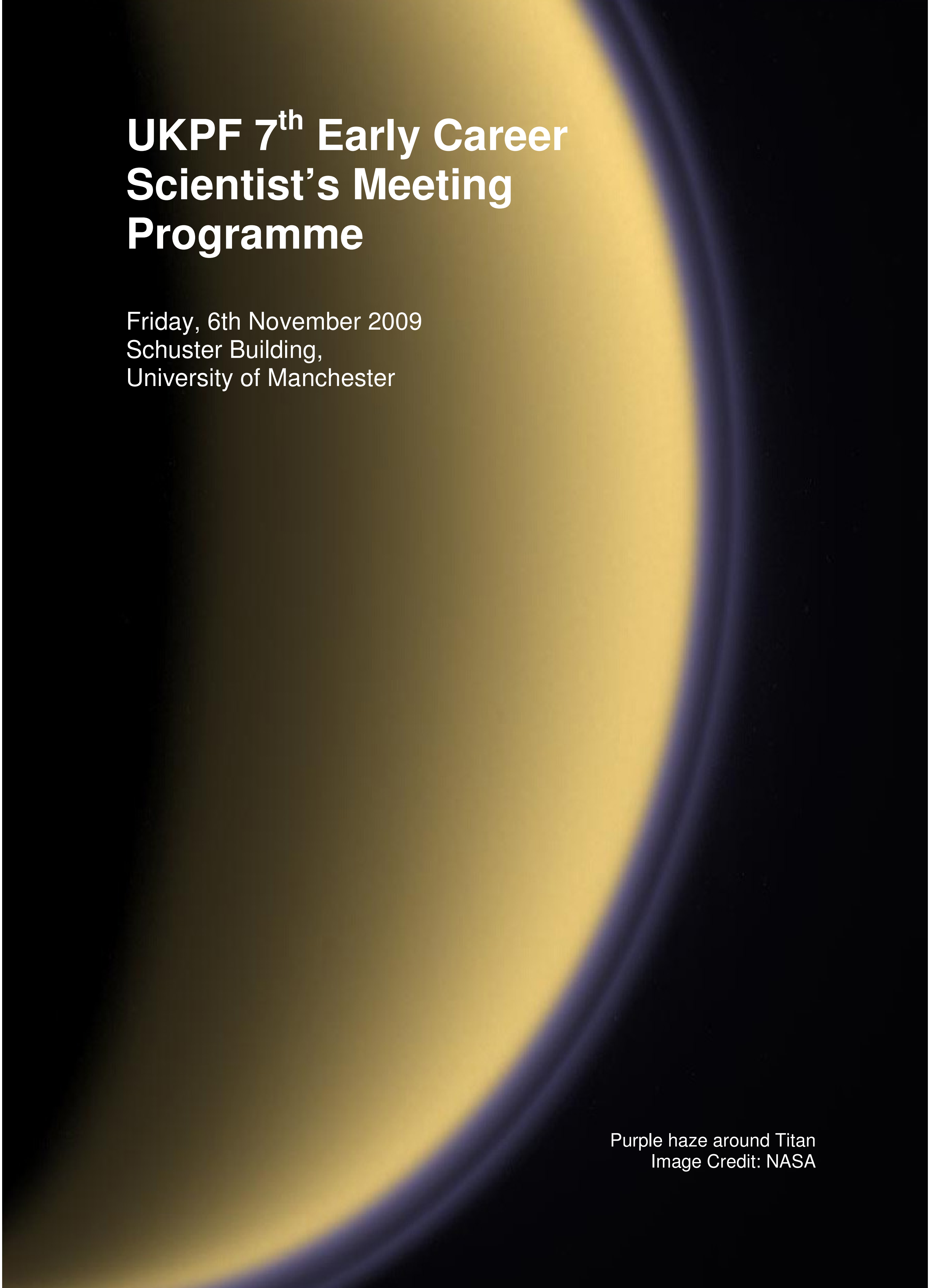
UKPF 7th Early Career Scientist's Meeting Programme

Friday, 6th November 2009
Schuster Building,
University of Manchester



Purple haze around Titan
Image Credit: NASA

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10.05 - 10.20

NATURAL NUCLEAR REACTORS ON EARTH AND MARS

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In the past the ^{235}U to ^{238}U ratio was higher as the result of the shorter half life of ^{235}U. This raises the possibility that ancient, large, high grade uranium deposits were sufficiently enriched to sustain fission chain reactions. This has been observed to be the case on Earth with well studied, 2 Ga old reactors at Oklo in West Africa (1). These developed shortly after the atmosphere became oxidizing, and the formation of large redox boundary hosted deposits was feasible. This work examines the possibility of such redox boundary deposits occurring on Mars, where the present surface is highly oxidized. Their implications for martian heavy noble gases is discussed. The possibility of detecting redox hosted deposits from orbit (from coloured uranium/vanadium minerals), or using rover based radiation detectors is investigated.

In the early Archaean and Hadean on Earth the atmosphere was non-oxidising, and redox boundary uranium deposits could not form. However, uranium did concentrate as detrital uraninite in placer deposits (2). Such deposits formed as a result of erosion of uraninite containing (S-type) granites, derived either from crustal melting or subduction-like processes, or in the Hadean, from the differentiation of impact melts. The non-oxidising environment ensured that the heavy uraninite grains did not oxidize to soluble uranium(VI) species. These locally reached high enough grades (3) for natural reactors to operate, particularly at the high levels of $^{235}U/^{238}U$ which would have been present in the Hadean. While the mass of uranium in a placer of fissionable grade at any one time may have been small, such alluvial systems were dynamic, constantly reworking material. The overall mass of uranium processed over time could be large. The implications of this for fission noble gases are examined, in particular, in the context of Hadean zircons, which would have been processed by the same placer systems. The effects of such reactors would be especially evident in zircon xenon isotopes. The possibility of such reactors operating on Noachian Mars is also discussed. Impact melt differentiation would have occurred, and Noachian Mars shows evidence of intense tectonic activity. The key questions for producing uraninite enriched granites on Mars, and also for redox boundary deposits, is whether large quantities of organic material are required as reductants, and if they are necessary, whether they were present on ancient Mars.

References

[1] Gauhtier-Lafaye F., *et al.*, *in Energy, Waste, and the Environment: a Geochemical Perspective* 2004.
[2] Frimmel H.E. and Minter W.E., et al. *Earth-Science Reviews*, 70, 1-46 2005
[3] Mikhailov V.A., *Lithology and Mineral Resources*, 41, 4, 389–398 2006

10.20 - 10.35

POSSIBLE SIGNATURES OF KELVIN-HELMHOLTZ WAVES ON THE DUSK FLANK OF THE KRONIAN MAGNETOPAUSE

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A comprehensive survey of crossings of both Saturn's magnetopause and bow shock on the dusk side between January 2007 and December 2007 was compiled, using data from the Cassini fluxgate magnetometer and the Cassini electron spectrometer. Bow shock and magnetopause crossings were determined by the criteria discussed in *Masters et al.*, 2008 and *Masters et al.*, 2009 [1] respectively. 396 magnetopause crossings and 165 bow shock crossings were identified with large spatial variation; the high temporal frequency of crossings combined with the large radial variation was indicative of highly dynamic boundaries. A set of magnetopause crossings occurring near the nose of the magnetopause on the 30th June and 1st July 2007 were then analysed using minimum variance analysis (MVA) of the magnetic field vectors over the crossing interval to determine the direction of the boundary normal at each crossing. Using MVA analysis again to calculate the maximum variance direction of the magnetopause normals, I found a clear preferred direction of variance of the normals. The normals were found to deviate by an average of 30° about the average normal direction in the plane of maximum variance, but only by 12° in the perpendicular plane. The observed oscillation of dawn side crossing normals (*Masters et al.*, 2009) was not present throughout the whole dusk set, but was present for subsets, which is suggestive of wave activity. Considering the orientation between the magnetospheric magnetic field and the direction of maximum variance of the normals, the Kelvin-Helmholtz (K-H) instability is the likely driving force of these boundary perturbations. Current work involves analyzing two further magnetopause crossing sets, one further dusk-ward and one closer to noon (SLT), to identify whether K-H waves are also present at these locations.

References

[1] Masters, A.; McAndrews, H. J.; Steinberg, J. T.; Thomsen, M. F.; Arridge, C. S.; Dougherty, M. K.; Billingham, L.; Schwartz, S. J.; Sergis, N.; Hospodarsky, G. B.; Coates, A. J. *Hot flow anomalies at Saturn's bow shock,* J. of Geophys. Res., Vol. 114, 2009

11.30 - 11.45

ALTERATION ASSEMBLAGES IN THE NAKHLITES: VARIATION WITH DEPTH ON MARS

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Introduction & Techniques: The nakhlite SNCs are clinopyroxenites thought to have crystallised as cumulates within a thick basic-ultrabasic lava flow or shallow (~100 m) intrusion on Mars 1.3 Ga.[1,2] They contain evidence of water-based weathering processes on their parent body-Mars. This is in the form of secondary alteration assemblages present in olivine fractures and also within the mesostasis.[2] The secondary mineral assemblages include siderite, clay-like phases and evaporite salts.[1] The nakhlites are also thought to sample different depths relative to one another, with the Yamato 000593/749 rocks (and Miller Range 03346) at the top and Lafayette at the base.[1,3] We report the results of a Transmission Electron Microscopy (TEM) and Electron Probe Micro Analysis (EPMA) study of Nakhla, Lafayette, Y000593, Y000749 and GV in order to document in more detail how the mineralogy of the secondary mineral assemblages within olivine fractures and mesostasis varies between the nakhlites. FIB-SEM techniques were used for sample preparation and High Resolution TEM (HRTEM), Energy Dispersive X-ray spectroscopy (EDX), Selected Area Electron Diffraction (SAED) and nano beam diffraction and were performed for subsequent TEM.

Results: All of the nakhlites studied - Lafayette, Nakhla, GV, Y000593, Y000749 have fracture-filling veins in the olivine which consist largely of amorphous hydrated silicate – a gel. Sawtooth shaped veins in Lafayette at the bottom of the pile consist of a siderite-smectite-ferrihydrite-hydrated silicate gel assemblage. TEM shows progressive cooling and oxidation of a fluid which initially precipitated siderite along the vein margins.[4,5] This has been corroded and replaced by coarsely crystalline clay. Zones of coarse clay transition to finer grained clay and ferrihydrite eventually leading to the gel in the centre of the veins. The crystalline clay in Lafayette is chemically close to saponite composition but with unusually large amounts of Fe and is also structurally close to a nontronite standard analysed by SAED. Corresponding veins in Nakhla and GV further up the pile predominantly contain a siderite-gel assemblage, with additional evaporites including gypsum. Y000593/000749 veins are only dominated by the gel. EPMA of the gel in each of the nakhlites shows its composition to be a hydrated Fe-Mg-Al silicate. The gel's Mg/Mg+Fe ratio (Mg#) decreases from Lafayette to GV to Nakhla and then Y000593. The gel of Lafayette has a similar Mg# to the coarse smectite but is marginally higher in Fe + Si abundances. Thus, TEM observations coupled with Fe and silica enrichment from the clay to gel suggest that later stages of rapid cooling of the nakhlite fluid led to precipitation of the gel in the centre of the veins. These final 'pulses' of fluid also seem to be related to a single fluid evident. The volume of alteration minerals in Lafayette is highest (10% of olivine) followed by Y000593 (4%) and similar volumes for Nakhla and GV (3%).

Nakhlite Hydrothermal Cell: Compositional fractionation of the gel suggests the nakhlite hydrothermal fluid flowed up this depth profile. Based on this the hydrothermal fluid may have been initiated by melting of buried H_2O-CO_2 below the base of the nakhlite parent body. Our results suggest that the siderite and Fe-smectite formed at close to neutral pH, 100-170 ^oC. Relatively low water to rock ratios (W/R) of 1-10 may have occurred in Lafayette[6] with smaller values for the other nakhlites. This is also reflected in the volume of alteration minerals acting as proxy for W/R values. Textural evidence of rapid cooling by

TEM, together with the W/R and likely fluid velocities, imply that the secondary assemblages formed within months. The sawtooth fracturing found especially within Lafayette, Nakhla and GV has led us to propose a model describing the formation of secondary assemblages in the nakhlites by an impact-induced hydrothermal system terminated by precipitation of the amorphous gel and evaporation of soluble salts.[2,5] The similarity between the nakhlite secondary assemblages and those recently identified on Mars[7,8] also suggest that impact-induced hydrothermal alteration was a major process in the alteration of the near-surface of Mars.

References
[1] Bridges J. C. & Warren P. H., *J. Geol. Soc.* 163., 229-251 (2006).
[2] Bridges J. C. & Grady M. M., *Earth & Planet. Sci. Lett.* 176., 267-279 (2000)
[3] Mikouchi T. *et al*., *LPSC* XXXVII #1865 (2006).
[4] Changela H. G. & Bridges J. C. *LPSC* XXXX #2302 (2009).
[5] Changela H. G. & Bridges J. C. *MAPS* (2009) *in review*
[6] Baker L. L. *et al*., *MAPS* 35., 31-38 (2000).
[7] Mustard *et al*., *Nature* 454.,305-309 (2008).
[8] Ehlmann *et al*., Science 322., 1828-1832 (2008).

11.45 - 12.00

SILICON ISOTOPES IN METEORITES AND THE LIGHT ELEMENT IN THE EARTH'S CORE

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It has long been proposed that the Earth's core must contain significant quantities of light elements, such as H, C, Si, S and K [1]. The superchondritic Mg/Si of the terrestrial mantle has been used to argue that Si in particular is an important component in the core [2].

One possible tool for constraining the Si concentration in the core is stable Si isotope ratios. The difference in structure between the silicate mantle and metallic core could lead to Si isotope fractionation. If silicon isotopes entered the core and fractionated, there should be a difference between the silicon isotope signature of the silicate material of undifferentiated meteorites (chondrites) and that of the Earth's mantle. Georg et al. [3] reported a measureable difference in the silicon isotopes signature between chondrites and the bulk silicate Earth (BSE). It was suggested that the fractionation was result of silicon entering the core. However, the initial findings by Fitoussi et al. [4] found barely resolvable differences between carbonaceous chondrites and terrestrial samples.

The new results from Oxford support Georg et al.'s findings that there is a measureable difference between the silicon isotope signature of chondrites and that of BSE. It was also found, as in [3], that chondrites and achondrites have the same average Si isotope signature which points to a fractionation event unique to the Earth that has not been experienced by the differentiated bodies of Mars and Vesta. One possible event is high pressure and high temperature core formation. With a chondritic $\delta^{30}Si = -0.48$, BSE $\delta^{30}Si = -0.32$ and the maximum range of published fractionation factors (0.5-2) [5,6] basic mass balance calculations constrain the Si budget in the core to 3.6-20wt%. This is well within the constraints from seismology and conceivably suggest that Si is the only light element in the Earth's core.

References

[1] Birch, F. *Journal of Geophysical Research*, 69, 4377-4388 (1964)
[2] Ringwood, A. E., *Earth and Planetary Science Letters* 95, 1-7 (1989)
[3] Georg, R. B., *et al. Nature* 447, 1102-1106 (2007)
[4]Fitoussi, C. *et al.. Geochimica et Cosmochimica Acta* 72, A273 (2008)
[5]Schauble, E. A., *et al .Eos Trans. AGU* 88(52), Fall Meet. Suppl., Abstract V42A-07 (2007)
[6] Shahar, A. *et al. Geochimica et Cosmochimica Acta* 72, A848.(2008)

12.00 - 12.15

NEGATIVE IONS AT TITAN – DENSITY TRENDS.

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The Electron Spectrometer of the Cassini Plasma Spectrometer (CAPS-ELS) has revealed the existence of negative ions in Titan's ionosphere (Coates et al, 2007, Waite et al, 2007). These are observed when the instrument points in the ram direction at altitudes between 950 and 1400 km. The ions have masses up to 13 800 amu/q. This indicates that complex hydrocarbon and nitrile chemical processes take place in Titan's upper atmosphere. With data from over 20 encounters and using spacecraft attitude changes and an increased number of measurements from recent CAPS actuator fixed flybys we have accumulated a large negative ion data base. Coates et al. (2009) discussed trends of the highest masses with solar zenith angle (SZA), altitude and latitude. We now extend this study to *density* trends of different masses. Groups of masses can be identified because similar peaks are observed in the mass spectra of different encounters. We investigate the effects of different controlling parameters such as altitude, solar zenith angle, latitude, Titan local time, and the angle between magnetospheric and solar ionisation sources. The aim of this study is to help constrain the chemical formation and destruction processes of negative ions in Titan's ionosphere. We present the results and discuss their implications. For instance, for higher masses of 110-200 amu at an altitude range of 950 – 1050 km the highest densities can be found on the nightside, whereas the highest densities of low masses (10 – 30 amu) can be found on the dayside at low SZAs in the same altitude range. Therefore, nightside reactions seem to yield the highest densities for higher masses and photochemical reactions yield the highest densities for the lower mass negative ions.

12.15 - 12.30

EMISSION MEASUREMENTS OF LUNAR ANALOGUE MINERALS IN A SIMULATED LUNAR ENVIRONMENT FOR INTERPRETATION OF RETURNING DATA FROM THE DIVINER LUNAR RADIOMETER ON LRO

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A lunar thermal environment simulator has been constructed, in order to measure emission spectra of lunar analogue minerals in the same thermal environment as is present on the surface of the Moon. This data is directly comparable to measurements made by the Diviner instrument, currently in orbit around the Moon onboard the Lunar Reconnaissance Orbiter (LRO), allowing the composition of the Moon's surface to be further determined, as part of the Diviner Compositional Investigation[1].

Diviner is a nine-channel infrared mapping radiometer, currently making high resolution (~160m per pixel) observations of the lunar surface from a ~50km lunar orbit[2]. The instrument's filters are designed to map the temperature, mineralogy, albedo, rock abundance and bulk thermal properties of the surface regolith (soil)[2]. Three channels, located around 8µm, are capable of determining the spectral location of the Christiansen Feature (CF)[3], the primary spectral feature observed in mid-infrared measurements of the Moon[4,5]. Four other channels, from 13 to 400µm, are capable of mapping variations in emissivity of the lunar surface.

The CF of a feldspathic mineral is located at a shorter wavelength than a mafic mineral, hence this emissivity maximum can be used as a compositional indicator[6,7]. It is observed as an emissivity maximum, and is enhanced by the lunar environment. In the top few hundreds of microns, at low to mid-latitudes during the daytime, large thermal gradients are induced due to very low heat transport within the lunar regolith[8,9,10,11]. The surface is cooled as it radiates to cold space, but soil transparency in the spectra around the CF region causes radiation to be emitted from the deeper, hotter layers, producing an emission maximum. Regolith grain size, mixing ratios, and the lack of atmosphere on the Moon also affect the shape and location of the CF[6,7,9,12].

The lunar thermal environment simulator creates an equivalent thermal gradient in lunar analogue minerals in the laboratory, by heating the minerals to ~400K while they are surrounded by a shroud cooled to ~120K by liquid nitrogen, all in a vacuum of <10^(-4)mbar. The simulator is attached to both a Brüker Fourier Transform Spectrometer and a Bentham Monochromator at the University of Oxford. This setup is capable of measuring emission spectra in a simulated lunar environment from the mid to far-infrared of a wide range of minerals of various grain size distributions. The analogous lunar minerals available are albite, andesine, anorthite, augite, bytownite, diopside, enstatite, fayalite, forsterite, ilmenite, quartz etc, and several mineral mixtures.

References

[1] Greenhagen B.T. & Paige D.A.(2009) LPS XL
[2] Paige, D.A. et al.(2009) Space Sci.Rev.
[3] Greenhagen B.T. & Paige D.A.(2006) LPS XXXVII
[4] Murcray F.H. et al.(1970) JGR, 75
[5] Lucey P.G.(1991) LPS XXI

[6] Salisbury J.W. & Walter L.S.(1989) JGR, 94
[7] Cooper B.L. et al.(2002) JGR, 107
[8] Logan L.M. & Hunt G.R.(1970) Science, 169
[9] Logan L.M. et al.(1973) JGR, 79
[10] Henderson B.G. et al.(1996) JGR, 101
[11]Henderson B.G. & Jakosky B.M.(1997) JGR, 102
[12]Nash D.B. et al.(1993) JGR, 98

14.00 - 14.15

A NEW FORM OF SATURN'S MAGNETOPAUSE USING A DYNAMIC PRESSURE BALANCE MODEL, BASED ON IN-SITU, MULTI-INSTRUMENT CASSINI MEASUREMENTS

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The shape and location of a planetary magnetopause can be determined by balancing the solar wind dynamic pressure with the magnetic and thermal pressures found inside the boundary. Previous studies have found the kronian magnetosphere to show rigidity (like that of Earth) as well as compressibility (like that of Jupiter) in terms of its dynamics. In this paper we expand on previous work and present a new model of Saturn's magnetopause. Using a Newtonian form of the pressure balance equation, we estimate the solar wind dynamic pressure at each magnetopause crossing by the Cassini spacecraft between Saturn Orbit Insertion (SOI) in June 2004 to January 2006. We build upon previous findings by including an improved estimate for the solar wind thermal pressure, and include low energy particle pressures from the Cassini plasma spectrometer's electron spectrometer (CAPS-ELS) and high energy particle pressures from the Cassini magnetospheric imaging instrument (MIMI). Our improved model has a size-pressure dependence described by a power law $D_P^{-1/5.0\pm0.8}$. This exponent is consistent with that derived from numerical magnetohydrodynamic (MHD) simulations.

14.15 - 14.30

EXPERIMENTAL STUDY OF SEDIMENT TRANSPORT BY WATER FLOWING UNDER MARTIAN CONDITIONS: APPLICATION TO GULLIES ON MARS

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The aim of this study is to explore the sediment transport and erosional capacity of water at current martian temperature and pressure. We performed laboratory simulation experiments in which a stream of water flowed over test beds at low temperature (~ -20 °C) and low pressure (~ 8 mB). The slope angle was 14° and three sediment types were tested. We compared the erosive ability and resulting morphologies to experiments performed at ambient terrestrial temperature (~ 20°C) and pressure (~1000mB) and also runs performed under low pressure only.

We observed that, as expected [1], water is unstable in the liquid phase at low temperature and low pressure, with boiling and freezing in competition. Despite this, our results show that water at low temperature and low pressure has an equivalent and sometimes greater erosion rate than at terrestrial temperature and pressure. Water flows faster over the sediment body under low temperature and low pressure conditions because the formation of ice at the liquid-sediment contact inhibits infiltration and thus increases flow speed and, as channels are formed, also flow depth. The increased flow depth increases both the thermal and mechanical erosive capacity of the flow.

We observed that low atmospheric pressure allowed bubbles to form within the sediment-ice mix, and note that the resulting surface roughness and increase in volume could be detected by present or future remote sensing instruments. Experiments at low pressure but Earth-ambient temperature revealed that the flow speeds are faster under these conditions than under Earth-ambient pressure and temperature. We hypothesise that this is due to gas bubbles impeding liquid infiltration. Differences in material permeability have a less marked effect on erosion and channel formation at low pressure and temperature, but still have an effect on runout distance.

Any future modelling of gullies on Mars should consider the extra mobility of flowing water and sediment under freezing conditions, especially as the process of freezing at the base of the flow that inhibits infiltration into the substrate. Previous models have shown fluid loss and flow velocity to be important parameters [2] and our work illustrates simple assumptions cannot be made. These results suggest that high discharge rates and thus large volumes of water suggested by other authors [3, 4] are not required to form martian gullies.

References

[1] Hecht M. H. *Icarus,* 156, 373-386, 2002.
[2] Pelletier J. D. *et al.*, *Geology,* 36, 211-214, 2008.
[3] Hart S. D. *et al.*, *LPSC XL*, abs#:2349, 2009.
[4] Heldmann J. L.and Mellon M. T., *Icarus,* 168, 285-304, 2004.

14.30 - 14.45

METEORITE KR IN EARTH'S MANTLE SUGGESTS A LATE ACCRETIONARY SOURCE FOR THE ATMOSPHERE

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Introduction: Noble gases are key tracers for the origin of volatiles in the terrestrial planets and of interaction between mantle reservoirs and the atmosphere. General consensus is that material accreting in the solar nebula and nebula gases from the Sun itself were incorporated into the terrestrial planets, providing a starting point for models of planetary evolution. However, the isotopic signatures of these accretion processes are often masked by air contamination and therefore deviations from air may be <1%, requiring high precision measurements. Typically, oceanic basalts, continental diamonds and xenoliths have provided the noble gas data for the mantle. Our current work focuses a suite of samples from individual wells that extract almost pure (>99%) CO_2 from beneath New Mexico, USA. These well gases have been shown to contain magmatic volatiles retained from the earliest stages of planetary formation [1].

Results: ^{82}Kr/^{84}Kr/^{86}Kr have been measured in 15 samples from individual wells from the Bravo Dome region, USA. Recent acquisition of the HELIX multicollector noble gas instrument manufactured by Thermo Scientific provides an improvement in precision of at least an order of magnitude over single collector instruments. The spectrometer operates with 5 Faraday collectors and 10^{12} ohm resistors, allowing determination of isotopic compositions with a precision of ~0.3‰. This has led to discovery of the first primitive Kr isotope signature in a terrestrial sample (Fig. 1).

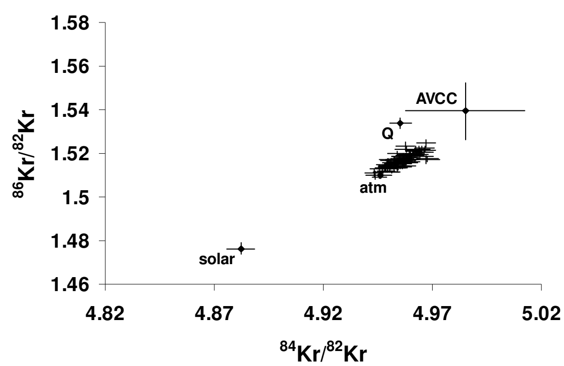

Figure 1: Kr isotope measurements of well gases showing a clear primordial component (Holland et al., 2009 in press). This is the first detection of non air Kr isotopes in a terrestrial sample.

Conclusions: We show this primitive signature is consistent with a meteorite or fractionated solar nebula source, but preclude an unfractionated solar source. The high precision Kr (and Xe) isotope data suggest that the Earth's interior acquired its volatiles from accretionary material similar to average carbonaceous chondrites and that the noble gases in Earth's atmosphere and oceans are dominantly derived from later volatile capture rather than impact degassing or outgassing of the solid Earth during its main accretionary stage. Whether this can be applied to the martian atmosphere, which has similar Kr/Xe isotopic and elemental ratios, is unclear.

References

[1] Holland G. and Ballentine C.J. *Nature* 441, 186-191. (2006).
[2] Holland G. *et al.*, *Science* In press (2009).

14.45 - 15.00

INVESTIGATING THE RHEOLOGICAL PROPERTIES OF PLANETARY ICES USING NEUTRON DIFFRACTION

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A clear understanding of the properties of ices and ice-rock mixtures at planetary conditions is important when considering the evolution of icy bodies in the solar system. In order to simulate structural and thermal evolution of planetary processes in these bodies using computer models, it is necessary for accurate input parameters to be available.

Currently there is very little data in the literature on the properties of ice-rock mixtures at the conditions relevant to icy bodies in our solar system. We are addressing this lack of data with a targeted experimental campaign both in the Ice Physics Laboratory at UCL and on Engin-X, the dedicated engineering diffraction beamline at the ISIS neutron spallation source (Rutherford Appleton Laboratory, U.K.)

Our experiments at UCL take the form of traditional uniaxial and triaxial deformation tests, where the samples are subjected to a differential stress sufficiently high to cause ductile shortening at a measureable strain rate [e.g., 1]. We can perform these measurements at temperatures as low as 220 K and at confining pressures up to 300 MPa. The properties observed in these experiments are those of the whole rock, whereas for multiphase materials it is often useful to know how each phase deforms. For instance, when considering ice-rock mixtures, the rock phase acts to pin grain boundary migration [2].

The neutron diffraction experiments at ISIS will allow us to investigate how each phase in the polyphase ice-rock samples is affected by the deformation of the whole sample. Neutrons are highly penetrating, so can pass through surrounding sample equipment (e.g. pressure vessels) and diffract from the entire sample. Each phase will give a distinct diffraction pattern, allowing strain partitioning between the phases to be investigated.

Engin-X is designed to carry out differential strain measurements [3] whilst collecting neutron diffraction data. In order to perform these experiments at the planetary conditions we require, we have adapted a previous pressure vessel design [4] and will use this with closed-cycle refrigerators to provide planetary pressures and temperatures.

We will present an overview of neutron diffraction and its applications for the characterisation of solar system ices, also summarising our preliminary studies of ice + fluorite mixtures at UCL and outline the scope for further studies.

References

[1] Durham et al., *J. Geophys. Res.* 102, 16293 (1997).
[2] Durham et al., *J. Geophys. Res.* 97, 20883 (1992).
[3] Santisteban, et al., *J. Appl. Cryst.* 39, 812 (2006).
[4] Covey-Crump et al., *J. Appl. Cryst.* 39, 222 (2005).

15.30 - 15.45

GROWTH OF THE KELVIN-HELMHOLTZ INSTABILITY AT SATURN'S MAGNETOSPHERIC BOUNDARY

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We present the first observations of a vortex structure in Saturn's dayside, outer magnetosphere. The identification of the structure provides conclusive evidence of the operation of the Kelvin-Helmholtz (K-H) instability [1] in Saturn's magnetospheric boundary region. Cassini observations taken during the inbound pass of the spacecraft's Revolution B orbit in Decmber 2004 are analysed. Magnetic field conditions during the magnetopause crossings that occurred on this orbital pass suggest that the magnetopause was highly K-H unstable. Following multiple magnetopause crossings the spacecraft encountered the low-latitude boundary layer [2]. Magnetic field, thermal plasma, and superthermal plasma observations made by Cassini during the spacecraft transition between the boundary layer and magnetosphere proper are consistent with an encounter with a vortex structure on the edge of the boundary layer – this interface is also anticipated to be K-H unstable [3]. High-energy (>20 keV) electrons observed while the spacecraft was within the vortex suggest that the structure was associated with auroral emissions [4]. A model of the coupling between an outer magnetospheric vortex and Saturn's ionsphere via field-aligned currents is proposed. Estimates based on Knight's theory [5] imply that field-aligned potentials of a few kV were associated with the region of upward-directed field-aligned current in the northern ionosphere, and that the resulting precipitation of accelerated electrons produced UV auroral emissions with an intensity of a few kR. We propose that K-H vortices in Saturn's outer magnetosphere produce bright spots of UV aurora. This discovery has implications for our understanding of the interaction between the solar wind and Saturn's magnetosphere.

References

[1] Kivelson M. G., and Pu Z. –Y., *Planetary and Space Science*, 32, 1335, 1984.
[2] Sckopke N., et al. (1981), *Journal of Geophysical Research – Space Physics*, 86, 2099, 1981.
[3] Ogilvie K. W., and Fitzenreiter R. J., *Journal of Geophyscial Research – Space Physics*, 94, 15113, 1989.

[4] Saur J., et al. (2006), *Nature*, 439, 699, 2006.
[5] Knight S., *Planetary and Space Science*, 21, 741, 1973.

15.45 - 16.00

USING INFRARED LASER HETERODYNE RADIOMETRY TO SEARCH FOR METHANE ON MARS

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Introduction: Methane has been detected in the atmosphere of Mars by several research teams in the last few years. Ground-based observations[1][2] and space-based instruments (e.g. the Planetary Fourier Transform spectrometer on Mars Express[3]) have reported low levels of methane gas (approximately 10 ppb) in the Martian atmosphere. An overview of these research findings will be presented.
Methane detection is important as its presence could imply a biological origin, and Martian methane sources are still unknown. However, current methane concentration measurements are at instruments' lower limits of detection. The viability of remote sensing using infrared laser heterodyne radiometry (LHR) to detect methane in the Martian atmosphere is being investigated. The LHR technique allows high spectral resolution (greater than 0.001 cm^{-1}) measurements over a narrow spectral range (~10 cm^{-1}) when a quantum cascade laser is used as local oscillator. The advantages of such an instrument, including its compact lightweight design, over current remote sensing spectral instruments are reviewed.

The Laser Heterodyne Radiometer: Laser heterodyne radiometers have been used extensively, and with much success, for atmospheric studies, such as work on stratospheric ozone[4], mainly because of their ability to make measurements with an ultrahigh spectral resolution (greater than 0.001 cm^{-1}).
A carefully selected specific high resolution microwindow provides as much information as a medium resolution radiometer covering a broad spectral range[5]. This major advantage favours the development of a small and lightweight LHR instrument over the current large and heavy Fourier transform spectrometers (FTS). FTS instruments require large optical path differences to achieve a high spectral resolution, which result in their large physical size and mass.
At the heart of the state of the art infrared LHR is the use of a Quantum Cascade Laser (QCL) as the local oscillator. QCLs are an ideal local oscillator for this instrument as they provide the necessary optical power and have spectral purity in the kHz to MHz range[5]. They have the advantage of continuous frequency tuning over a specific spectral window that can be precisely tailored to specifications. They also have the advantage of being extremely compact, robust and reliable devices which make them ideal candidates for flight and satellite deployment.

References

[1] Krasnopolsky et al. *Icarus*, 172, 537-547, 2004.
[2] Mumma et al. *Science*, 323, 1041, 2009.
[3] Formisano et al. *Science*, 306, 1758-1761, 2004.
[4] Weidmann et al. *Applied Optics*, 46, 7162-7171, 2007c.
[5] Weidmann et al. *Review of Scientific Instruments*, 78, 73107, 2007b.

16.00 - 16.15

GENTLE SEPARATION OF PRESOLAR GRAPHITE

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All presolar graphite grains analyzed to date were extracted from their host meteorite using acid dissolution techniques [1-4]. Recent studies have suggested that the use of harsh acids may significantly alter the outer surface of presolar SiC grains extracted in this way [5], and similarly may also affect graphite grains. We have previously described a technique for "gently separating" presolar SiC (i.e. without the use of acids) from meteorites [6], and have now adapted this procedure in order to isolate presolar graphite.

Approximately 116mg of CAI- and chondrule-free Murchison matrix material was crushed using a stainless steel mortar and pestle. This was further broken down into grain sizes of <20μm with 138 freeze-thaw cycles while suspending the sample in ultra-pure water. Using a fixed angle rotor centrifuge the grains were first separated into four grain-size fractions. A series of organic, heavy liquids was used to separate each size fraction according to density, selecting for presolar graphite between 1.6–2.26gcm^{-3}.

Small aliquots of several separations were distributed over cleaned, ultra-pure gold foils. An electron microscope was used to locate candidate graphite grains. The sample was then transferred to a Time-of-Flight Secondary Ion Mass Spectrometer (TOFSIMS) for sub-micron spatial resolution and high mass resolution (m/δm ~3000) analyses.

To date 23 candidate grains have been located in four different size and density separations. On average, graphite grain abundances are enriched from ~5ppm in bulk Murchison to 0.17% of the total deposited separation. Fifteen of the grains have been analysed using the TOFSIMS, of which 3 contain isotopically heavy C (lower than solar $^{12}C/^{13}C$ ratio) and likely formed in an AGB stellar environment. One grain has an apparent $^{14}N/^{15}N$ anomaly although this may have resulted from reactions in the solar system [7]. A trace element depth-profile for one grain shows no significant variation in trace element abundances within the grain.

In contrast to acid extracted presolar graphite grains, which are typically spherical in shape, these grains have irregular morphologies. Raman spectroscopy has previously shown that the structure of acid extracted presolar graphite ranges from highly disordered, to relatively well crystallised [3]. It is now being applied to gently separated graphite. Further work is required in order to clarify whether the irregular shapes of the grains reported here are potential artifacts of the separation procedure, or instead reflect the grains' original morphology.

References

[1] Amari et al. 1994. *Geochimica et Cosmochimica Acta* 58; 459-470.
[2] Hoppe P. et al. 1995. *Geochimica et Cosmochimica Acta* 59; 4029-4056.
[3] Zinner E. et al. 1995. *Meteoritics & Planetary Science* 30; 209-226.
[4] Jadhav M. et al. 2006. *New Astronomy Reviews* 50; 591-595.
[5] Henkel T. et al. 2007. *Meteoritics & Planetary Science* 42; 1121-1134.
[6] Tizard J. et al. 2005. *Meteoritics & Planetary Science* 40; 335-342.

[7] Amari et al. 1993. Nature 365; 806-809.

16.15 - 16.30

MAPPING MEDUSAE FOSSAE FORMATION OUTLIER MATERIALS IN THE SOUTHERN HIGHLANDS OF MARS

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The Medusae Fossae Formation (MFF) is an extensive deposit (2.2 x 10^6 km^2, [1]) of wind-eroded, friable material of widely debated origin which unconformably overlies a considerable area of the crustal dichotomy boundary on Mars. The MFF shows a variety of layering patterns, erosional styles and channel-like forms. We aim to constrain the origins and post-emplacement processes of this formation.

The Medusae Fossae Formation materials have been mapped into five main outcrops and into three geological members according to exposure and stratigraphy [2,3]. Away from these outcrops, there are numerous examples of materials across the Northern lowlands that have surface morphology and erosional characteristics similar to MFF material [4,5] but few studies have examined the possibility of MFF outliers on high ground south of the dichotomy boundary.

A preliminary transect survey revealed apparent outlying MFF materials in the southern region of the Mangala Valles area of Mars. A more intensive study of MOC NA images in this region resulted in many observations of similar material. The majority of these examples were found to have a NW orientation, consistent not only across this area but also with the dominant orientation of the main MFF outcrops. This provides the first evidence for MFF-like deposits on the southern highlands. We suggest that there might be two possible explanations for these outliers:

1) The MFF had a much greater pre-erosional extent than previously estimated
2) Materials from the main outcrops were eroded and then blown south to accrue in the highland areas, where they were subsequently reworked

Our ongoing work seeks to identify links between the outliers and the main outcrops, and to establish which of the above two possibilities is most likely. If the materials are found to drape the topography (option 1), this would support an airfall deposition process.

References:

[1]Bradley et al., 2002, JGR 107
[2]Tanaka & Scott, 1986, USGS Map I–1802–A
[3]Zimbelman et al., 1996, LPSC Abstract 1495-1496
[4]Watters et al., 2007, Science 318
[5]Keszthelyi et al., 2008, LPSC Abstract #2420.

16.30 - 16.45

LUNAR LANDING SITE SELECTION WITHIN THE SOUTH-POLE AITKEN BASIN – LPI LUNAR EXPLORATION SUMMER INTERN PROGRAM 2009.

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Constellation is the National Aeronautics and Space Administration's (NASA) successor to the Apollo program. A significant part of the Constellation program is the selection of lunar landing sites which will maximise the scientific return of a manned mission to the Moon. The Lunar and Planetary Institute in Houston, Texas is working closely with NASA on this issue. It has initiated an intern program which, for the last two years, has allowed graduate students in geology and planetary science to be involved in the site selection process. This year we were tasked with the process of examining the potential of landing sites within the South Pole-Aitken Basin, based on the scientific objectives set out in the 2007 report by the American National Research Council [1].

With a diameter of ~2500 km [2], the South Pole-Aitken Basin is one of the largest impact structures in our Solar System, and as such provides a unique opportunity study large, basin forming impact processes. It is believed by many that the formation of the South Pole-Aitken Basin excavated material from deep within the Moon's lower crust and possibly even the lunar mantle [3][4]. It is also the oldest of the known basins on the Moon [2]. Therefore, constraining the age of the South Pole-Aitken Basin would be of great value in determining the early impact history of the Moon.

Site locations were constrained using mission architectures described in previous studies [5][6]. These involve having an outpost at the lunar south pole, and making traverses with maximum distances of 500-1000 km from the pole. A scenario of longer range sortie type missions was also considered. Based on these limits, three sites were identified within the basin. Within 500 km of the south pole, Schrödinger basin is believed to offer the optimum opportunities for scientific return, especially with regard to increasing our understanding of lunar volcanism [7]. The possible presence of excavated mantle material exhumed by Antoniadi basin (within 1000 km of the south pole) make it another important target location. Finally, geochemical anomalies around Von Karman crater [8] in the north of the basin, make it an area of particular interest for a sortie type mission architecture.

References

[1] National Research Council, *The scientific context for exploration of the Moon*, The National Academies Press, Washington D.C., 2007.
[2] Wilhelms D.E., *USGS Professional Paper* vol. 1347, p. 148, 1987.
[3] Pieters, C. M., et al., *Geophysical Research Letters* vol. 24, 1903–1906, 1997.
[4] Lucey, P. G., et al., *Journal of Geophysical Research* vol. 103, 3701, 1998.
[5] Spudis P. D. and Bussey D. B. J., *Lunar and Planetary Institute Science Conference Abstracts* vol. 34, 1693, 2003.

[5] Clark P. E., et al., *Lunar and Planetary Institute Contributions*, 1415, 2008.
[6] Clark P. E., et al., *Lunar and Planetary Institute Science Conference Abstracts* vol. 40, 1135, 2009.
[7] Kohout T. et al., *Lunar and Planetary Institute Science Conference Abstracts* vol. 40, 1572, 2009.
[8] Garrick-Bethell, I., and Zuber M.T., *Geophysical Research Letters* vol. 32, L13203, 2005.

Poster

MINERAL MAPPING OF INTERIOR LAYERED DEPOSITS ON MARS

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Evidence of water on Mars is considered vital in the quest for surface materials of exobiological significance. The surface mineralogy can indicate the presence of past water by identifying deposits of water-altered minerals [2].

The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), a mineral mapping, visible-infrared spectrometer flying onboard the Mars Reconnaissance Orbiter (MRO) [6], can map mineralogy to a resolution of 15-19 m per pixel [5]. With a wavelength range of 362 to 3920 nm over 544 separate channels, CRISM can identify a broad range of minerals and produce images up to 20 times the resolution of past Mars mineral mappers [6]; leading the search for evidence of past water on Mars. The hyperspectral CRISM data can be condensed to thematic colour images; detailed “mineral indicator maps” that show spectral variations related to the types of minerals present.

The initial research focuses on a 10km square area, within the 167 km diameter Becquerel Crater in Arabia Terra. This area has one of the best exposed Interior Layered Deposits (ILD) on Mars [1]. Mineral maps were created from targeted observations captured by CRISM on October 24, 2006, corrected for both atmospheric and photometric effects using the CRISM Analysis Tool [4].

The ILD within Becquerel Crater exhibit a variety of compositional signatures in several maps, demonstrating mineralogical diversity. Colour-coded evidence of compositional variations coincides with the observed light-dark layering. The ILD area is generally of basaltic composition, with a ferric coating of dust on layer edges. This registers as fine-grained high-Ca pyroxene and olivine minerals; dark layers exhibiting stronger low-Ca pyroxene with ferric coatings. Loose material accumulates on some layers, similar in signature to the dark basaltic sand grains, which also surrounds the ridges of light material.

Our preliminary maps enable qualitative compositional analysis. A fuller interpretation will include consideration of possible false mineral identifications due to illumination or instrumental effects. Future use of hyperspectral data will also use the entire spectral signature as opposed to the selected band depths used in this study so far. An accurate spectral characterisation across the layered structures will further our understanding of suggested relationships between obliquity and climate variations [3] and assess the role of water in their deposition [1].

References

[1] Bridges, J.C. *et al.*, *Lunar and Planetary Science XXXIX* no.1319, p1913, 2008.
[2] Carr, M.H. *The Surface of Mars,* Cambridge, 307pp, 2006.
[3] Laskar, J. *et al.*, *Icarus*, vol. 170, *2*, p343-364, 2004
[4] Morgan, F. *et al., CRISM Data Users' Workshop: CAT Tutorial*, 2009.

[5] Murchie, S. *et al.*, *6th International Conference on Mars*, p3062, 2003.
[6] Murchie, S. *et al., J. Geophys. Res.,* vol.112, E05S03, 2007.

Poster

UNDERSTANDING ANCIENT MARS THROUGH ALH84001 CARBONATE SYNTHESIS

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The origins of the carbonates within martian meteorite ALH84001 are of great importance for understanding the ancient martian environment. Thought to have formed ~3.9 Ga [1], they are assumed to have precipitated from fluids with neutral to alkaline pH in contact with CO_2. Approximately 0.6 Ga separates primary crystallization of ALH84001 from formation of secondary mineral assemblages. The period in which the carbonates formed has been called the Phyllosian era, owing to the outcrops of phyllosilicates discovered by the OMEGA and CRISM spectrometers [2, 3]. Their ancient age, abundance and mineralogical variations make ALH84001 carbonates ideal candidates to provide insights into early martian environmental conditions.

We are attempting to constrain the carbonate precipitation environment by modelling how changes in fluid and atmospheric composition, oxygen fugacity, temperature, etc change the final precipitation products. We are using the Geochemist Workbench™ (GWB) program to assist with modelling the Mg-Fe-Ca system. A variety of initial concentrations will be combined with CO_2 fugacities and temperatures to assess the effect of each variable on the system.

In order to determine the boundary conditions for precipitation, without straying into kinetically, or thermodynamically, unviable environments, we are also producing synthetic carbonates from fluids of known composition at known temperatures, following on from the precipitation experiments by Golden et al. [4, 5]. The resulting samples will then be characterized by XRD and SEM for compositional analysis, imaging and mapping. We will compare the synthesized carbonates with carbonate from ALH84001 to ensure that our derived environments are realistic for the martian surface. Solution compositions from our synthetic carbonate production experiments, as well as simulated or approximated compositions taken from literature [4, 6] will define the initial starting conditions for the modelling.

The results from modelling and carbonate synthesis will help reveal the conditions of the period on Mars that is of greatest interest for future missions when the planet may have had a 'warm and wet' environment. The results from planned future work will provide insights into more recent cold and dry environment and how aqueous solutions have evolved over the history of Mars.

References

[1] Borg, L.E. et al. (1999) *Science*, 286, 90-94.
[2] Bibring, J.-P. et al. (2006) *Science*, 312, 400-404.
[3] Mustard, J. F. et al. (2008) *Nature*, 454, 305-309.
[4] Golden, D. C. et al. (2001) *American Mineralogist*, 86, 370-375.
[5] Golden, D. C. et al. (2000) *LPSC. XXXI*, Abs #1799.
[6] Corrigan, C. M. and Harvey R. P. (2004) *MAPS*, 39, 17-30.

Poster

RESONANCE PHOTOIONIZATION MASS SPECTROMETRY FOR DETERMINATION OF ISOTOPE RATIOS OF KRYPTON IN EXTRATERRESTRIAL SAMPLES

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Analysis of samples returned by e.g. the Genesis and Stardust NASA missions requires instrumentation with extremely high sensitivity (~1000 atoms). Information about krypton isotope ratios of primitive meteorites or individual SiC grains can help to better understand the irradiation history of the early solar system [1,2] and to study the physics (e.g. s-process temperature and neutron flux) of nucleosynthesis sites [3].

A time of flight mass spectrometer with pulsed resonant laser ionization system capable to perform the measurements at ultra trace level has been developed in our laboratory [4, 5]. An example of TOF spectra of Stannern meteorite and air samples containing ~10^6 krypton atoms can be seen in Fig.1.

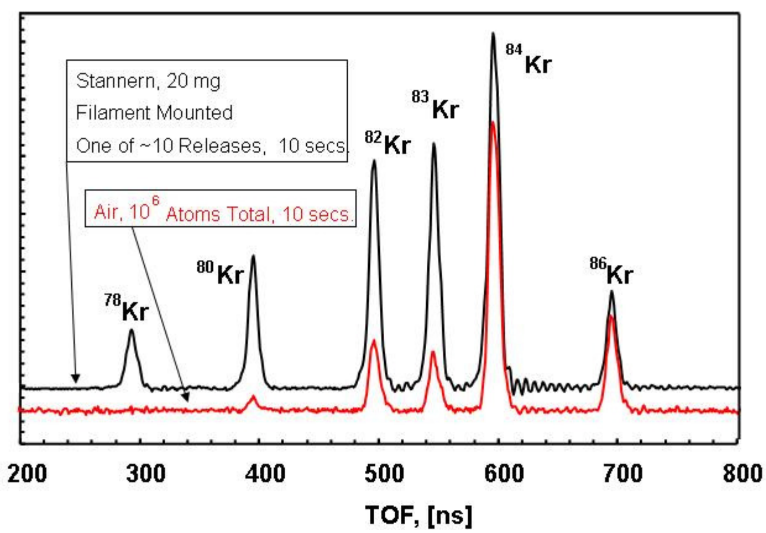

Figure 1: TOF spectra of Krypton measured for air samples and Stannern meteorite. In both cases the total Kr content was 10^6 atoms. In the air spectrum the ^{84}Kr peak corresponds to 5.7×10^5 atoms and ^{80}Kr peak to 2.3×10^4 atoms.

References

[1] Eugster et al. (2002) MAPS 37, 1345-1360.
[2] Polnau et al. (2001) GCA 65, 1849-1866.
[3] Lewis et al. (1994) Geochim.Cosmochim.Acta 58(1) 471-494.
[4] I.Strashnov et al., Opt. Comm., 282, 17, 3487-3492 (2009).
[5] I.Strashnov et al., Opt. Commun. 282, 5, 966-969 (2009).

Poster

THE TRANS-TERMINATOR ION FLOW IN THE VENUSIAN IONOSPHERE NEAR SOLAR MINIMUM

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The Venusian ionosphere is dominated by flow from the subsolar region towards the night sector, driven primarily by the day-to-night pressure gradient. Pioneer Venus Orbiter made extensive in-situ plasma observations close to solar maximum, which showed that this flow was a substantial source of nightside plasma [1]. At solar minimum radio occultation profiles showed that this mechanism was severely inhibited by a lower dayside ionopause [2]. However, prior to Venus Express, data coverage at the lowest part of the solar cycle was extremely limited.

The ASPERA-4 instrument on Venus Express is currently conducting in-situ measurements of plasma in the Venusian ionosphere close to the terminator near solar minimum. There are assymetries in the distribution of the plasma in both the dawn-dusk and noon-midnight planes. In the dawn-dusk direction a greater number of ions are observed on the dusk side compared to dawn. As dayside plasma in the post-noon sector has a larger ion density than the pre-noon sector this is consistent with the antisunward transport of plasma. In the noon-midnight direction ions are observed nightward of the terminator, which is not inconsistent with antisunward flow. The difference in ion energies observed when the spacecraft orbits in the noon to midnight direction compared to when it flies from midnight to noon suggest a nightward ion flow of some 5 km s^{-1}.

References

[1] Knudsen et al. (1981) *GRL,* 8, 241-244.
[2] Knudsen et al. (1987) *JGR,* 92, 13391-13398.

Poster

CARBON ISOTOPES IN THE SOLAR SYSTEM

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The ratio of 12-carbon to 13-carbon throughout the Solar System shows homogeneity whether one looks at the centre, the Sun, or at the farthest components, comets. This homogeneity runs contrary to chemical models of carbon fractionation in the early Solar System, where distinct regions of similar $^{12}C/^{13}C$ ratio arise due to the chemical and physical processes which are ongoing in those regions. Here we present such a chemical model and discuss how heterogeneity can become homogeneity, and the implications this has for the formation of the Solar System.