic spherules (CS) were obtained in the 30-350 µm diameter range. Several independent measurements were performed on the same site allowing to infer a well constrained absolute value of both the uMMs and CSs fluxes.
Combined with previous measurements performed at the South Pole Station, the results allow to derive the global flux of uMMs and CSs over the 12-700 µm diameter range. The global annual input of micrometeorites on Earth extrapolated from this study is 5,200 tons·yr-1 (3600 tons·yr^{-1} from CSs and 1,600 tons·yr^{-1} from uMMs). That value is substantially higher than the one derived from the South Pole collection but stays, about a factor of 3, below the flux expected at atmospheric entry. This study confirms that about 2/3 of the mass of the incoming flux is ablated at atmospheric entry. The flux of carbon on Earth carried by micrometeorites is estimated to range from 20 to 100 tons·yr^{-1}. Using the mass distributions obtained, a Monte-Carlo simulation was performed to calculate the statistical uncertainties related to variations of the exposure parameter. The results obtained allow to infer the statistical uncertainties on such type of flux measurements.

THE EXTRATERRESTRIAL DUST FLUX: SIZE DISTRIBUTION AND GLOBAL MASS INPUT INFERRED FROM THE TRANSANTARCTIC MOUNTAINS MICROMETEORITE COLLECTION

Luigi Folco (luigi.folco@unipi.it)
Dipartimento di Scienze della Terra, University of Pisa, Italy

The Transantarctic Mountains (TAM) micrometeorite collection samples the accumulation of micrometeorites at the Earth's surface over significant timescales (>1 million years). Thus, the collection has the potential of providing us with a qualitative and quantitative definition of the cosmic dust flux to Earth over the Quaternary in terms of mass, size, compositional type and source bodies in the Solar System, for the 100 to 2,000 µm size range.

We investigate a single sediment trap (TAM65), performing an exhaustive recovery and characterization effort and identifying 1,643 micrometeorites (between 100 and 2,000 µm). Approximately 7% of particles are unmelted or scoriaceous, of which 75% are fine-grained. Among cosmic spherules, 95.6% are silicate-dominated S-types, and further subdivided into porphyritic (16.9%), barred olivine (19.9%), cryptocrystalline (51.6%), and vitreous (7.5%). Our (rank)-size distribution is fit against a power law with a slope of –3.9 (R-2 = 0.98) over the size range 200-700 µm. However, the distribution is also bimodal, with peaks centered at ~145 and ~250 µm. Remarkably similar peak positions are observed in the Larkman Nunatak data. These observations suggest that the micrometeorite flux is composed of multiple dust sources with distinct size distributions. In terms of mass, the TAM65 trap contains 1.77g of extraterrestrial dust in 15 kg of sediment (<5 mm). Upscaling to a global annual estimate gives 1,555 (± 753) t/year, consistent with previous estimates and almost identical to the South Pole Water Well estimate (~1,600 t/year), potentially indicating minimal variation in the background cosmic dust flux over the Quaternary. The greatest uncertainty in our mass flux calculation is the accumulation window. A minimum age (0.8 Ma) is robustly inferred from the presence of Australasian microtektites, while the upper age (~2.3 Ma) is restrained based on 10Be exposure dating of glacial surfaces at Roberts Butte (6 km from our sample site).

INVESTIGATING THE ORIGIN OF THE ^{16}O-POOR GROUP – PERSPECTIVES FROM LARGE UNMELTED MICROMETEORITES

Martin D. Suttle[1,2,3.], L. Folco[1,4.], Z. Dionnet[5,6.], M. Van Ginneken, M., T. Di Rocco[8.], A. Pack[8.]., M. Scheel[9], A. Rotundi[6] (martin.suttle@open.ac.uk)

[1.]Dipartimento di Scienze della Terra, Università di Pisa, 56126 Pisa, Italy, [2.]Planetary Materials Group, Department of Earth Sciences, Natural History Museum, Cromwell Road, London, SW7 5BD, UK, [3.]School of Physical Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK [4.]CISUP, Centro per l'Integrazione della Strumentazione dell'Università di Pisa, Lungarno Pacinotti 43, 56126 Pisa, Italy, [5.]Institut d'Astrophysique Spatiale, Université Paris-Saclay, 3 rue Joliot Curie, Bâtiment Breguet, 91190 Gif-sur-Yvette, France, [6.]DIST-Università di Napoli "Parthenope", Centro Direzionale Isola C4, 80143 Naples, Italy, [7.]Centre for Astrophysics and Planetary Science, School of Physical Sciences, Ingram Building, University of Kent, Canterbury, CT2 7NH, UK, [8.]Geowissenschaftliches Zentrum, Universität Göttingen, 37077 Göttingen, Germany., [9.]SOLEIL synchrotron, Gif-sur-Yvette, France.

We investigated 21 large (420-2000 µm) unmelted micrometeorites using a combination of µ-CT (to characterise their internal textures) and laser fluorination oxygen isotope mass spectrometry (to determine their relationship to established meteorite groups). We identified three hydrated fine-grained micrometeorites with anomalous ^{16}O-poor isotopic compositions (δ^{17}O: +16.4‰, δ^{18}O: +28.4‰ and Δ^{17}O: +1.4‰). These particles represent either a new carbonaceous chondrite group or an extension of the CY chondrite isotopic range. In addition, the position of these micrometeorites in O-isotopic space implies they originate from the same reservoir as the anomalous "group 4" cosmic spherules previously reported by Suavet et al. 2010 (EPSL: 293:313-320) and several subsequent isotopic studies. Furthermore, being unmelted these micrometeorites are less affected by mass dependent fractionation processes or mixing with atmospheric oxygen and are therefore more representative of the pre-atmospheric parent body composition of this group. By analysing unmelted micrometeorites we are able to infer the texture and approximate alteration history of the ^{16}O-poor group. All three micrometeorites are dominated by phyllosilicate matrix and contain embedded small chondrules (<170 µm), Fe-sulphides and rare anhydrous silicates. They originate from a water-rich C-type asteroid. Our work underscores how the analysis of micrometeorites complements the perspective obtained by investigating larger meteorites and expands our understanding of the geological diversity of the solar system.

A POTENTIAL ORIGIN FOR ^{16}O-POOR COSMIC SPHERULES: A NEAR-EARTH SOURCE AND PARENTAGE WITH CY CHONDRITES.

Matthias Van Ginneken[1], S. Goderis[2], R. Maeda[2,3], P. Wozniakiewicz[1], M. Genge[4], L. Folco[5], M. Suttle[6], A. Yamaguchi[7], S. Decrée[8] (m.van-ginneken@kent.ac.uk)

[1]Centre for Astrophysics and Planetary Science, School of Physical Sciences, University of Kent, United Kingdom (m.van-ginneken@kent.ac.uk), [2]Department of Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel, Belgium, [3]G-time laboratory, Université Libre de Bruxelles, Belgium, [4]Impacts and Astromaterials Research Centre, Department of Earth Science and Engineering, Imperial College London, United Kingdom, [5]Dipartimento di Scienze della Terra, Università di Pisa, Italy, [6]School of Physical Sciences, Open University, United Kingdom, [7]National Institute of Polar Research, Japan; [8]Belgian Geological Survey, Royal Belgian Institute of Natural Sciences, Belgium.

Oxygen isotopes are a powerful tool to determine the parent bodies of cosmic spherules (CSs), which are the totally melted endmember of micrometeorites. Considering fractionation processes affecting their original oxygen isotope signatures, more than 90% of CSs larger than 200 µm appear to be related to chondrite clans established studying chondritic meteorites. About 8% of CSs that show clear chondritic major element compositions also exhibit unusual ^{16}O-poor oxygen isotopic compositions that are not linked to chondritic material present in meteorite collections. Simultaneously, a subset of porphyritic (Po) cosmic spherules named Cumulate Porphyritic Olivine (CumPo) CSs, exhibit textures testifying to settling of olivine crystals during atmospheric deceleration. This unusual texture suggests these particles entered the Earth's atmosphere at velocity of ~16 km s-1, which corresponds to orbital eccentricities >0.3, which is higher than most asteroidal dust bands. In the present study, we explore the potential link between these two unusual subsets of CSs that are the ^{16}O-poor and CumPo spherules. To achieve this, we randomly selected 17 Po CSs from the Sør Rondane Mts. Collection and one CumPo from the Larkman Nunatak micrometeorite collection. Major element and oxygen compositions of the particles were determined. Based on their internal texture, nine particles in our selection can be classified as CumPo CSs, whereas the rest are normal Po CSs. Five of these CumPo CSs exhibit ^{16}O-poor values and exhibit mineralogical and geochemical characteristics suggesting a coherent subset. Based on these criteria, a parentage with the newly defined CY carbonaceous chondrite group is likely. We suggest that about 10% of CSs reaching the Earth surface have a near-Earth origin that is rare in meteorite collection, demonstrating the importance is fully characterizing the flux of micrometeorites to understand the composition of the Solar System.

HOT DESERT MICROMETEORITES: CONCENTRATION, PRESERVATION AND RELATION WITH SURFACE AGES

Jérôme Gattacceca (gattacceca@cerege.fr)
CEREGE, CNRS, Aix-Marseille Univ, IRD, INRAE, Aix-en-Provence, France

We have characterized micrometeorite collections extracted from the surface layer of several hot deserts: Atacama (Chile), Tunisian Sahara, Dar al Gani (Libya), Oman. The same surfaces were dated using ^{10}Be dating of quartz pebbles, or ^{36}Cl dating of surface carbonates. The raw sandy material was wet-sieved, and micrometeorites extracted by magnetic separation followed by hand-picking under a binocular microscope. We measured the diameter of micrometeorites, and classified them into the S, I, and G types (as defined by e.g., Genge et al. 2008, MAPS 43:497-515).

The results show that the concentration of micrometeorites is much lower than what would be expected from perfect accumulation with time, with a preferential loss of small micrometeorites, and a strong preservation bias toward the densest micrometeorite types (I and G).

The cumulated concentration of I and G micrometeorites correlates relatively well with the desert surface age. We also evidence a correlation between the concentration of micrometeorites and the concentration of meteorites on the same surfaces. As a result, assessing the micrometeorite concentration on a given hot desert surface is an efficient tool to determine its potential for meteorite recovery.

Finally, our results show that hot desert surfaces represent an underexploited source of micrometeorites, with the oldest surfaces of the Atacama desert yielding several thousands of micrometeorites > 200 µm per square meter of desert.

THE CONCORDIA MICROMETEORITE COLLECTION, RECENT RESULTS AND FUTURE CURATION AT MNHN.

Jean Duprat[1,2], C. Engrand[2], E. Dartois[3], L. Delauche[2], J. Rojas[2], B. Guérin[2], B. Augé[4] (Jean.Duprat@mnhn.fr)

[1]IMPMC, CNRS-MNHN-Sorbonne Universités, UMR7590, 57 rue Cuvier, 75005 Paris, France, [2]Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France, [2]IMPMC, CNRS-MNHN-Sorbonne Universités, UMR7590, 57 rue Cuvier, 75005 Paris, France, [3]ISMO, CNRS, Univ. Paris Saclay, Bât 520, 91405 Orsay, France, [4]Institut de planétologie et d'astrophysique de Grenoble, CNRS, Université Grenoble Alpes, 38000 Grenoble, France

Since 2000, we perform micrometeorites (MMs) collections at the vicinity of the French-Italian (IPEV/PNRA) station Concordia located at Dome C (75° S, 123°E) thanks to the financial and logistic help of the French polar institute (IPEV). The central regions of the Antarctic continent present major advantages to recover MMs with a minimal terrestrial weathering. We performed 6 fields trips at Dome C and collected and melted several tens of m3 of ultra-clean snow in 5-8 deep trenches. The key advantages of Dome C allowed to identify several MMs with exceptionally high concentration in carbon (UCAMMs). The mineralogical, chemical, and isotopic characteristics of these particles indicate that their parent body most probably originate from the outer regions of the solar system.
I will present the results obtained, within the framework of B. Augé PhD and J. Rojas PhD, on the isotopic composition of UCAMMs and on experiments performed to simulate the synthesis of the organic matter of UCAMMs. These experiments show that isotopic heterogeneous organic matter similar to that of UCAMMS can be produced by irradiation of N-rich ices by Galactic Cosmic Rays. I will review the current status of the Concordia collection and its future curation within a large facility currently under study at the MNHN in Paris. This future national curation center will provide dedicated cleanrooms to gather the MNHN national meteorite collection and the micrometeorite collection, analytical standards, terrestrial analogues and samples returned by spatial missions.

Building a collection for the future: Potential insights from the NHM's Micrometeorites Collection

Gerallt E. Hughes (g.hughes@nhm.ac.uk)
Earth Sciences Department, Natural History Museum, London

Fossil micrometeorites are increasingly recognised in the geological record (e.g., Onoue et al., 2011; Tomkins et al., 2016; Suttle and Genge, 2017), and sample return missions (e.g., Hayabusa2, Tachibana et al., 2014; OSIRIS-REx, Lauretta et al., 2017) will make small particulate material from asteroids and comets available for study. Hence there is a necessity to establish a dedicated collection to conduct targeted study of modern and fossil micrometeorites and prepare protocols for future sample return material. The Natural History Museum (NHM) has one of the largest and oldest meteorite collections and is a hub of meteorite research, and hence is a logical location to host such a collection. The incipient micrometeorite collection at the NHM currently hosts historically important material from the HMS Challenger (1872–1876) expedition, some of the world's first described micrometeorites (Murray and Renard, 1891), and this work seeks to expand these collections through systematic processing of these ocean bottom sediments to extract modern micrometeorites. Fossil micrometeorites in ancient rocks provide a record of extraterrestrial flux to Earth, their features allow us to investigate atmospheric processes and conditions during entry, and their incorporation into rocks provide insights into post-depositional and diagenetic processes (Genge et al., 2008). This project aims to target Devonian (420-350 Ma) sediments, extract I-type micrometeorites, and constrain extraterrestrial flux during this period. Textural and geochemical analysis will be used to characterise these micrometeorites and infer changes in atmospheric oxidation during this crucial period in Earth's history, when plants colonised the land. Future work on Permo-Triassic and Miocene sediment residues will also aim to collect micrometeorites throughout the geological column, providing a more complete picture of extraterrestrial flux throughout Earth's history. Developing this collection will enhance an existing world-leading repository of extraterrestrial material and develop novel techniques to study the development of life on Earth.

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COSMIC DUST INFERRED BY MACHINE LEARNING

Thomas Y. Chen (thomaschen7@acm.org)
Academy for Mathematics, Science, and Engineering

Neural networks are a nascent technology utilized for computer vision and other applications of artificial intelligence. Roughly simulating the structure of the human brain, these networks provide high-level insights into large-scale astronomical and cosmological datasets. The James Webb Space Telescope enables the collection of big data relating to cosmic dust. In this work, we discuss how neural networks can be trained to aid in inferring cosmic dust properties and determine effective wavelengths for dust inference.

STARDUST HUNTERS

Sarah Roberts (s.g.roberts@swansea.ac.uk)
College of Science, Swansea University, U.K.

Every year, approx. 3,000 tons of cosmic dust falls to the surface of the Earth – in this poster we present an STFC-funded Public Engagement Project called 'Stardust Hunters' which aims to engage and enthuse school pupils aged 8-14 years in the relatively new research area of urban micrometeorites.

The 'Stardust Hunters' pilot project enables school children in Wales to carry out searches for these tiny particles using a specially designed 'Stardust Hunter's Toolkit' which consists of a microscope, USB camera, sieves, examples of real micrometeorites, sample bags and magnets along with training workshops. Once the pupils have found potential micrometeorites, they are sent to Swansea University to be analysed using equipment at the University's Advanced Imaging for Materials (AIM) facility.

The overall aim of the 'Stardust Hunters' project is not only to involve school students with real research and help them develop their scientific research skills, but we also aim to contribute to this growing field of study. We would therefore welcome collaborations and feedback from specialists in the field.

RESOLVING MASS-DEPENDENT ISOTOPE FRACTIONATION PROCESSES IN GLASSY COSMIC SPHERULES FROM THE SØR RONDANE MOUNTAINS, EAST ANTARCTICA

Steven Goderis (Steven.Goderis@vub.be)
Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel, Belgium

During atmospheric entry, micrometeorites experience variable degrees of evaporation due to gas drag heating and mixing with atmospheric oxygen. Evaporation affects both the chemical and isotopic compositions of fully melted cosmic spherules (CSs). Oxygen isotope ratios are commonly used to relate micrometeorites to their respective parent body types. However, atmospheric processes can obscure the initial oxygen isotope ratios, which complicates precursor identification. Here, we explore the potential of Fe isotope ratios to constrain the degree of modification experienced during atmospheric passage, in addition to routinely applied geochemical proxies, such as the Mg/Al ratio or $CaO+Al_2O_3$ content. Thirty-seven vitreous CSs of chondritic composition and 4 potentially achondritic particles have been analysed for their Fe and O isotope ratios and bulk chemical composition. Because the initial Fe isotope ratios of chondrites display limited variation (<0.02‰ for $\delta^{56}Fe$), the positive $\delta^{56}Fe$ values of up to ~40‰ are interpreted to result mainly from evaporation. Based on the observed relationship between δ57Fe and $\delta^{18}O$, a correction for the effects of evaporation on O isotope ratios is proposed. Three out of 4 previously identified chondritic CS groups are tied to specific chondrite groups with additional confidence. After correction for a ~25‰ difference in $\delta^{18}O$, two ^{16}O-poor CSs also cluster closely together, confirming the probable existence of a chondritic group with no equivalent among known meteorite groups. Two out of 4 achondritic particles overlap with HED meteorites after correction, while the corrected oxygen isotope composition of the remaining two achondritic particles ($\delta^{18}O$ = 12.54–12.79 ‰) does not match any known meteorite fields, indicating a previously unsampled parent body or residual fractionation effects after the applied correction. These findings stress the importance of developing additional isotopic tools to better constrain the primary origin of micrometeorites and their subsequent modification during transfer from parent body to planetary surface.

EXPLORING THE POTENTIAL OF (SEDIMENTARY) MICROMETEORITE TRAPS IN THE ARCTIC

Flore Van Maldeghem (Flore.Van.Maldeghem@vub.be)
Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel, Belgium

The past years, the search for micrometeorites has increased tremendously, in part thanks to the increased accessibility of remote locations. Several collections of micrometeorites have been gathered in Antarctica from an array of environments. Micrometeorites have been collected from snow (e.g., the Concordia collection), from ice (e.g., the South Pole Water Well collection) and more recently also from sediment-filled cracks and fissures in granitic and metamorphic lithologies outcropping at high altitude, like the collections from the Transantarctic mountains and the Sør Rondane Mountains. The Antarctic micrometeorite collections are characterized by long accumulation times, little to no anthropogenic contamination and a highly pristine nature. Because of the cold and dry climate, weathering remains limited, and a high number of relatively large micrometeorites can accumulate over time. A large variety of micrometeorite types, and other extraterrestrial debris (e.g., airburst debris and microtektites), have been identified in these sedimentary collections. On the other side of the world, a similar environment can be found in the Arctic. Several decades have passed since micrometeorites were actively searched for in the Arctic environment, specifically in Greenland snow and cryoconite. Both Greenland and Svalbard show potential for Arctic micrometeorite collections proven by the presence of micrometeorites in small, randomly picked sediment samples from traps similar to those found in Antarctica. In this preliminary report on extraterrestrial particles recovered at several locations on Svalbard and Greenland, we explore what extraterrestrial mysteries the Arctic has to offer.

UNDERSTANDING OLIVINE AND PYROXENE IN CHONDRITIC IDPS

Michael Zolensky[1] and D. Frank[2] (michael.e.zolensky@nasa.gov)
[1]ARES, NASA Johnson Space Center, Houston, TX 77058 USA, [2]HIGP, University of Hawai'i at Manoa, Honolulu, HI 96822, USA

There is a widespread depletion of Cr from the FeO-rich olivine in Wild-2, relative to type IIA chondrules (Frank et al., 2014) - the degree of this depletion is akin to that in unequilibrated chondrites such as Krymka (LL3.2) or Rainbow (CO3.2). Since Cr is highly mobile under even mild thermal metamorphism (as low as 200ºC), it is a sensitive indicator of such an event, showing greater depletion in smaller grains (i.e., matrix vs. chondrules) (Grossman and Brearley, 2005). Grossman and Brearley (2005) found that the distribution of Cr in FeO-rich olivine systematically changes as metamorphism increases between type 3.0 and type 3.2. Thus, Wild-2 olivine appears to carry evidence of mild thermal metamorphism. It is critical to determine whether there is any evidence for this from samples of other comets. For this we can examine anhydrous chondritic IDPs. Unfortunately, the data for olivine and pyroxene in IDPs is sparse, mainly decades old and lacks useful information on minor elements.

We have begun to collect new compositional data for olivine and pyroxene in chondritic interplanetary dust particles (filling a major gap in our knowledge, as approximately half of these grains derive from comets), to determine whether the results obtained for Wild-2 are typical for comets in general, or whether Wild-2 (or its accretion components) has experienced an atypical geological history. A determination that a comet, or its accretion components, had experienced significant thermal metamorphism would greatly alter models of early solar system history.

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OXYGEN ISOTOPE STUDY OF COMETARY DUST

Daisuke Nakashima (dnaka@tohoku.ac.jp)
Graduate School of Science Earth Science Division of Earth and Planetary Materials Science, Faculty of Science, Tohoku University, Japan

It has been suggested that the major source of crystalline silicates in comets is CR chondrule-like materials based on the comparisons of oxygen isotope systematics between cometary silicates and chondrules from various types of primitive chondrites. However, cometary silicates used for these studies are from two comets: Wild2 and a parent comet of the giant cluster interplanetary dust particle (GC-IDP) U2-20GCA. To explore whether crystalline silicates in all comets have similar oxygen isotope systematics, other materials of likely cometary origin, such as anhydrous IDPs and ultracarbonaceous Antarctic micrometeorites (UCAMMs), are needed to be measured for oxygen isotopes.

Cometary AMMs and IDPs in this study and previous studies show a negative correlation between Mg# and Cap17O values; samples with Mg# > 90 tend to have negative Cap17O values with an average of –2.1 ± 3.4‰ (2SD), and those with Mg# < 90 have variable Cap17O values from –2.6‰ to +2.7‰. Similar correlations are also observed for GC-IDP U2-20GCA and Wild2 particles. For the GC-IDP, the average Cap17O value of FeO-poor particles is –1.5 ± 3.5‰, and Cap17O variation of FeO-rich ones is from –2.8‰ to +3.4‰. For Wild2 particles, the average Cap17O value of FeO-poor particles is –2.2 ± 4.4‰, and Cap17O variation of FeO-rich ones is from –3.8‰ to +2.5‰. Thus, the oxygen isotope systematics of randomly sampled cometary AMMs and anhydrous IDPs, which derive from various comets, is similar to those of crystalline silicates from single comets like Wild2 and the parent comet of GC-IDP U2-20GCA. Although the number of data from AMMs and IDPs is very limited, it is proposed that every comet has a common oxygen isotope systematics similar to that of CR chondrite chondrules.

^{3}He FLUX OBTAINED FROM SOUTH POLE COSMIC DUST AND ITS IMPLICATIONS

Susan Taylor[1] and K. A. Farley[2]

[1]Cold Regions Research and Engineering Laboratory, USA (retired), [2]Division of Geological and Planetary Sciences, California Institute of Technology, USA

Cosmic Dust is the term for small extraterrestrial (ET) particles arriving on Earth and includes Interplanetary Dust Particles (IDPs), generally <20 µm in size, and Micrometeorites (MMs), generally <2mm in size. MMs account for most of the ET mass deposited on present day Earth, while IDPs are thought to deposit little mass but most of the ET helium. We hoped to provide the missing link between the IDP flux measured in the stratosphere and 3He flux measured in ice cores and deep-sea sediments. To this end, we subsampled and analyzed for 3He 13 of 41 air filters collected at South Pole and melted, filtered and analyzed for 3He 141, meter long sections of a 201m ice core drilled at South Pole.

The ^{3}He depositional fluxes (units of 10^12cc STP cm^2-ka^1) for the South Pole air filters (1.4 ± 1.2) and ice cores (1.2 ± 0.3) are similar to the stratospheric inputs (1.8 and 3.75) and the average 3He terrestrial deposition rates measured in sections of the Vostok (0.77 ± 0.25) and GISP2 ice cores (0.62 ± 0.27) and in a variety of deep-sea sediments (~ 1). The similarity in fluxes indicates that: 1) IDPs carry the ET 3He, which is retained while transiting the atmosphere and during terrestrial burial; 2) poleward stratospheric transport of IDPs must be small or we would see higher 3He fluxes in the Antarctic air and ice samples; and 3) measured mass and particle size distributions of stratospheric IDPs can be used to assess sedimentary redistribution and the variability in ^{3}He abundances in terrestrial sediments. Despite large uncertainties, it is striking that variations in ^{3}He flux among sampling localities and archives on Earth, and 1 to 100 Myr time scales, are within a factor of two.

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Organic and minerals phases in ultracarbonaceous Antarctic Micrometeorites (UCAMMs).

Cecile Engrand[1], J. Duprat[2,1], E. Dartois[3], B. Guérin[1], C. Le Guillou[4], H. Leroux[4], J. Rojas[1], J. Mathurin[5], E. Charon[1], K. Benzerara[2], S. Bernard[2], L. Delauche[1] (cecile.engrand@ijclab.in2p3.fr)

[1]Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France, [2]IMPMC, CNRS-MNHN-Sorbonne Universités, UMR7590, 57 rue Cuvier, 75005 Paris, France, [3]ISMO, CNRS, Univ. Paris Saclay, Bât 520, 91405 Orsay, France, [4]UMET Univ. Lille 1, 59650 Villeneuve d'Ascq, France, [5]LCP, CNRS, Université Paris Sud, Université Paris-Saclay , Orsay, France,

Ultracarbonaceous Antarctic micrometeorites (UCAMMs) are cosmic dust particles with extreme concentration in carbonaceous matter. They have been found both in the French Concordia micrometeorite collection and in Japanese collections so far. Similar particles are also probably present among the IDPs collected in the stratosphere.

UCAMMs are dominated by organic matter with large D enrichments, and contain minor mineral components. The organic matter exhibit three different phases with distinct spectroscopic characteristics and different nitrogen contents. The « type III » organic matter has large N/C atomic ratios that can reach 0.2. Minerals included in the UCAMM organic matter exhibit both crystalline and amorphous phases. The large amount of organic matter and the high D/H ratios of these particles strongly suggest a cometary origin. The type III organic matter can have formed by Galactic cosmic ray irradiation of N-rich ices at the surface of the UCAMM parent body. The presence of crystalline minerals in the UCAMM organic matter requires the existence of radial transport of small minerals grains in the early protoplanetary disk.

PROJECT STARDUST: THE SEARCH FOR MICROMETEORITES ON THE OREGON COAST

William D. Lilley[1], H. Dean[2] and M. Fries[3] (wlillel@twcny.rr.com)
[1]State University of New York at Potsdam, New York, USA, [2]Oregon State University, USA, [3]ARES, NASA Johnson Space Center, USA

The search for micrometeorites on the Oregon Coast started in 2019 with Jon Larson's 2017 book In Search of Stardust and grants from NASA and the Oregon Coast Community College Foundation. The plan was to investigate several potential locations where micrometeorites might be found: 1. Roofs, 2. Roof drains, 3. Coastal Beaches, 4. Coastal Streams and 5. Bedrock Talus Slopes. After searching each of these areas with the large magnets, the samples were screened and sorting with microscopes. The most of micrometeorites candidates came for the large roof at the local high school and few micrometeorites candidates came from about 20 roof drains fitted with magnets. The micrometeorites ranged in size from 0.1 mm to 1 mm with most less than 0.5 mm. The micrometeorites ranged in colors of green, pink, yellow and most were black. The 40 of the candidate micrometeorites were sent to NASA's meteorite laboratory in Houston, Texas for SEM final analysis

PERSONAL COLLECTION OF URBAN MICROMETEORITES

Scott Peterson (Mnmicrometeorites@gmail.com)
Minneapolis, Minnesota, USA

Since 2017 I have collected more than 2,100 micrometeorites from 47 different rooftops in 3 different states, including Minnesota, Wisconsin, and Maryland. Additionally I have found them at ground level on the roads in my neighborhood and even in front of my own house. Lastly, I have found them in the sediment from the bottom of Lake Michigan and the bottom of the Atlantic Ocean.
I have developed a somewhat decent imagining system with a Olympus BHS BH2 microscope and a Nikon D5200 attached. Multiple images are taken (around 300-500 individual images) to perform focus stacking, this is done with a custom 3D printed attachment with a stack shot stepper motor system. Lighting from a Schott lighting system and diffused with 3D printed light diffusers.
I also worked with the University of Minnesota to image the micrometeorites with their state of the art JEOL JXA-8530FPlus Electron Probe.