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Dr Iver Cairns
Chair, National Committee for Space Science
School of Physics
University of Sydney NSW 2006

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Submission to the Australian Decadal Plan for Space Science

Dear Dr. Cairns:

Planetary science will be one of the most exciting and rapidly expanding research areas of the coming decade. The recent discovery of more than 130 extrasolar planets and the continuing exploration of our Solar System through spacecraft missions and studies of extra-terrestrial materials provides powerful stimuli for understanding the geological and astrophysical processes that create planetary systems and shape the surfaces and interiors of planetary bodies.

Planetary science is inter-disciplinary and international in scope, linking earth scientists, astronomers, physicists, chemists, biologists, engineers, and mathematicians working independently on topics as diverse as the origin of our Solar System, global climate change, and development of new technologies for laboratory analysis and remote sensing. The knowledge base among planetary scientists in Australia is vast but somewhat disjointed and less effective than it might be, mainly because of lack of coordination at the national level. National support will drive breakthrough science, grow new technologies, and enhance Australia's international prestige.

This submission is from the Specialist Group in Planetary Geoscience, which was created under the auspices of the Geological Society of Australia with the following goals:

- Provide a national focus for research into the origin and evolution of planets and planetary systems.
- Support Australian research on extra-terrestrial materials, the origin of the solar system, surface processes on other planets, the nature of planetary interiors, the effects of impacts, and the long-term development and evolution of planetary atmospheres and climatic systems.
- Advance national strategic goals for research and education in geosciences relevant to planetary studies.
- Encourage development of national and international linkages with other societies and organisations that benefit Australian geoscience.
- Promote planetary geoscience to the broader community.

The GSA-SGPG represents planetary geoscientists from over 25 different educational, governmental, and industrial institutions across Australia. The development of an Australian

Decadal Plan for Space Science is most welcome, and the GSA-SGPG thanks the Academy's Space Science national committee for the opportunity to present this submission.

The GSA-SGPG has identified the following areas of existing national strengths in planetary sciences:

* **Geophysics of Stellar Disks and Planetary Interiors**

  This work concentrates on modeling the 3D thermal, chemical, and mechanical evolution of stellar disks, planetary orbits, and the interiors of planetary bodies on scales ranging from crustal thickness to the entire globe. Australian research groups have developed an extensive repertoire of modeling algorithms and implementations for handling the strongly non-linear, history dependent constitutive properties of planetary materials, and dealing with the large range of emergent length scales. The primary Australian research groups involved in modeling solar system dynamics and planetary geophysics are at Monash and the Australian National University, with nuclei developing at the University of Queensland and Sydney University.

* **Astrobiology and Extra-solar Planets**

  The question of how life began on Earth, and possibly elsewhere in the solar system and universe, is one for which Australia holds unique natural resources, such as the oldest known minerals and fossils. However, the leap from abiotic organic precursor molecules to functioning metabolic processes remains mysterious. Addressing this issue will involve understanding the co-evolution of the Earth and its biosphere, issues such as the history of life's origin, timing, and critical intervals, and the interaction of extraterrestrial, geological, and biological processes.

  The study of planetary systems around other stars is a rapidly developing, astronomically-based field that provides an observational basis for evaluating the diversity of planetary habitats across the galaxy and the universe. Significant national strengths in astrobiology and extra-solar planetary systems have been developed at Macquarie University, The University of Western Australia, and The Australian National University.

* **Cosmochemistry**

  Understanding how the Solar System formed and evolved requires knowing about the chemistry of planets and their precursors, and the ways in which elements are created in stars. Cosmochemistry is the laboratory study of extraterrestrial materials (meteorites, cosmic dust, lunar samples) aimed at understanding the formation and development of the Solar System from a chemical perspective.

  There are significant national strengths in cosmochemistry in Australia, including groups at the Australian National University, Monash University, Curtin University, Macquarie University, and the Western Australian Museum. Current cosmochemical research in Australia is focused on the time scales of planetary formation, processes that construct and modify planets on global scales, conditions in the solar nebula, and the delivery of supernovae and interstellar products to the early solar system.

  The coming decade will present significant opportunities for discovery as spacecraft missions to asteroids, comets, and the Moon return new types of extra-terrestrial material

to Earth, new meteorites continue to be discovered in Antarctica and the hot deserts of the world, and new analytical facilities are developed.

*** Australian Analogues of Mars Environments**

The ability of planetary geoscientists to extrapolate their understanding of physical processes that have shaped the Earth to other planets provides the most fundamental and advanced interpretative tool for building comprehensive models of the evolution of Mars and martian environments. Analogue studies related to aeolian, flood, periglacial and glacial, marine, volcanic, tectonic and impact processes bear directly on our understanding of climatic, hydrologic, and geologic conditions on Mars and its potential for life. The exploration of Mars has captured the imagination of the public, providing a vehicle for education on a variety of scientific issues relevant to planetary environments.

Australia represents one of the most versatile grounds in the world to conduct analogue studies of the martian environment, and there is broad national interest in this type of research, which links space science, earth science, and technology development. Research activities are diverse and range from spectral mapping of alteration mineralogy using airborne instruments for predicting signatures of martian hydrothermal systems, to modelling the geography of planetary surfaces using spatial analysis of landform distributions, patterns and relationships between comparative Mars-Earth land systems. The 2004 meeting of the Australian Geological Convention hosted special sessions on martian analogue research, emphasising Australian connections and contributions. This was followed by a thematic issue of the Australian Journal of Earth Sciences (June 2005) highlighting Australian-led research on Mars analogues in the Australian geological record.

This type of research has the potential to generate national benefits in the areas of information and instrumentation technology, as well as scientific gains. For example, the GeoSpatial Group at the University of South Australia aims to develop a geographical information and analytical system for planetary data. Research by CSIRO and commercial companies have delivered a suite of instruments that allows spectral mineral mapping and analysis at a range of scales. These systems have been widely used in mineral exploration and regolith research in Australia and overseas, and they provide a strong technological base for the development of spectral instruments for planetary exploration by robot rovers, automated drilling systems, or flyby and orbiter probes.

An important infrastructure component for Mars analogue research is the establishment of a field station in the Northern Flinders Ranges, where operational and laboratory tests can be conducted. These capabilities will support planning and exploratory missions to Mars. While still in its infancy, this initiative, if adequately supported in Australia, has the potential to become an essential asset for mainstream international space missions to the red planet, and as such it has attracted attention from both NASA and the European Space Agency. The availability of a large planetary science knowledge base in Australia makes this initiative particularly attractive to potential international collaborators.

*** Meteorite impacts – the Australian record**

The old age and stable surfaces of Australia provide one the best regions worldwide for exploration of the impact history of Earth. There are 26 established impact structures in Australia, and at least that many more structures for which an origin by meteorite impact has been proposed. The record of impact events in Australia spans 3.5 billion years of

earth history, from the oldest known impact ejecta in the Pilbara to young, well-preserved craters such as Wolfe Creek and Woodleigh, the world's 4th largest impact structure. Over the last few years a small group of dedicated geoscientists have established a discovery rate of approximately one impact structure per year, using sophisticated geophysical and geochemical methods.

Current research programs include examination of potential relations between large impacts, large volume volcanic eruptions, and global scale environmental changes. To date most impact studies in Australia have been conducted on an individual basis with scant funding. As an indication of the level of national interest in this topic, the Australian Journal of Earth Sciences recently published a volume in honor of Eugene Shoemaker that contains 22 papers updating the Australian impact record, and placing it within the context of planetary and space sciences.

*** Spacecraft missions**

Individual Australian geoscientists in various institutions across the country are involved in NASA and ESA space missions, albeit typically at a secondary level. A number of Australian geoscientists have collaborations with the International Research School of Planetary Sciences in Pescara, Italy, and either are negotiating for or have been granted direct access to data from the ESA Mars Express mission High Resolution Stereo Camera and the Mars Advanced Radar for Subsurface and Ionosphere Sounding experiments.

Considerable effort in Europe, Japan, and the USA is being directed toward sample-return and remote sensing missions to the Moon, Mars, and small bodies such as comets and asteroids. Australian geoscientists are well positioned to participate in these missions, a fact clearly recognised among colleagues outside of Australia as the individual collaborations attest. For example, Australian cosmochemists have been invited by the Japanese MUSES-C asteroid sample return mission to serve on the preliminary examination team and conduct invited research on the returned material.

The scale and scope of Australian involvement in spacecraft missions could be magnified through national support for space science. For example, formal links between Australia, European countries, Japan, and the USA to allow Australian scientists direct access to mission planning and data retrieval could be encouraged and actively pursued. Support for mission participation by Australian scientists would benefit the nation by providing more direct access to technology developments, in addition to a higher profile for Australian scientific achievements.

Sincerely,

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On behalf of the Geological Society of Australia Specialist Group in Planetary Geoscience.