Outline of Aurora funding

The £3 million from the Aurora Science Programme has gone to the following 17 academics and individual scientists working at UK research organisations:

1. **An improved understanding of Mars photochemistry using NOMAD and ACS measurements – Professor Paul Palmer, Edinburgh University -** £73,442

   The proposal aims to develop the existing photochemistry (the chemistry effects of light) to prepare for measurements collected by the NOMAD and ACS instruments aboard the Trace Gas Orbiter. They will develop the chemical mechanism so it can be used to interpret observed variations of atmospheric gases on Mars.

2. **Dust storms and the dust transport cycle: their impact on the Martian climate in a multi annual reanalysis of MCS, THEMIS and TGO/ACS data – Professor Peter Read, Oxford University -** £346,592

   The proposal aims to improve our understanding of the Martian dust cycle, its impact on climate and the physical features of the Martian surface. Using a new approach towards analysing daily variations in the Martian atmosphere it is proposed to extend this dataset using measurements of the Martian atmosphere from the Mars Reconnaissance Orbiter and Mars Odyssey missions in orbit around Mars, and from the Atmospheric Chemistry Suite (ACS) on ESA's Trace Gas Orbiter mission when they become available. This may be useful for future spacecraft operations at the Martian surface, as well as to improve our understanding of both the present and past states of the Martian climate.

3. **ExoMars TGO Guest Investigator Support – Dr Matt Balme, Open University** - £56,367

   This proposal seeks funding for a Guest Investigator position on ESA's ExoMars Trace Gas Orbiter mission. The aim of this mission is to measure methane and other atmospheric trace gases present in the atmosphere that could be evidence for possible biological or geological activity. CaSSIS is the camera on the mission. The research proposed for the position has two strands based on the on-going research activities: the first to use CaSSIS to investigate dust devils; the second to use CaSSIS to aid analysis of the geological history of the Arabia Terra region of Mars (the region that contains the candidate ExoMars Rover landing sites).

4. **UK ExoMars Rover Landing Site Science and Characterisation – Dr Matt Balme, Open University -** £293,101

   The goals of this project are to conduct geological analysis of the proposed ExoMars landing sites, identify key scientific targets of interest at the landing sites, and to characterise major hazards to Rover mobility.

5. **In-situ measurements of thermosphere densities using ExoMars TGO on-board accelerometers – Dr Ingo Mueller-Wodarg, Imperial College London** - £26,042

   The project consists of analysing the readings from the TGO during the aerobraking phase in order to infer atmospheric densities in Mars' upper atmosphere. This will complement the on-going upper atmosphere observations by NASA's MAVEN spacecraft, representing a unique chance for simultaneous 2- spacecraft observations in the Martian atmosphere. The work will be done in close collaboration with colleagues at the French Space Agency (CNES) in Toulouse, France.

6. **Mapping Martian water vapour using ExoMars 2016 Trace Gas Orbiter – Professor Patrick Irwin, Oxford University** - £74,348

   This project aims to produce the most accurate map yet of how water vapour in the Martian atmosphere varies throughout the Martian year. Identifying its atmospheric sources and sinks will help to understand variability not only of water but also of the other trace gases targeted by the TGO mission. In addition to understanding the behaviour of trace gases, identification of source/sink regions at the surface is directly relevant to targeting investigations for the ExoMars 2020 rover and its drilling campaigns.

7. **Characterisation of the volatile reservoirs and their sources in the lunar regolith – Dr Romain Tartese, Manchester University -** £304,613

   To understand and interpret the types of lunar soil samples that will be analysed by the Luna-27 mission the aim of this project is to thoroughly characterise the inventory of the lunar soil components that we already have in the Apollo and Luna sample collections. The approach will use state of the art techniques to measure the distribution of many types of volatiles in these samples and determine their make-up. These samples will allow understanding of the composition of ice-free lunar soil before we study ice-rich material from the lunar poles. This will provide essential baseline information for understanding and interpreting bulk measurements obtained on the lunar surface in the future.

8. **tRacE Gas-mineral inteRactIoNs During aeolian erosion on Mars (REGRIND) – Dr Jonathan Telling, Newcastle University** - £249,514

   REGRIND fills a major gap in our knowledge by carrying out experiments mimicking wind erosion on Mars. It will carry out experiments grinding materials representative of the Martian surface, using rates of erosion, temperatures, pressures, atmospheric compositions, and UV irradiation typical of present day Mars. The controls on the release and uptake of gases will be assessed and results compared to maps of Martian gas fluxes, sand movement and temperature derived from the European Space Agency ExoMars Trace Gas Orbiter (TGO) mission, and on-going NASA Mars Reconnaissance Orbiter High Resolution Imaging Science Experiment (HiRISE) mission. This interdisciplinary project will help identify the sources and sinks of a range of trace gases in the Martian atmosphere. It will provide insight into key

questions including whether the appearance and disappearance of methane and other trace gases on Mars is driven by chemistry, geology or life.

9. **PROspecting lunar VolatilEs (PROVE) – Dr Mahesh Anand, Open Univeristy** - £106,869

   This project will investigate the nature and abundance of volatiles (gases such as carbon dioxide, carbon monoxide, nitrogen and hydrogen) released during heating of lunar soils collected during Apollo missions. This study will provide the first estimate of gases released at different temperatures that will directly feed into defining the performance requirements for ESA's PROSPECT instrument package which is being developed for a joint Russia-ESA lander mission to the south polar region of the Moon in 2021.

10. **The thermochemical evolution and state of Mars' deep interior – Dr Robert Myhill, Bristol University -** £302,051

    This proposal will conduct experiments to figure out Mars' internal structure, and work out how this structure came into being over the last 4.5 billion years.
    In the first part of this project, high pressure laboratory experiments will be conducted to recreate conditions at the bottom of Mars' mantle, about 1500 km beneath its surface. These experiments will be conducted to look at reactions between the iron and sulphur in Mars' deep interior. The resulting data will be compared with data returned from InSight.

    The second part of the project will look back in time, to the first few million years after Mars' formation, when its core was separating from a huge ocean of magma. High pressure experiments will be conducted to look at how conditions and composition affected how elements such as tungsten and tantalum were dissolved into the magma ocean. The concentrations of these elements are known from Martian meteorites, and contain information about the composition of Mars' core. Data recorded by InSight will also contain information about the composition of Mars' core, allowing us to combine two independent datasets to make the best possible models of Mars' interior and evolution.

11. **Characterizing the Martian water cycle by assimilating ExoMars 2016 Trace Gas Orbiter data – Dr Stephen Lewis, Open University** - £329,278

    The study of water vapour and water ice on Mars is the focus of this proposal, in terms of understanding the distribution of water, the effect of water ice clouds on the structure of the atmosphere, the impact of dust storms on the water cycle, and the transport of water over a complete Martian seasonal cycle. The project will combine standalone simulations of Mars' atmosphere and subsurface with the NOMAD data.

As NOMAD will be making a large number of observations they are ideally suited for integration into a global atmospheric model. Through this project the Martian water cycle can be investigated in much greater detail than can be achieved through use of NOMAD observations alone.

12. **Continued geochemical investigation of Noachian crust at Endeavour Crater with Mars Exploration Rover Opportunity – Dr Christian Schroeder, Stirling University** - £9,496

    In her 10th extended mission, Mars Exploration Rover (MER) Opportunity will investigate Noachian bedrock that predates Endeavour crater, study sedimentary rocks inside Endeavour crater, and explore a fluid-carved gully. The applicant will continue his support of Opportunity's operations and its Alpha Particle X-ray Spectrometer (APXS) to evolve his work using iron geochemistry and mineralogy. Opportunity is the only rover exploring Noachian bedrock in situ until the landing of the ExoMars rover and has investigated a variety of clay minerals. Her continued investigation is therefore highly relevant to prepare for the ExoMars rover's landing at Noachian, clay-rich Oxia Planum.

13. **Linking atmospheric and surface processes with ExoMars 2016 – Dr Nicholas Teanby, Bristol University** - £58,768

    The first part of the project will analyse the EDM MetWind and DREAMS-P wind and pressure records. Even though these datasets will only be from a short duration, the high sample rate provides a unique opportunity to characterise high frequency atmospheric behaviour for the first time. The primary aim is to use these records to determine accurate estimates of seismic noise on Mars' surface. Seismic noise on Mars is currently unknown and predictions are based on extrapolations of data using scaling that may not be applicable to Mars. These data can also be used to determine the depth of the planetary boundary layer, which has implications for how trace gases are transferred between the atmosphere and surface.

    The second part of the project will use infra-red spectra measured by TGO to determine the global energy balance of Mars' climate. This will allow atmospheric circulation to be inferred and will help interpret how trace gases are redistributed around the planet.

14. **ExoMars TGO Guest Investigator Support: Active Surface Processes on Mars – Dr Pete Grindrod, Natural History Museum -** £305,742

    Using a new image analysis approach this study will identify three different types of active surface process on Mars. First, young fault systems on Mars will be studied to determine whether they are active today, by measuring any surface movement down to the millimetre per year scale. The discovery and analysis of Marsquakes using this method offers an important complementary data set to that of the InSight mission.

Second, surface deposits that are thought to be rich in ice and similar to glaciers on Earth will be studied to determine whether they are flowing today. Glaciers can flow in a range of different ways, but most involve at least small amounts of meltwater, which is vital in studies of habitability on Mars. Third, wind-blown deposits such as dunes and ripples will be monitored to calculate how fast sand is transported across Mars, which is important in modelling the Martian atmosphere and climate and also for the safety and operation of future lander missions.

15. **Exploring the lunar polar environment, supporting PROSPECT Aurora 2016 (Academic Support) – Dr Neil Bowles, Oxford University** - £94,033

    Recent results from NASA's Lunar Reconnaissance Orbiter (LRO) spacecraft are showing that the Polar Regions of the Moon are quite unlike places that have been explored. In particular there is an intriguing trend in the most recent measurements that suggest that the surface nearer the poles may be significantly less dense than previous landing sites. This project will allow us to work out if this trend is real. It will also allow us to provide further, targeted observations from LRO to assist the engineering teams developing the PROSPECT instrumentation.

16. **Mars past climate and current heat flow – Dr Axel Hagermann, Open University** - £370,494

    The Heat Flow and Physical Properties Package (HP3) on board the InSight lander will measure Mars' heat flow. This project helps interpret HP3 data by establishing to what extent Mars' present-day subsurface temperature at the InSight landing site could be the result of catastrophic events such as atmospheric collapse. The results will be a set of reliable boundary conditions for the first-ever planetary heat flow measurement outside the Earth-Moon system and contribute to understanding if Mars' past subsurface temperatures were ever compatible with life as we know it.

17. **UK ExoMars Rover Landing Site Science and Characterisation – Dr John Bridges, Leicester University -** £42,858

The goals of this project are to conduct geological analysis of the proposed ExoMars landing sites, identify key scientific targets of interest at the landing sites, and to characterise major hazards to Rover mobility.