

Planetary Sciences at The Australian National University

– an RSES perspective

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The ANU Planetary Science Institute

ANU has a distinguished history in the Planetary Sciences. Within the Research School of Earth Sciences, geochemical and geophysical research has focussed on the Earth as a planet including its role in our own solar system, as well as the mechanistic aspects of what makes this planet work in terms of its structure, driving forces for plate tectonics, and the unique aspects that make Earth suitable for life. We are continually faced with the question of whether Earth is unique in terms of the myriad aspects that make it the way it is. A recent development at the ANU's Research School of Astronomy and Astrophysics is a programme in exoplanet research. These studies allow the Earth to be placed in a planetary context throughout the galaxy. At this stage, the planets being found are large and eccentric and it will be some time before we can gain insights into smaller terrestrial-style planets. The joint interests at RSES and RSAA have led to the formation of the Planetary Science Institute (PSI), a jointly funded initiative between the two schools. The concept is to develop cross-disciplinary research programs between astronomers and geoscientists, and new expertise in planetary systems.

Dr Charley Lineweaver has been appointed as the lead scientist in PSI. His research interests focus on the nature of exo-planetary systems and what are the requirements of making any of these systems habitable. Given that our current understanding of life requires carbon-based systems mediated by liquid water, the search for sites where water is stable is an essential element for the possibility of life on other planets.

Dr Yuri Amelin, is the second continuing appointment within PSI. His research focuses on the timescales of solar nebula and planetary evolution. Recent results indicate rapid timescales (2-5 million years) for nebula contraction and formation of the initial solids. Placing these results within an astrophysical setting will be a prime area for collaboration within PSI.

The PSI is currently in the process of appointing a dynamical modeller to work on the mechanisms by which protoplanetary nebulae accrete into planetary systems.

Planetary Sciences at RSES

From the inception of RSES, planetary sciences has played a major role in research activities. The return of lunar samples in 1969 was followed by major advances in analytical techniques, leading to higher precision analyses of smaller and smaller samples. The fall of two major meteorites, Allende in Mexico and Murchison in Australia also led to research relating to the earliest history of the solar system, through to the role of meteorite components in the source region of Earth. RSES established an international reputation in these fields through the efforts of Professors Ted Ringwood (planetary chemistry), William Compston (isotope chemistry) isotopes), and Ross Taylor (analytical chemistry). Instrumentation developed at RSES during that era was unsurpassed in their fields. Ringwood's high-pressure apparatus allowed minerals to be grown at temperatures and pressures of Earth's

mantle. Taylor's mass spectrometer allowed measurements of chemical abundances of many elements in ultratrace quantities. Compston's mass spectrometer developments led the world in terms of sensitivity and precision, and ultimately led to the development of the SHRIMP (sensitive high resolution ion microprobe). SHRIMP has revolutionized geochronology allowing micron-sized grains of suitable U-bearing materials (zircon, monazite) to be dated using the U-Th-Pb decay schemes. This analytical success has led to commercialisation and the sale of SHRIMP instrumentation internationally.

Today, RSES continues its research in the planetary sciences, with active investigations into a variety of topics ranging from the nature of the earliest solids in the solar system, origins of presolar materials, planetary chemistry, and geophysics of planetary interiors.

Professor Hugh O'Neill studies planetary chemistry from the perspective of source materials and the processes that have affected their abundances in planetary objects. Specific research interests include the oxygen fugacity in Earth and planetary materials.

Dr Trevor Ireland uses the SHRIMP instruments at RSES to study isotopic systems in the earliest solids from the solar nebula (refractory inclusions found in the most primitive meteorites), and the isotopic systematics of presolar grains that incorporate great isotopic diversity through components of stellar nucleosynthesis. Current research includes obtaining an oxygen isotopic composition of the Sun through analysis of solar wind-implanted iron grains from the Moon.

Dr Marc Norman has worked extensively on the chemistry and isotopes systematics of lunar samples and meteorites to better understand the formation and evolution of the Moon, Mars, and asteroids.

Dr Geoff Davies uses numerical modelling to produce synthetic planets on computers. The incorporation of physical data from Earth allows the development of self-consistent models for the evolution of planetary interiors and the testing of such models through current geophysical and geochemical observations.

Other researchers contribute to our research in planetary sciences particularly through studies into the evolution of the earliest Earth. Professor Mark Harrison, Dr Vickie Bennett, and Dr Allen Nutman seek out the earliest vestiges of the Earth in Western Australia (oldest detrital zircons) and Greenland (oldest rock sequences) to elucidate conditions on Earth's surface at these ancient times. Dr Bennett is also pursuing a programme of understanding large-scale planetary differentiation and planetesimal populations in the early Solar System using isotope systematics of the Earth and Moon. Dr. Richard Armstrong is engaged in studies of the geochronology of terrestrial impact structures.

A new and exciting development in planetary research is the number of space missions that are being constructed with the intent of bringing extraterrestrial samples back to Earth. Genesis has already returned with samples of solar wind, and despite a hard landing, the samples are in hand that will allow the planetary system to be precisely compared with the dominant mass in the solar system. Early next year,

Stardust returns with cometary particles from comet Wild-2. In mid 2007, Hayabusa will land in Woomera bringing back samples from a near-Earth asteroid. Other missions to return samples from the Moon, Mars, and the asteroids are also in the planning stage. While Australia has not played any formal role in developing these missions, Australian planetary scientists are well positioned to contribute to the ensuing science through analysis and interpretation of returned extraterrestrial materials.