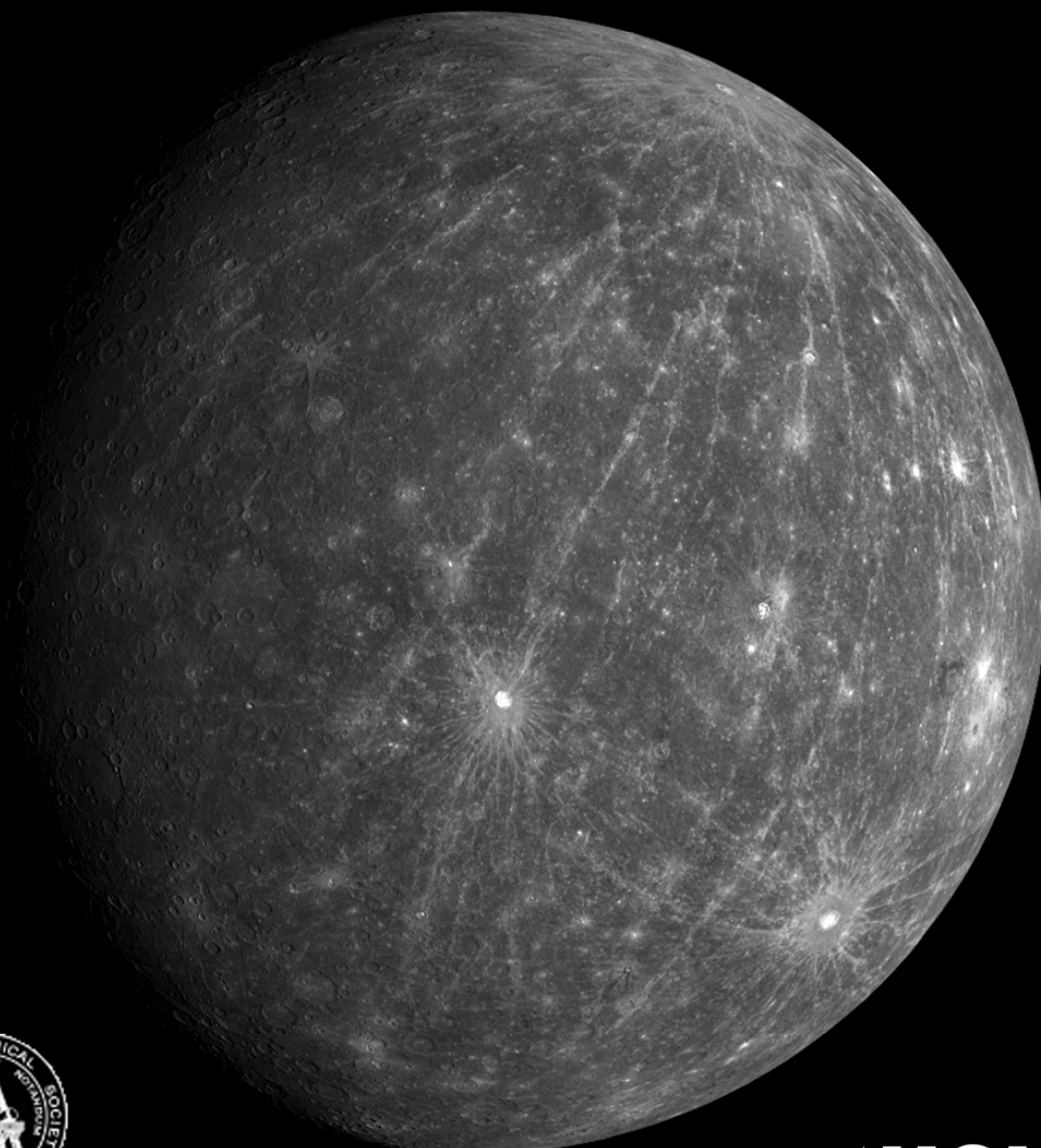
UK Planetary Forum

Early Career Scientists' Annual Meeting

3rd November 2008

University College London



UCL

The UK Planetary Forum

http://ukplanetaryforum.org
ukpf@hotmail.co.uk

Affiliated to the Royal Astronomical Society
http://www.ras.org.uk

The UK Planetary Forum (UKPF) was founded in 1996 as a representative body of the planetary science community. Its main aim is to promote planetary research in the UK among scientists and the public. UKPF is affiliated with the Royal Astronomical Society (RAS).

The UKPF maintains a website and mailing list through which announcements, news and opportunities are posted. There are currently over 300 members of the UKPF from institutions across the UK and the worldwide community of planetary scientists. The list also includes research council and media representatives.

We are keen to develop innovative activities to promote planetary science in the UK and welcome suggestions and ideas from members.

How to join:
We urge all members of the planetary science community to join the UKPF. Email your name and research details to the address above, or contact one of the committee members directly.

UKPF Committee:
Katherine Joy (Chair, Birkbeck College /University College London: k.joy@ucl.ac.uk)
Vic Pearson (Vice-Chair, The Open University: v.k.pearson@open.ac.uk)
Caroline Smith (Vice-Chair, Natural History Museum: c.l.smith@nhm.ac.uk)

Acknowledgements

The UCL Faculty of Mathematical and Physical Sciences (MAPS) have very kindly assisted in purchasing refreshements for the meeting. We are greatful for their generous donation. Details of the MAPS Faculty can be found http://www.ucl.ac.uk/maps-faculty/

Representatives from Astronomy Now Magazine and Astronomy Now Website ttp://www.astronomynow.com/ will be attending the meeting. This will provide a good opportunity for early career scientist's to practice their media skills, and to discuss their planetary science research interests. For more details please contact Dr. Emily Baldwin atemily@astronomynow.com .

Cover: Mercury from NASA Messenger's closest approach. 7 Oct 2008. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington.

UK Planetary Forum, Early Career Scientist's Meeting 2008.
Scientific Programme

09.00	Registration and coffee
09.25	Welcome from Katherine Joy, UKPF Chair and Prof. Richard Catlow, Head of Faculty of MAPS
09.30	Plenary - Dr. Tom Pike, title TBC
10.00	Characterisation of Near Earth Asteroids for a Sample Return Mission: Thermophysical Modelling *Rozitis, B. and Green, S. F*
10.15	Xenon Isotopes in Shergottites: RBT04262, DAG489, Shergotty and EET79001 *Cartwright, J. A., Ocker, K. D., Busfield, A., Holland, G., Crowther, S., Burgess, R. and Gilmour, J. D.*
10.30	Analysis of Hydrous Phyllosil;icates in Stardust Type B Track Analogues *Forster, N. J., Kearsley, A. T., Burchell, M. J., Wozniakiewicz, P. J., Creighton, J. A. and Cole, M. J*
10.45	Coffee and tea
11.00	Electron Absorption Microsignatures of Saturn's Icy Moons *Kanani, S., Jones, G. H. and Roussos, E.*
11.15	Identifying the Meteoritic Building Blocks of Earth *Steele, R., Elliott, T., Coath, C. and Regelous, M.*
11.30	Prompt Gamma Activation Analysis of Martian Analogues at the FRM-2 Neutron Reactor *Skidmore, M. S., Ambrosi, R. M., Benedix, G., Bucheri, T. and Schillinger, B.*
11.45	Findings of the LPI's 2008 Lunar Exploration Summer Intern Programme *Weider, S., Kohout, T., Losiak, A., O'Sullivan, K., Thasien, K. and Kring, D.*
12.00	Recent Gullies on Mars - Does this mean Water on Mars? *Conway, S. J., Balme, M. R., Towner, M. C., Murray, J. B. and Decaulne, A.*
12.15	Lunch
13.30	What Ureilite Meteorites can tell us about the Geological History of a Differentiated and Undifferentiated Asteroid *Downes, H. D.*
13.45	Lunar Crustal Magnetism: A Magnetisation Model of the Reiner Gamma Region *Carley, R. A., Whaler, K. A. and Purucker, M. E.*
14.00	Reflectance Properties of Low T_J Objects in the Near-Earth Population *Duddy, S. R., Fitzsimmons, A. and Lowry, S. C.*
14.15	Planslife for Venus: A Code to Assist in the Interpretation of Ionospheric Observations *Wood, A. G., grande, M. and Pryse, S. E.*
14.30	Understanding Ancient Mars through Isotope Studies and Synthetic Formation of ALH84001 Carbonate Rosettes *Tomkinson, T., Busemann, H., Franchi, I. A. and Grady, M. M.*
14.45	Coffee and tea
15.00	Photoelectrons at Venus in the Ionosphere and the Tail *Tsang, S. M. E., Coates, A. J., Jones, G. H., Frahm, R. A., Winningham, J. D., Federov, A., Barabash, S. and Lundin, R.*
15.15	Habilibility of Subglacial Volcanic Environments on Mars: An Experiment and Culture-based Test of Viability *Cousins, C. R., Towner, M. C. Crawford, I. A. and Ward, J.*
15.30	Planetary-Period Oscillations in Saturn's External Magnetic Field *Andrews, D. J., Cowley, S. W. H and Provan, G.*
15.45	Warped Accretion Discs in Binary Star Systems *Fragner, M. M. and Nelson, R. P.*
16.00	Geochronological Investigations of Mare Basalts from the Apollo Collection using SHRIMP Technology *Hallis, L. J., Anand, M., Russell, S. S. and Terada, K.*
16.15	Developments and Applications of Deriving Best-Fit Thermal Inertia and Albedo from THEMIS Images of Mars *Sefton-Nash, E. and Catling, D. C.*
16.30	Summary and final address
16.45	Networking session – The Marlborough Arms

List of Speakers

Name	Institution	Email
David Andrews	University of Leicester	dja13@ion.le.ac.uk
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Ruth Carley	University of Edinburgh	r.a.carley@sms.ed.ac.uk

Plenary Speaker – Dr. Tom Pike (Imperial College London)

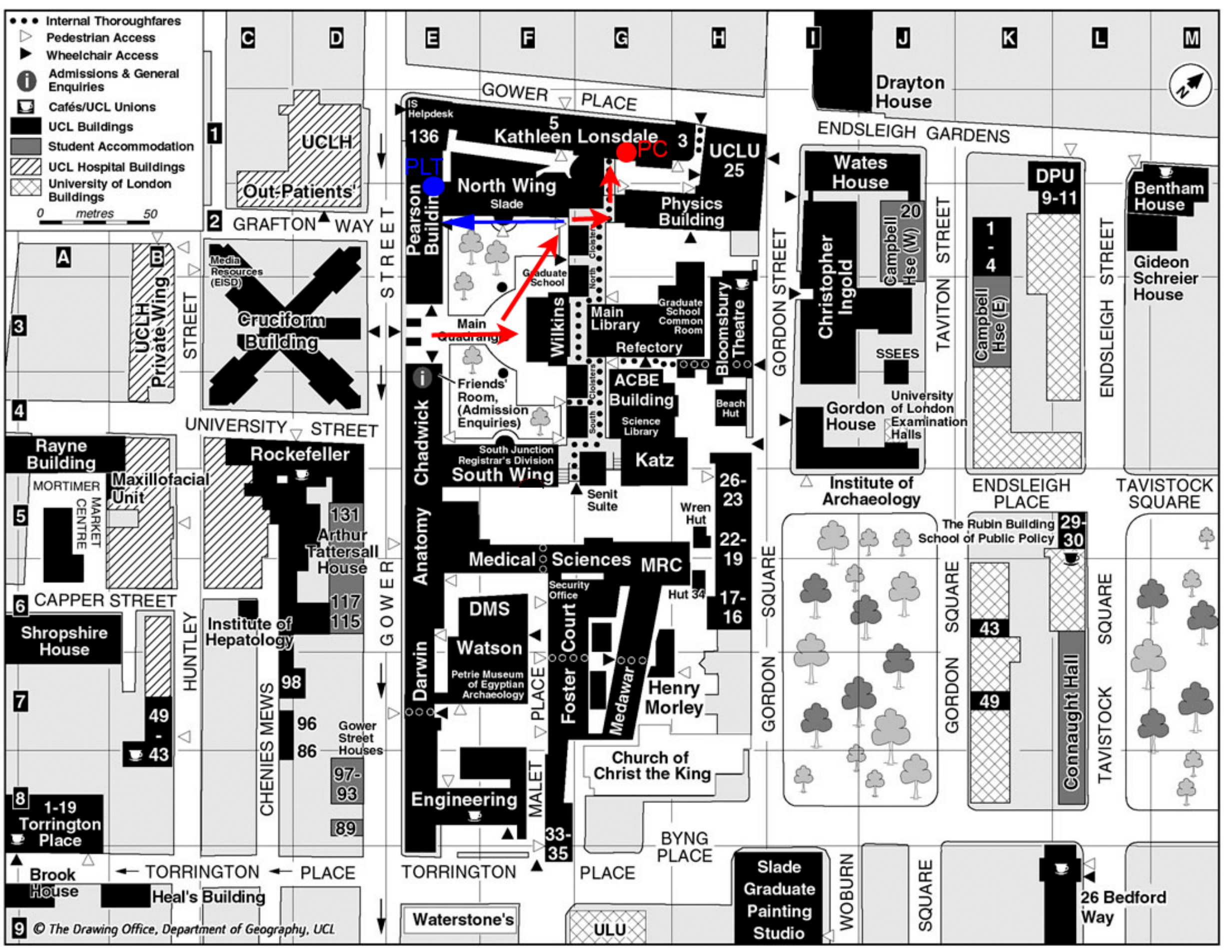
Meeting Logistics

The 6th annual UKPF meeting is this year to be hosted by University College London http://www.ucl.ac.uk/.

UCL is located in the heart of London's Bloomsbury District and is closely located to Euston and King's Cross train stations, and easily accessed from Euston Square, Euston and Warren Street tube stations. Details of how to get to UCL can be found at http://www.ucl.ac.uk/maps/

Meeting registration and welcome tea, coffee and refreshments will be served in the Planetary Centre which is located on the main UCL campus in the Kathleen Lonsdale Building (see the map below). The Planetary Centre hosts the UK's NASA Regional Planetary Image Facility
http://www.es.ucl.ac.uk/research/planetary/rpif/rpifindex.htm .

The oral presentations will be made in the UCL Pearson Lecture Theatre (located two minutes walk away from the Planetary Centre, across the UCL quod – please see the map below).



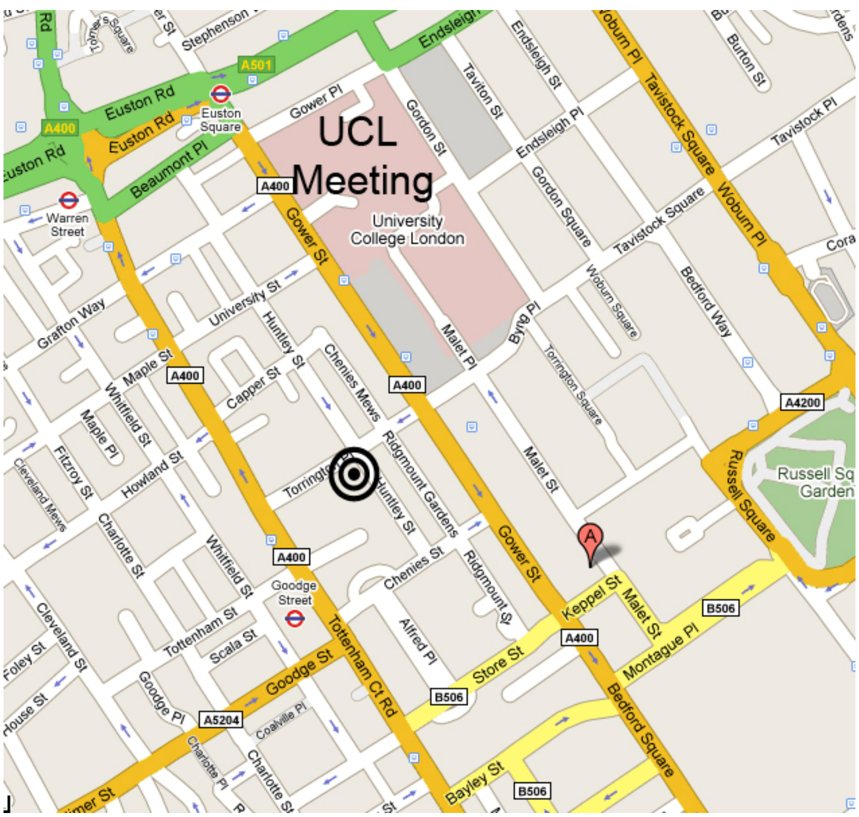
Map of the UCL main campus located off Gower Street. Guides to get to the Planetary Centre (meeting registration and refreshments) are shown in red and marked PC. Guides to get from the Planetary Centre to the Pearson Building are shown in blue and the Pearson Lecture Theatre is marked PLT.

Post-Meeting Networking Event

Following the formal proceedings, there will be an opportunity for informal networking in the **The Marlborough Arms**:

The Marlborough Arms
36 Torrington Place
Bloomsbury
London
UK
WC1E 7HJ

To get to the pub from UCL – exit onto Gower Street, turn left, walk down Gower Street fro ~300 m, turn left down Torrington Place, and the Malborough Arms is 30 seconds down on the left hand side of the road.



Map showing the location of UCL and the location of the Malborough Arms pub (target symbol)

Abstracts

CHARACTERISATION OF NEAR EARTH ASTEROIDS FOR A SAMPLE RETURN MISSION: THERMOPHYSICAL MODELLING

Rozitis, B.[1], Green, S. F.[1]

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The thermal infrared emission from an asteroid is dependant on its surface temperature distribution, which in turn is dependant on the global shape and its thermal properties. Simple thermal models using idealised spherical geometry and idealised assumptions of the level of thermal inertia have previously been used to determine asteroid diameters and albedos [1]. Although successful in their application to main-belt asteroids, these models have obvious limitations when it comes to interpretation of high quality spacecraft/observational data. This is especially true for irregular shaped near Earth asteroids. Thermophysical modelling is an attempt to account for all of the physical and thermal processes involved. Applications of such a model include detailed analysis of spacecraft and observational infrared data, and investigating the Yarkovsky and YORP effects on a target body.

A thermophysical model coupled with data from a spatially resolved mid-infrared spectrometer onboard a spacecraft can produce surface temperature maps of an irregular shaped body (e.g. Deep Impact [2]). This could lead to a mapping of thermal inertia across the body on which the surface temperature is strongly dependant. Since the thermal inertia depends on regolith particle size and depth, degree of compaction, and exposure of solid rocks and boulders within the top few centimetres of the subsurface; it can be used to infer the presence or absence of loose material on the surface [3]. This information will be especially useful in selecting an appropriate sampling site for a future sample return mission from a near Earth asteroid. Before such a mission is launched a thermophysical model can be used to place technical constraints on the mid-infrared spectrometer required and the level of detail required from the shape model derived from imaging.

Presented here is work in progress of a thermophysical model suitable for these applications. It is intended to include shape shadowing, self-radiation, and surface roughness (thermal beaming) effects. The model can readily be applied to existing shape models derived from extensive lightcurves, radar observations, and imaging from previous spacecraft encounters. Examples of its application are presented and discussed.

References

[1] Harris A. W. and Lagerros J. S. V. (2002) *Asteroids III*, 205-218.
[2] Groussin O. et al. (2007) *Icarus*, *187*, 16-25.
[3] Delbo M. et al. (2007) *Icarus*, *190*, 236-249.

XENON ISOTOPES IN SHERGOTTITES: RBT 04262, DAG 489, SHERGOTTY AND EET 79001.

Cartwright, J. A. , Ocker, K.D., Busfield, A., Holland, G., Crowther, S., Burgess, R. and Gilmour J. D.

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Martian shergottite Roberts Massif 04262 (RBT 04262) was recovered from Antarctica in 2004 [1]. Petrography, major and trace element analyses indicate that RBT 04262 is an olivine-phyric shergottite [2-4], although some authors suggest possible basaltic and lherzolitic shergottite origins (e.g. [5-6]). We report the first Xe isotope ratios for RBT 04262, building on our preliminary data [7], and compare these results with new and previously reported data for Shergotty [8] and unpublished data from shergottites Elephant Moraine 79001 (EET 79001) and Dar al Gani 489 (DaG 489). Distinct Xe components in Martian meteorites thought to represent different Martian reservoirs including Martian atmosphere, and multiple Martian interior components containing varying amounts of fission have been identified [8-13]. However, the sources and trapping mechanisms of these components is controversial and poorly understood. By performing mineral separate analysis on RBT 04262, EET 79001, Shergotty and DaG 489, we hope to provide further insight into the location and trapping mechanisms of noble gases in meteorites. Moreover, comparing crystallisation histories of the different shergottite groups by investigation of melt inclusions may improve the understanding of their formation and relationship with each other, and increase understanding of the interior and atmospheric evolution processes on Mars. Physically hand-picked mineral separates of olivine, pyroxene, maskelynite and spinel/opaques from all four meteorites were analysed on the RELAX instrument using laser step-heating experiments. Our results show that of the four meteorites, RBT 04262 released the most gas, with ^{132}Xe concentrations approaching 10^{-10} STP cm^{-3} g^{-1}, possibly related to a high melt inclusion content. DaG 489 released similar amounts of gas, whilst EET 79001 and Shergotty ^{132}Xe concentrations were similar to previous Shergotty data (10^{-11}-10^{-12} STP cm^{-3} g^{-1}) [8]. The RBT 04262 Xe isotopic data indicate the presence of three Xe components similar to reservoirs of terrestrial atmosphere, Martian atmosphere and Martian interior within the mineral separates. The highest ^{129}Xe/^{132}Xe value of ~1.14 was obtained from the spinel mineral separates, suggesting a large contribution from a Martian atmospheric reservoir (consistent with previous data for Shergotty [8]). The olivine and pyroxene separates exhibited Xe components similar to terrestrial atmosphere. By contrast, mineral separates for Shergotty, EET 79001 and DaG 489 contain a fourth Martian Xe component with excess fission, and have high ^{129}Xe/^{132}Xe values. This suggests that the original melt that produced RBT 04262 had no contact with the excess fission component, possibly due to different formation conditions or environment. Further work on the location of noble gases must be performed to increase understanding of meteorite formation, and evolution of Mars.

References:

[1] Satterwhite C. and Righter K. (2007) *Antarctic Meteorite Newsletter*, 30, 1-20, 2007. [2] Dalton H. A et al., (2008) *LPSC XXXIX*. [3] Lapen T. J. et al., (2008) *LPSC XXXIX*. 2008. [4] McCoy T. and Reynolds V. (2007) *Antarctic Meteorite Newsletter* 30, 16, 2007. [5] Anand M. et al., (2008) *LPSC XXXIX*. [6] Mikouchi T. et al.,

(2008) *LPSC XXXIX*. [7] Cartwright J. et al., (2008) *LPSC XXXIX*. [8] Ocker K. D. and Gilmour J. D. (2004) *MAPS*, 39, 1967-1981. [9] Gilmour J. D. et al., (1998) GCA 62, 2555-2571. [10] Gilmour, J.Det al., (2001) GCA 65, 343-354. [11] Mathew K. J. and Marti K. (2001) *JGR* 106, 1401 – 1422. [12] Mathew, K. J. and Marti K. *EPSL* 199(1-2), 7-20, 2002. [13] Swindle T. D. (2002) *Noble gases in geochemistry and cosmochemistry.*, 47 Mineralogical society of America, 2002.

ANALYSIS OF HYDROUS PHYLLOSILICATES IN STARDUST TYPE B TRACK ANALOGUES.

Foster, N. J.[1], Kearsley, A. T.[3], Burchell, M. J.[1], Wozniakiewicz, P. J.[3], Creighton, J. A.[1] and Cole, M. J.[1].

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Introduction: Much work has been carried out to analyse laboratory impacts into aerogel to help us better understand the impact process & the behaviour of mineral projectiles during capture. This directly benefits analysis of Stardust cometary samples [1]. Here we look at the behavior of a hydrous phyllosilicate material, lizardite, during laboratory impacts with similar conditions to that of Stardust. Lizardite was chosen because it is of the same mineral group common in Type 1 & 2 CC meteorites and usually attributed to hydration of anhydrous mafic silicate precursors during parent-body processing. The issue of whether there are hydrous minerals in a comet is clearly of interest. Lizardite was also chosen as it doesn't survive the capture process well, thus leaving us with Type B tracks [2]. EDX & Raman analysis were undertaken on both the track walls and terminal particles.

Method: Laboratory analogues where made using a Light Gas Gun [3]. Samples of lizardite ≈ 100 µm were used as the projectile. They came from a catalogued sample at the NHM. SiO_2 aerogel $\rho = 60$ kg m^{-3} was used. All shots where carried out at a speed of 5 km s^{-1}. Once tracks had been produced those for EDX were cleaved length ways down the track exposing the inside of the track for EDX analysis. Those for Raman remained intact. EDX was carried out at the NHM, BEI and EDX spectra were recorded. Rough powder projectile samples were also studied to check composition. Both the aerogel track and rough projectile remained uncoated and were examined under low vacuum. Raman Spec. was carried out at the Univ. of Kent.

Results: EDX analysis of the track walls revealed the presence of abundant magnesium signals along its entire length, indicating that the lizardite particle had broken up during capture. Only a fraction of its original size was left as the terminal particle. Five tracks were analysed by Raman. Of these, four exhibited lizardite signals, whilst one displayed peaks indicative of olivine (at 824 & 857 cm^{-1}). Heating of the samples due to the laser were not a contributing factor in this case, and remained to a similar range of that found in [4]. This result is a significant as lizardite is a member of the serpentine group of hydrous phyllosilicate minerals, and decomposes with loss of water at a relatively low temperature, usually with generation of olivine. This could imply that hydrous materials from comet 81P/Wild2 may not be being preserved during capture.

Conclusion: EDX and Raman provide us with valuable tools for investigations into the capture process. These techniques have also raised some interesting questions as to this process. It has shown that some mineral groups are susceptible during capture, shedding material as it passes through the aerogel. One case has shown that heating was enough to alter hydrous materials into a different form. The temperature required for change is ≈ 600K and it is thought that temperatures of particles during capture may rise as high as 2050K [5].

References:

[1] Brownlee D. E. et al. (2006) *Science, 314*, 1711-1716.

[2] Hörz F. et al. (2006) *Science*, *314*, 1716-1719.
[3] Burchell M. J. et al. (1999) *Meas. Sci. Tech.*, *10*, 41 – 50
[4] Burchell, M.J. et al. (2006) *MAPS*, *41*, 217-232.
[5] Hörz F. et al. (2008) *LPSC XXXIX* Abstract #1391.

ELECTRON ABSORPTION MICROSIGNATURES OF SATURN'S ICY MOONS

Kanani S.[1,2], Jones G.H.[1,2], Roussos E.[3]

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The Cassini spacecraft regularly crosses the paths of Saturn's inner moons. These moons reside in a region containing high energy particles trapped in Saturn's radiation belts. Because these particles can strike the moons, depletions, termed microsignatures, are sometimes seen in the energetic particle population when near a moon's orbit. A less extensive cavity is also formed in the lower energy magnetospheric plasma that flows past the moons. Studies of microsignatures have been carried out, investigating how their characteristics change as a function of longitudinal separation from the moon. These tell us about the absorber and the energetic electron population, hence aiding in characterising the magnetospheric dynamics of Saturn. From the infilling of these wakes it is possible to learn about diffusion mechanisms and plasma transport. Since orbit insertion in 2004 Cassini has observed dozens of microsignatures from all the large icy moons. In this talk we present some case studies of icy moon microsignatures and discuss their implications.

IDENTIFYING THE METEORITIC BUILDING BLOCKS OF EARTH

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The composition of Earth can be investigated using meteorites. Compositional models of Earth generally draw on three sources: seismology, experimental mantle petrology and comparisons with primitive meteorites (eg 1). The results of these models can vary depending on which meteorite group is used as the protolith. Therefore, it is important to identify which groups most closely represent the meteoritic building blocks of Earth. Primitive meteorites exhibit striking isotopic and chemical similarity with each other. This testifies to the efficiency of mixing in the early Solar System. However, the discovery of small, mass independent, isotopic variations (eg 2; 3; 4) showed that mixing in the proto-solar nebula did not fully extinguish pre-solar signatures. These isotopic anomalies have been found in bulk samples at the 10 ppm level for Ti, Cr and Ni (3, 4, 5, respectively). Using these variations allows the provenance of meteorites from the early Solar System to be tested.

Ni isotopes offer an inviting opportunity to examine the early Solar System. Ni is abundant in the Solar System, moderately siderophile and moderately refractory so is found in all classes of meteorites, often as a major element. This means Ni isotopic variations can be used to study links between the parent bodies of various differentiated and undifferentiated meteorite groups and planetary bodies. They can also be used to describe the components that carried heterogeneity in the early Solar System. Which was caused by incomplete mixing of sources with differing nucleosynthetic histories.

A preliminary study (5) found small but significant variations in Ni isotopes. They showed a positive correlation between the neutron rich end-member of Cr, described by $\varepsilon^{54}Cr$, and $\varepsilon^{62}Ni$. The Ni neutron rich end-member, $\varepsilon^{64}Ni$ is expected to correlate both with $\varepsilon^{62}Ni$ and $\varepsilon^{54}Cr$ and to give larger variations. Therefore by using the varying influence of this neutron rich end-member, characterised by elevated $\varepsilon^{64}Ni$, $\varepsilon^{54}Cr$, and $\varepsilon^{50}Ti$, Ni isotopes will provide an exciting opportunity to investigate the provenance of early Solar System bodies in the form of primitive meteorites. $\varepsilon^{64}Ni$ was not included in the original study due to the technical difficulties of these measurements. Advances have been made in the Ni isotope technique and we hope that $\varepsilon^{64}Ni$ data shall follow soon.

References

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[2] Clayton, R., Grossman, J. and Mayeda., T., (1973) *Science*, 182, 485–488.
[3] Niemeyer, S. (1985) *Geophysical Research Letters*, 12, 733–736.
[4] Trinquier, A., Birck, J.-L. and Allègre, C. J. (2007) *ApJ*, 655, 1179–1185.
[5] Regelous, M., Elliott, T. and Coath, C. D. (2008) *EPSL*, 272, 330–338.

PROMPT GAMMA ACTIVATION ANALYSIS OF MARTIAN ANALOGUES AT THE FRM-2 NEUTRON REACTOR, GERMANY

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A hybrid X-ray and gamma ray detector is being developed at the Space Research Centre at the University of Leicester that will simultaneously carry out X-ray spectroscopy, gamma ray spectroscopy and gamma ray backscatter densitometry. Gamma ray spectroscopy, X-ray spectroscopy and gamma ray backscatter densitometry are three complementary analytical techniques that can be used to determine surface and sub-surface composition, constrain heat flow through a planetary regolith and hence understand more about the processes that formed planetary bodies. Evaluating different detector types and configurations in order to achieve these scientific objectives is a key step for a successful flight instrument development programme. Modelling the performance of possible detectors is a key step in this evaluation.

Gamma ray emission from a planetary surface is induced by the interaction of GCR and solar protons with a planetary atmosphere and surface. We can re-create these emissions on Earth using a technique called prompt gamma activation analysis using a neutron beam. The ANTARES neutron beam at FRM-2, Munich, Germany was used to induce neutron capture reactions in three Martian analogues and their prompt gamma emission was examined. This data is being used to verify a simulation of a planetary surface and its radiation environment that is being developed in MCNPX™. This simulation will be used to model the hybrid detector as part of a sub-surface probe/ penetrator within a simulated planet. In this study the experimental campaign at FRM-2 will be reported along with some of the results obtained.

FINDINGS OF THE LPI'S 2008 LUNAR EXPLORATION SUMMER INTERN PROGRAM

Weider S.[1,2], Kohout T.[3,4,5], Losiak A.[6], O'Sullivan K.[7], Thaisen K.[8], Kring D.[9]

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[9]Lunar and Planetary Institute, Houston, TX, USA

Since NASA announced its intention to renew exploration of the Moon (with crews landing on the surface before 2020) it has been engaged in the planning of the initiative with its academic and industrial partners. As part of this, the American National Research Council (NRC) followed a mandate from NASA and developed a set of science priorities for this new wave of lunar exploration. Their report[1] summarises their findings and formed the basis for the work carried out by five graduate student interns at the Lunar and Planetary Institute (LPI), under the guidance of Dr D Kring, for ten weeks over the summer. The NRC report outlines eight science concepts and numerous, more specific scientific goals that could, and should, be achieved through future exploration of the Moon. These concepts deal with all aspects of the Moon; its history and evolution, internal structure, geochemistry, and surface conditions.

The aim of the program (in its inaugural year) was to evaluate the best lunar landing sites for each of the NRC's science concepts and goals. Over the length of the summer we focused on the first of the science concepts: *the bombardment history of the inner solar system is uniquely revealed on the Moon*. The findings from our work on the first four of the science goals will be outlined. These goals are as follows: a) test the cataclysm hypothesis by determining the spacing in time of the creation of lunar basins, b) anchor the early Earth-Moon impact flux curve by determining the age of the oldest lunar basin (South Pole-Aitken basin), c) establish a precise absolute chronology, and d) assess the recent impact flux.

Our work gave rise to a number of end products, including: the presentation of our findings at a morning's workshop and in a full-written report; a number of conference abstracts and posters[2-5]; a newly updated, comprehensive database of lunar craters along with many of their characteristics; and a collection of newly produced images and maps.

References

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RECENT GULLIES ON MARS – DOES THIS MEAN WATER ON MARS?

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The low average temperatures and pressures on Mars prevent the formation of liquid water on Mars, hence the discovery of recently active gullies [1,2] on Mars presents an apparent paradox. To investigate this issue in my PhD I am using remotely sensed data, Earth analogues and laboratory simulations.

NASA's Mars Reconnaissance Orbiter is sending back images of mars from its HiRISE camera with unprecedented detail (up to 25cm/pixel). Using stereo photogrammetry with these images we can get extremely high resolution elevation data of gullies on Mars [1,2]. We utilise a manual point matching technique on the processed imagery, which was developed by Dr M Kreslavsky [2], to extract morphometrics of gullies on Mars at 1-5m posting, with an error of ±0.5-5.0m.

The NERC Airborne Research and Survey Facility flew LiDAR and an aerial camera as part of a survey in the Westfjords of Iceland in 2007. This has given us elevation data with an average posting of 1.5m over and area of ~100km^2 with an RMS error of ±15cm and aerial photography with a resolution of 0.5-0.25m/pixel. This is equivalent resolution to that of the data from HiRISE of Mars. I intend to present results from this field-season from GPS surveying of debris flows that have occurred in the area since the baseline survey. We will be comparing detailed long sections and cross sections from Iceland to Mars to see if debris flow contributes to the formation of gullies on Mars. If debris flow morphology is recognised on Mars, this is strong evidence for the presence of water on Mars, which has implications for astrobiology, climate modelling and human exploration.

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WHAT UREILITE METEORITES CAN TELL US ABOUT THE GEOLOGICAL HISTORY OF A DIFFERENTIATED AND DISRUPTED ASTEROID

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Ureilites are primitive achondrite meteorites that have experienced strong igneous processing whilst retaining nebula-derived heterogeneity in mg# and oxygen isotopes. Polymict ureilites represent regolith breccia material derived from the surface of the ureilite parent asteroid(s). Electron microprobe analysis of more than 500 olivine and pyroxene clasts in six polymict ureilites reveals that they cover an identical range of compositions to that shown by all known monomict ureilites. This is convincing evidence for derivation from a single parent asteroid. Furthermore, material covering the whole range of compositions and different states of shock must have been present at its surface, suggesting a rubble-pile origin. Many of the polymict ureilites also contain clasts that have identical compositions to the anomalously high Mn/Mg olivines and pyroxenes from the Hughes 009 monomict ureilite (here termed the "Hughes cluster"). The presence of several common distinctive lithologies within the polymict ureilites is additional evidence that the ureilites were derived from the surface of a single parent asteroid. SIMS oxygen isotope analyses on individual minerals clasts also cover the observed range of data for monomict ureilites. They fall on a narrow trend directly along the CCAM line, and show a good anti-correlation with mg# of the analysed phases.

This study [1] confirms that olivine clasts with mg#s < 85 are much more common than those with mg# > 85, which also show much more variable Mn contents. This distinction is also seen in olivines from monomict ureilites, suggesting that there are two types of ureilites. We interpret this to indicate that the parent asteroid was disrupted by a major impact at a time when melt was still present in regions with a bulk mg# > 85, giving rise to the two types of ureilites: ferroan ones that were already residual after melting and magnesian ones that were still partially molten when disruption occurred. Melt-inclusion-bearing "Hughes cluster" ureilites are considered to be the result of interaction of melts with residual mantle during this disruption. A single daughter asteroid re-accreted from the disrupted remnants of the mantle of the proto-ureilite asteroid, giving rise to a "rubble-pile" body that had material of a wide variety of compositions and shock states present on its surface. The analysed polymict ureilite meteorites represent regolith that subsequently formed on this asteroidal surface.

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LUNAR CRUSTAL MAGNITISM: A MAGNITISATION MODEL OF THE REINER GAMMA REGION

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A crustal magnetisation model of the Reiner Gamma high albedo feature has been produced from the equivalent source dipole technique [1] using the radial component of the crustal magnetic field isolated from Lunar Prospector's (LP) magnetometer data [2]. This technique was adapted to find the magnitude and direction of magnetisation [3] of individual dipoles in a set volume homogeneously distributed with spacing ≤0.5° over the region centred on the Reiner Gamma anomaly.
The three components of crustal magnetisation which can reproduce the observed magnetic field are estimated from a damped least squares inversion of the equivalent source dipole model predictions. Of the many possible solutions, the chosen model of magnetisation represents a smooth solution with magnitudes above those required by ideal body analysis to produce the observed anomaly [4]. This model shows that the strongly magnetised areas of this region coincide with the main high albedo feature and along its track to the north east. Predictions of the surface magnetic field from this magnetisation model show reasonable spatial agreement with surface field estimates from the LP Electron Reflectometer [5], but have lower magnitude.
Unlike other models for this region employing geometric shapes [6], single dipoles [7], dipoles with fixed directions [8], and recently monopoles [9], the directional information of this model can be used to discuss the origin, configuration, and intensity of the ancient field that produced this magnetisation. Inclination and declination values for the most strongly magnetised regions show significant variation in direction over a small region suggesting a variable rather than constant direction for the magnetising field. Thus it is tentatively suggested that the magnetising field that produced this estimated crustal magnetisation is impact related rather than relating to magnetisation in the presence of a global (dipole or other) field.

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REFLECTANCE PROPERTIES OF LOW T_J OBJECTS IN THE NEAR-EARTH POPULATION

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The most exact method of concluding whether an object is a comet or asteroid is if a coma caused by the out-gassing of sublimating volatiles from the object's surface is observed. However, over time, volatile material capable of sublimating may be completely depleted from the comet leaving a bare nucleus. Another possibility is that non-volatile material may build up on the surface of the comet nucleus preventing further sublimation and out-gassing. These end states (extinct and dormant) cause the unresolved nucleus to resemble an asteroid. The implication is that the exact contribution of the comets and asteroids to the NEO population is difficult to accurately determine. Dynamical models suggest a cometary contribution as low as 6% [1] while observational studies allow the fraction to be as high as 18% [2].

Previous investigations have shown that extinct or dormant comets can closely resemble D-type asteroids [3,4]. The present study has used SUSI2 and SOFI on the NTT to obtain quasi-simultaneous optical and NIR observations of a sample of NEOs with a Tisserand Parameter of $2 \leq T_J \leq 3$ to determine whether any of the objects could be extinct comets. Aperture photometry was performed to obtain *BVRI JHKs* colours for each of the objects. The optical colours were compared to colours previously calculated for each taxonomic type [5] and the NIR colours were compared to those in the 2MASS Asteroid and Comet Survey [6]. Reflectance spectra were compared to asteroid spectra presented in [2]. Three of the objects are possible cometary candidates with a taxonomic classification of either a D or B and a further four objects are possibly C or X type. The remaining ten objects have been classified as S, Q, V or A indicating a silicate composition.

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PLASLIFE FOR VENUS: A CODE TO ASSIST IN THE INTERPRETATION OF IONOSPHERIC OBSERVATIONS

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On 4 August 2008 the Venus Express spacecraft was inserted into a new orbit with a lower perigee. During the current phase of the mission the altitude of the pericentre is between 185 and 300 km allowing in situ observations of the plasma environment deeper in the ionosphere. The ASPERA-4 experiment (Analyzer of Space Plasma and EneRgetic Atoms) will record the first extended data set of in situ measurements of the exosphere and ionosphere at these altitudes close to solar minimum. This will address questions of neutral-plasma interaction on Venus and the influence of the neutral gas on plasma dynamics [1].

PLASLIFE is a code that has been used to interpret observations in the terrestrial ionosphere [2 3]. It is one dimensional and is designed to be neither coupled nor self-consistent. Therefore direct observations of the ionosphere can be used as inputs. Thermospheric parameters from statistical studies or models are used to predict the evolution of the plasma and the resulting plasma density is compared with later observations.

The PLASLIFE code is introduced and previous results are briefly summarised. Developments to implement PLASLIFE in the ionosphere of Venus are detailed and applications of the code are discussed.

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UNDERSTANDING ANCIENT MARS THROUGH ISOTOPE STUDIES AND SYNTHETIC FORMATION OF ALH 84001 CARBONATE ROSETTES

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Martian meteorite samples provide an insight into the lithosphere, atmosphere and hydrosphere of Mars and thus can help us to determine the environments in which they formed. Owing to the igneous origins of martian meteorites, formation of secondary alteration products is particularly intriguing since such components can help cast light on their likely fluvial origins. The motivation to search for carbonates on Mars is because these minerals are associated with water and carbon dioxide, both of which are believed to have existed in relative abundance on early Mars [1]. Carbonates precipitate when carbon dioxide interacts with water, releasing carbonate anions (CO_3^{2-}) which bond with a range of cations such as calcium, iron or magnesium, typically present in the form of salts.

ALH 84001 is the oldest known martian meteorite we have on Earth; the carbonates within ALH 84001 precipitated ~3.9 Gya [2]. From the current martian meteorite collection, ALH 84001's carbonates are the most abundant (1 % vol) and varied in mineralogy, especially the carbonate "rosettes" that have an ankerite core leading to an alternating layer of magnesite to siderite and back to magnesite. The age, abundance, isotope and mineralogy variations make ALH 84001 an ideal candidate to provide insights into the primordial martian conditions.

The range in isotope values from rosettes (~37‰ and ~25‰ variations in $\delta^{13}C$ and $\delta^{18}O$ respectively [3]) requires significant change in composition and/or fluid temperature during formation. Studies of carbon and oxygen isotopes have been conducted on ALH 84001 carbonates using both bulk analysis and ion microprobes. However, because of the small size of these rosettes (100-250 µm), few studies have actually attempted to relate the mineralogical variations with isotopes. To rectify this issue I intend to use NanoSIMS (Secondary Ion Mass Spectrometer), an instrument that combines submicron ion beam spot sizes with high sensitivity, making it an ideal analytical tool for studying isotope variations with alternating mineralogy.

Carbonate rosettes analogous to those observed in ALH 84001 have been produced [4]; following on from these studies I intend to synthesize carbonates under a range of potential primordial martian environments, to synthetically reproduce these rosettes mineralogically and isotopically. From these results it should be possible to determine their most favorable formation conditions.

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PHOTOELECTRONS AT VENUS IN THE IONOSPHERE AND THE TAIL

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Pioneer Venus Orbiter has shown that there is no intrinsic magnetic field at Venus [e.g. Slavin *et al.*, 1980]. Instead, there is an induced magnetosphere caused by the solar wind interaction with the upper atmosphere of the planet. This interaction causes the solar wind's magnetic field lines to drape around the planet, dragging through the ionosphere where they continue on to form a magnetotail. [e.g. Luhmann and Cravens, 1991] Ionisation of the ionosphere by the solar HeII 30.4nm line leads to the production of ionospheric photoelectrons, recognisable by their characteristic spectral shape in the electron energy spectrum [Mantas & Hanson, 1979]. These photoelectrons have been seen at Venus [Coates *et al.,* 2008] by the electron spectrometer, part of the ASPERA instrument, onboard the Venus Express spacecraft due to its energy resolution of ~7% [Barabash *et al.*, 2007]. In addition, these ionospheric photoelectrons have now been seen in the induced magnetotail for the first time at Venus. Photoelectrons have previously been seen at Earth [Coates *et al.*, 1985], Mars [Frahm *et al.*, 2006a,b] and Titan. At Titan, they have been linked to ambipolar diffusion [Coates *et al.*, 2007].

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HABITABILITY OF SUBGLACIAL VOLCANIC ENVIRONMENTS ON MARS: AN EXPERIMENTAL AND CULTURE - BASED TEST OF VIABILITY

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Subglacial volcanism is a process widespread on Earth that is thought to also occur on Mars. The coupling of water ice with volcanic activity and associated high geothermal heat flow produces diverse environments that are readily colonised by microbial life on Earth, and can potentially provide a haven for life on Mars. This talk will briefly review the process of subglacial volcanism in terms of potential for microbial colonisation and habitability on Mars. Topics that are addressed include the environments that exist within such a volcano – ice setting, possible metabolic pathways, colonisation and habitat duration. To test the viability of a subglacial volcanic system on Mars, an experimental test on the survivability of an in-situ community within a simplified subglacial system exposed to Martian conditions was carried out. We found microbial populations were still culturable after 6 days of exposure within a simulated subglacial system, whilst the culturable community from lavas fully exposed to Martian conditions was not or displayed very limited growth. We have concluded that subglacial volcanic systems are potentially conductive to life on Mars, and that subglacial volcanic systems may provide at least a short-term isolated viable environment on Mars where microbial communities can survive. However, problems may arise within the initial colonisation of a system and the potential instability of these environments.

PLANETARY-PERIOD OSCILLATIONS IN SATURN'S EXTERNAL MAGNETIC FIELD

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Oscillations at the planetary rotation period of ~10.8 h are observed throughout Saturn's magnetospheric environment. Work will be presented based on both recently published and on-going work at Leicester on this topic [1,2]. We use the well-defined (but slowly varying [3]) period at which the Saturnian Kilometric Radiation (SKR) is modulated as a basis for analyzing the magnetic field oscillations, their amplitude and polarization. Overall, we find evidence for a rotating quasi-uniform "cam-like" field in the inner magnetosphere, though the system becomes more complex when we consider higher-latitude regions.

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WARPED ACCRETION DISCS IN BINARY STAR SYSTEMS

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Close binary star systems consisting of an evolved object (e.g. white dwarf, neutron star or black hole) and a main sequence star contain accretion discs that are formed by the transfer of gas from the normal star onto the compact object. Circumstances can arise in which the orbital plane is misaligned with the midplane of the accretion disc, leading to out-of-plane tidal forcing of the disc.
Protoplanetary discs may also occur in close binary systems where the disc plane and the binary orbit plane is misaligned as a result of the star formation process. It is expected that the excitation of bending disturbances will lead to the formation of warped, precessing discs, as are believed to occur in the X-ray binaries Her-X1 and SS433, and numerous protostellar disc systems.
The aim of this work is to study these systems with a three dimensional grid-based hydrodynamics code. In contrast to SPH codes that were employed in previous studies, the grid-based code allows much more control over the viscosity. Since the viscosity has a significant effect on the propagation of bending disturbances in accretion discs, it is important that a detailed study be made in which the effects of viscosity are tightly controlled.
We focus on the influence of the viscosity on the warp propagation and disc response for different inclination angles and disc thicknesses. We find that for thick discs with low viscosity the propagation is fast enough such that the discs precess as rigid bodies, as expected from linear theory. For thin discs with high viscosities the warp propagation efficiency is reduced, and the disc precesses differentially such that its underlying structure is disrupted. These results will have important implications for planet formation in binary systems.

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GEOCHRONOLOGICAL INVESTIGATIONS OF MARE BASALTS FROM THE APOLLO COLLECTION USING SHRIMP TECHNOLOGY

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Introduction: The Apollo mare basalts represent the largest and most pristine collection of lunar basaltic material on Earth. In the past numerous studies have shown that high-Ti basalt samples appear to be older than low-Ti basalt samples. However, previous techniques often gave ages with high amounts of error (as much as 0.5 Ga in some cases), which has commonly never been reduced by the application of more modern techniques. The aim of our research is to determine the mineralogical and petrological characteristics of a number of mare basalts from the Apollo 11, 12, 14, 15 and 17 sites. We then plan to utilise SHRIMP (sensitive high resolution ion microprobe) technology to date phosphates *in-situ* within thin sections of a number of these samples. This data will enable us to accurately group the samples within existing lunar classification scheme(s)[1,2] and gain a more precise chronology of basalt extrusion at each location, giving a better understanding of the early Moon's internal processes.

Methodology: Our analytical protocol includes the collection of backscatter and x-ray maps for a polished section of each sample followed by electron microprobe spot and transect analysis of individual mineral phases. LA-ICP-MS data reveals the trace element signature of minerals in each sample, while the solution ICP-MS technique is utilised for bulk chemical analysis. U-Pb age dating of phosphates is currently being carried out using the SHRIMP facility at Hiroshima University[3,4].

Results & Conclusions: Our data are consistent with previous observations that lunar basalts vary widely in terms of texture and mineralogy - a result of complex crystallisation processes. Initial LA-ICP-MS data not only confirm the heterogeneity of REE signatures between the Apollo sites but also between individual samples from the same site. Focusing on clinopyroxene for example, the variation in La/Yb ratio throughout the sample suite ranges from 0.5 to 0.008 while Eu anomalies ($Eu^* = Eu/\sqrt{(Sm*Gd)}$) range from 0.09 to 0.36. These variations were most likely produced by a combination of fractional crystallization of mare magma and source region heterogeneities. SHRIMP analysis has so far yielded inconclusive results, mainly due to the quality and size of the phosphates analysed. However we hope that subsequent analysis of plagioclase will give more precise results.

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DEVELOPMENTS AND APPLICATIONS OF DERIVING BEST-FIT THERMAL INERTIA AND ALBEDO FROM THEMIS IMAGES OF MARS

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The Thermal Emission Imaging System (THEMIS) aboard Mars Odyssey has, since 2001, rovided extensive coverage of the surface of Mars in 10 IR (6.78 – 14.88μm, at 100m/pix) bands. One quantity of interest is thermal inertia (measured in J m-2 s-1/2 K-1 or tiu [1]), which epresents a materials thermal response to changes in temperature of its surroundings. We follow the method of [2] to derive best-fit thermal inertia and albedo of the surface using pairs of overlapping day and night THEMIS images.

We calculate the best-fit brightness temperatures for each image using the Planck function. These temperatures represent the surface temperature of the Martian surface close to the diurnal thermal extremes. A simple thermal model derived by [3] calculates the diurnal temperature curve for large ranges of slope, azimuth, albedo and thermal inertia for a given latitude and season or solar longitude (Ls). We generate a lookup table of predicted surface temperatures at the local Mars time of acquisition of the THEMIS images. We use MOLA topography interpolated down to 100m/pix to calculate slope and azimuth for the region covered by both images. A best-fit routine then solves for the thermal inertia and albedo using the lookup table. The derived quantity is sensitive to the thermal response of the surface and immediately underlying units as well as grain size of particulate material. It therefore helps distinguish between e.g. sand sheets from bedrock covered in a dust/sand mantle. Typical thermal inertias range from < 150 tiu for fine dust to > 1000 tiu for bedrock.

We find that the time of acquisition of the THEMIS IR images is never exactly at the diurnal thermal extremes, which introduces errors that result in a lower derived thermal inertia. The error is mostly dependant on the offset of the night-time image from the thermal minimum. We therefore introduce a test for THEMIS IR images to determine if they will be suitable to produce accurate thermal inertias. We also find that the ~500m/pix native resolution of MOLA does not represent the surface at THEMIS IR resolution. We therefore introduce a method to incorporate topography at true 100m/pixel resolution derived from ESA's HRSC. Significantly improved detail in thermal inertia results and many more interesting features are now discernable.

We apply this improved method to a case study of 'White Rock' in Pollack crater, an indurated and wind-eroded dust deposit, and discuss preliminary results from a study of light-toned layered outcrops in Iani Chaos.

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RAS Specialist Discussion Meetings
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40th Lunar and Planetary Sciences Conference (LPSC)
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Houston, Texas 23-27 March 2009

RAS National Astronomy Meeting 2009
http://www.jenam2009.eu/
University of Hertfordshire, de Havilland Campus, 20-23rd April 2009

European Geosciences Union (EGU) General Assembly
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72nd Meeting of the Meteoritical Society (MetSoc)
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Notes

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