Spaceward Bound Australia 2009:

Expedition to Arkaroola and Sturts Stony Desert North of the Flinders Rangers.

Expedition Report

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Expedition Report

Executive Summary

The Mars Society Australia's Spaceward Bound Australia (SBA) in collaboration with 'NASA Spaceward Bound' in July 2009 undertook a 'Planetary and space science' expedition, to Arkaroola, Marree and Reedy Springs in the South Australian desert. The theme of the expedition was 'The evolution of life in our solar system'. Twenty seven planetary scientists, geologists, teachers and engineers from the US and Australia participated in the expedition.

The SBA 2009 expedition aim was in two parts:

- The first, was to undertake field science supporting research into 'the evolution of life' in our solar system; and,

- The second, was to invite teachers and students from the US and Australia to participate and work undertaking practical field science with the scientists closely involved in recent space exploration missions to the Moon Mars and Titan.

Science work included:

- Trialling Infrared Sensors;
- Advancing Teacher 'Hands On' Science Skills in the fields and Laboratory;
- Identifying Mars analogues for the 'Mars Science Laboratory' rover;
- Testing for biomass in clay minerals deposits adjacent to haematite-rich ironstones;
- The study of hydrologic systems as an analogue to similar systems on Mars as a way o finding possible locations for life on Mars;
- Searching for 'Desert Crust' and cyanobacteria living under a translucent desert stones;
- Biomineralization by microbes and the traces they leave behind as possible indicators of past life on Mars; and
- Distinguishing actual fossils from inorganic structures;

Prior to the expedition, participating teachers read papers on the principles of 'follow the water 'background theory over 6 main preparation sessions. They discussed the papers introducing teachers to a research culture, applying their subject knowledge to the background reading.

During the expedition specific new experimental skills undertaken by teachers included: general field observation work, sampling, measuring data in-situ, analysing hot spring systems, DNA extractions and sterile plate productions in the laboratory and thermographic techniques. Teachers also participated in numerous discussions to translate these skills to students.

Finally the expedition cost, starting and finishing in Adelaide, was $23,340 averaging $865 per person. The costs were shared proportionally between the Mars Society Australia and NASA Spaceward Bound.

Contents

1.0 Introduction

Spaceward Bound Australia (SBA) in collaboration with 'NASA Spaceward Bound' in July 2009 undertook a 'Planetary and space science' expedition, SBA 2009, to the South Australian desert visiting locations at Arkaroola, Maree and Reedy Springs, north of the Flinders Ranges in South Australia. The theme of the expedition was 'The evolution of life in our solar system'. Planetary scientists, geologists, teachers and engineers from the US and Australia participated in the expedition.

'Spaceward Bound Australia' is organized by the Mars Society Australia with aims that are in alignment with NASA Spaceward Bound. NASA Spaceward Bound is an educational program organized at NASA Ames Research Centre in partnership with the Mars Society (US) and funded by the 'Expedition Systems Mission Directorate' at NASA headquarters.

The focus of Spaceward Bound is to inspire and train the next generation of space explorers by having students and teachers participate with scientists in the exploration of scientifically interesting but remote and extreme environments on Earth as analogues for human exploration of the Moon and Mars. 2006 was the first year of the program.

For example, the first Spaceward Bound expedition led a group of US and Chilean teachers to the Atacama Desert in Chile to work alongside NASA field scientists to explore the limits of life in the dry, arid core of the desert. The teachers have returned to the classroom inspired and trained with NASA's Spaceward Bound planetary science curriculum. Students studying in school today, according to the time frame behind NASA' s current 'Vision for Space Exploration', may well have the opportunity to become the next generation of Moon and Mars explorers.

SBA expeditions undertaken prior to expedition SBA 2009 are:

- In 2007, two Australian teachers participated in a NASA Spaceward Bound expedition to the Mojave Desert, California; and,
- In 2008, a small expedition to Arkaroola and Woomera lead by SBA included two teachers/educators and a NASA representative.

Finally plans for 2010 are:

- The organising of three Australian teachers to participate in a NASA Spaceward Bound expedition to the Mojave Desert California in March;
- The organising of two Australian teachers to participate in a NASA Spaceward Bound expedition to Namibia in April;
- Undertake a reconnaissance expedition to the Pilbara region with some Australian and US Scientists as a lead up to a major Spaceward Bound expedition to the region in 2011; and,
- Teacher participation program at the ANU ion engine lab and similar engineering Labs in the US.

2.0 Expedition Aim and Program

The SBA 2009 expedition aim was in two parts:

- The first, was to undertake field science supporting research into 'the evolution of life' in our solar system; and,

- The second, was to invite teachers and students from the US and Australia to participate and work undertaking practical field science with the scientists closely involved in recent space exploration missions to the Moon Mars and Titan. Teachers and students had an an opportunity for additional training and inspiration which, as part of the NASA Spaceward Bound program, was intended to be passed on into school classrooms.

Expedition science activities are discussed in the section 'The Science Activities'.

The expedition took place from the 9th to 16th July 2009 starting and finishing in Adelaide. However teachers had been undertaking 'on line' training from NASA Spaceward Bound education coordinator, Dr Liza Coe in preparation to work with the scientists on the expedition. This work is discussed in the section 'Education Outcomes.

Finally Table 1 lists the program completed covering places visited, the travel times and science activities. A map of the region showing the locations is attached in the appendix.

3.0 The Expedition Team

The expedition team scientists and teachers from the US and Australia numbered 27 people with one another providing post expedition science support.

In summary:

- There were 12 US participants from 6 science institutions and 2 schools; and,

- There were 15 Australians including 3 scientists, 7 teachers and 5 support staff.

The participants, their affiliation, work and expedition roles are listed in Table 2.

Table1:Program

Day	Primary Activity	Travel Distance and time	Work Undertaken
Day 1, Thursday 9th July	Meet in Adelaide at: Mantra Hindmarsh Square 55-67 Hindmarsh Sq, Adelaide, SA 5000 Ph 61 8 8412 3333 hindmarsh.res@mantra.com.au Pick up vehicles		Team is gathers; Vehicles are collected; Science laboratory equipment collected from Uni SA
Day 2, Friday 10th July	Travel from Adelaide to Arkaroola village Ph:61 8 8648 4848 res@arkaroola.com.au	659 kM 9 hrs 21 min	Team travels all day to Arkaroola.
Day 3, Saturday 11th July	Science activities around Arkaroola Evening Presentations and/or astronomy	40 kM	Team undertakes a quick survey of various scientifically interesting locations around Arkaroola 3 presentations were given in the evening. These were: - The LCROSS mission; - MOL Survey of Mars poles - MSA activities in Australia
Day 4, Sunday 12th July	Science activities around Arkaroola	40 kM	The team divides into groups and investigate: - Paralana Spring - Old Paralana Spring - Black Spring - Stubbs Waterhole - Balcoracanna Outcrop - Nepowie Spring - The Mars-Oz site Location
Day 5, Monday 13th July	Travel from Arkaroola to slightly north of Marree along the Birdsville track. Stay at Marree Hotel Railway Terrace Marree, South Australia, Marree,	283 kM 5 hours	The team visits a site North East of Maree. Looking at dry soil areas, gypsum, clay and iron locations.

	Australia, 5733 Ph 61 8 8675-8344		
Day 6, Tuesday 14th July	Stay at Marree in Morning. Travel from Marree to Lyndhurst in afternoon. Stay at Lyndhurst Hotel-Motel: 3 Short Street, Lyndhurst, South Australia 5731 Ph 61 8 86757781 Lyndhurstpub@bigpond.com	230 kM 4hrs 40 min	The team divides into groups and investigates: - Cynobacteria activity under Translucent stones; - Spread and location of Desert Crusts - Iron and clay sites;
Day 7, Wednesday 15th July	Travel from Lyndhurst to Reedy Springs Work at Reedy Springs to late afternoon Travel from Reedy Springs to Lyndhurst	300 kM 4 hours 30 min	The team explored the Reedy spring location looking at water seepage and hydrologic systems from a natural spring in the desert.
Day 8, Thursday 16th July	Travel from Lyndhurst to Adelaide Stay at Mantra Hindmarsh Square	563 kM 7 hrs 40 min	Team travels all day to Adelaide.
		TOTAL 1965 kM	

Table 2: The Expedition Participants

The US Science Team	**Expedition role**	**Affiliation and State of Origin**
Dr Chris McKay	NASA Spaceward Bound Principal & US Expedition Leader	NASA Ames (CA)
Dr Jennifer Heldmann	NASA Spaceward Bound Coordinator	NASA Ames (CA)
Dr Adrian Brown	Astrobiology and remote sensing	Seti Institute (CA)
Dr Penny Boston	Geomicrobiologist	Dept of Earth & Environmental Science New Mexico Tech (NM)
Shannon Rupert	Ecologist	University of New Mexico (NM)
Elaine Bryant	PhD Student	San Jose State University(CA)
Dave Bryant	Engineer/Laboratory Technician	San Jose State University (CA)
Mike Spilde	Cave Research Scientist	Univ of New Mexico (NM)
Dr Rosalba Bonaccorsi	Astro-biologist	NASA Ames/ SETI institute (CA)
Jim Thompson	Cave Research Scientist	The Explorers Club (Florida)
US Teachers		
Stephen Joyce	San Jose State University (CA)	
Luther Richardson	Columbus High School (CA)	
The Australian Science Team	**Expedition role**	**Affiliation**
Dr Vic Gostin	Geologist (retired)	University of South Australia (SA)
Dr Paulo de Souza	Physicist (Post expedition Support Only)	CSIRO (TAS)
Eriita Jones	PhD Student	Australian National University (ACT)
Reut Abramovich	PhD Student	Australian Centre for Astrobiology, University NSW (NSW)
Australian Teachers		
Mark Gargano	SBA Teacher Coordinator	St Joseph's School (WA)
Joanne Berriman	Teacher	Oatlands District High School (TAS)
Jane Dobson	Teacher	Claremont College (TAS)
Liz Ryan	Teacher	Campania District High School (TAS)
Nicolette Burraston	Teacher	Armidale School (NSW)
Keith Treschman	Teacher	Brisbane Girls Grammar School (Queensland)
Naomi Mathers	Curriculum Developer	Victorian Space Science Education Centre (VIC)
Expedition Support Staff		
David Willson	Engineer/Australian Expedition Leader	MSA (TAS):
David Cooper	Pilot/Spaceward Bound Australia Coordinator & Expedition Safety Officer	MSA (WA):
Maureen Cooper	Information manager/Expedition Principal Cook	MSA (WA)
Nina Stansfield	Amateur Astronomer/Expedition Cook	MSA (SA)
Guy Murphy	Architect Historian/ Author/Expedition Media & IT Coordinator	MSA (VIC),

4.0 The Science Activities

A summary of science activities undertaken at the various locations on the expedition is:

- The study of biomineralization by microbes and the traces they leave behind at Akaroola as possible indicators of past life on Mars;

- The study of phyllosilicates formed from the weathering of mafic (basalts) and felsic (granites) rocks such as as those associated with silcrete at Arkaroola.

- Investigating the radioactive Paralana Hot Springs using infrared cameras at Arkaroola.

- The investigation of the geological record at Arkaroola including fossils. In particular distinguishing fossils from pseudo-fossils formed by chemical precipitation, physical deformation, or worm-like curved mud-cracks.

- The investigation of microbial ecology in springs and waterholes at Arkaroola and Wooltana. The springs in this region were investigated in 2004. At that time, streams had not flowed in seven years. Streams flowed again for the first time in 2009. The sites were revisited and water quality and vegetation characterized.

- The investigation of microbial diversity and identify diazotrophs (bacteria capable of fixing atmospheric nitrogen) which are an important niche in microbial communities and critical for nitrogen global productivity. The aim was to compare microbial communities between sites in order to highlight common bacteria in this unique area and ascertain, if possible, their ecological roles. The work entailed a culture-independent survey of archaeal, cyanobacterial and bacterial 16S rRNA, nifH genes and mRNA from the samples from all sites.

- The study of the survival of cyanobacteria under translucent desert stones near Marree;

- Investigation of 'desert crust' (microbiotic crust) near Marree;

- The study of how bacterial and Archaeal communities change in the top 7-8 cm of soil due to the availability of liquid water at Arkaroola and Marree;

- The study of Mars analogue hydrologic systems at Reedy Springs and making comparisons to potential groundwater discharge sites that have been identified on Mars; and,

- The identification of mars analogues for the 'Mars Science Laboratory' landing site candidates, and test hypotheses on preservation of organics/ total/viable and Gram negative biomass in clay minerals deposits adjacent to. hematite-rich materials/ironstones. These objectives used ATP luminometry and LAL (Lymulus Amebocite Lysate) assays in the field at all sites.
  The results will be compared to desert regions such as, Rio Tinto in Spain, Atacama in Chile, Death Valley in California, and the California coast.

The details of the science aims of the individual scientists are listed in the Appendix.

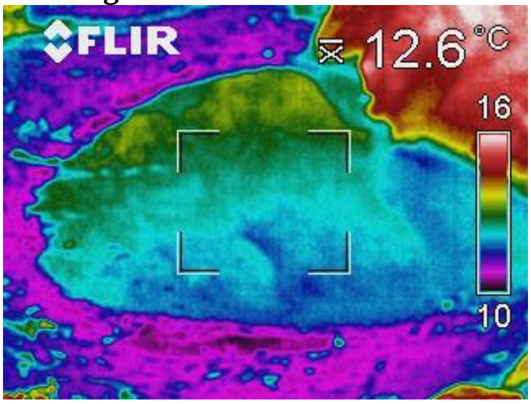
In addition CSIRO have taken expedition samples and are characterising the mineralogy and chemistry incorporating instruments that are to by carried by the 2011 Mars Science Laboratory rover. The tests include:

- Laser-induced breakdown spectroscopy (LIBS),
- X-ray diffraction (XRD),
- X-ray fluorescence (XRF),
- Infrared spectroscopy, and,
- Mossbauer spectroscopy.

The tests are still in progress.

The following pictures show some of the expedition science work that in particular work that connects the teachers to the practical hands on science.

Trialling Infrared Sensors:

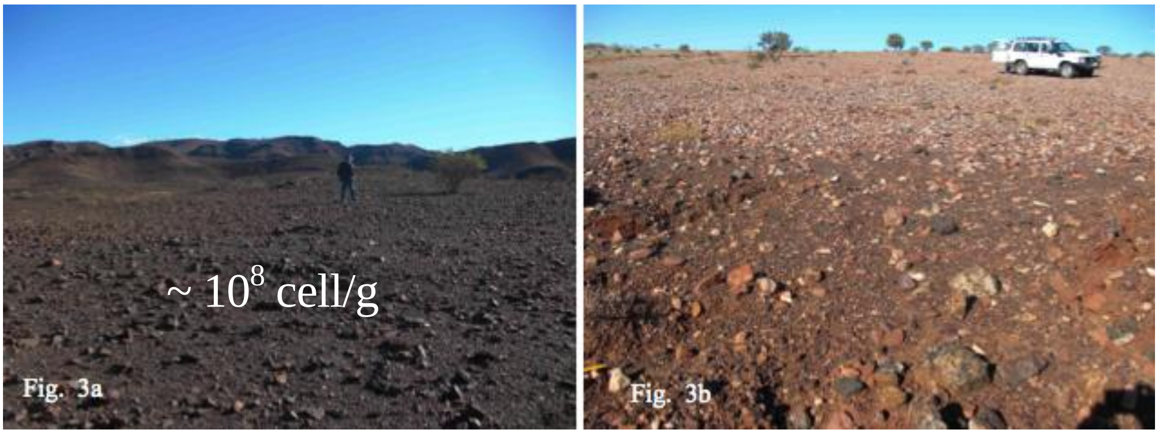


Teachers investigated Paralana Spring using infrared cameras at Arkaroola. The two pictures above are of Paralana Spring from an aircraft. The picture on the left was made by an infrared camera and on the right a standard camera. At the time of the photo a teacher measured the temperature of the spring to assist in calibrating the infrared photo.

Advancing Teacher 'Hands On' Science Skills:

At Arkaroola and Marree, teachers and scientists investigating as to how bacterial and Archaeal communities change in the top 7-8 cm of soil due to the availability of liquid water. The teachers were exposed to a range of 'hands on' sampling and laboratory techniques.

Identifying Mars analogues for the 'Mars Science Laboratory' rover and testing for biomass in clay minerals deposits adjacent to haematite-rich ironstones.



Samples taken from Arkaroola were analyzed for bulk organics and organic compounds in the lab. The main objective was to test for the preservation of organics and habitability potential of clay minerals-rich adjacent to. iron oxy-hydroxide-rich materials. Similar clay mineral rich sites occur on Mars. The results were compared to desert sites in Spain, Chile and California.

Near Marree, gypsum-rich soils were found with very sparse dark rocks or manganese/ironstone crusts. These rocks appear to be formed from chemically precipitated minerals in association with cm-sized gypsum crystals.

The black rocks are externally weathered and with several geoid-like filled with friable to indurated haematite (dusky red) and goethite (bright yellow/orange) minerals. Mineral samples from some of these cavities were taken to determine for furthers comparison of their gram-negative like microbial biomass vs. that of the surrounding surface soils.

The study of Mars analogue hydrologic systems at Reedy Springs and making comparisons to potential groundwater discharge sites that have been identified on Mars

At Reedy Springs, hematite spheres "blue berries" were found similar to those observed by the recent Mare Exploration Rovers mission at the Mars Meridiani Planum site.

Reedy Spring ponds and outflows contain fluids rich in dissolved iron, and complex mixtures of salts (including possibly Mg sulphates) and iron sulphates crystallizing surface environments surrounding the ponds and the drainage networks.

The site compares to groundwater discharge sites that have been identified on Mars

Searching for 'Desert Crust' and cyanobacteria living under a translucent desert stones

Looking for 'Desert Crusts' near Marree.

Cyanobacteria (the green material) under a translucent desert rock near Marree

Biomineralization by microbes;- indicators of past life on Mars and Teacher Laboratory Work

Investigation of ‘Desert Varnish’ as part of the study of biomineralization by microbes and the traces they leave behind as possible indicators of past life on Mars

Students and scientists working in the expedition portable microbiology lab.

Media and Teacher Activities

‘Discovery channel’ film crew interviewing a scientist for the National Geographic documentary series, 'Space Traveler: the astronaut's guide to leaving Earth'.

Teachers “trialling” space suits at Reedy Springs.

Finally the end goal of the expedition and astrobiology was summarized by the expedition science leader and NASA principle scientist, Chris McKay:

“The real treasure gained from Mars/planetary exploration is the possible finding a new genesis of life.”

6.0 Education Outcomes

Educators for NASA Spaceward Bound Australia 2009 were selected on merit, using a set of questions asking about their prior experiences, knowledge, interest and professional associations linked with Earth, planetary and space science education. In total there were 29 Expressions of Interest to attend this expedition, with advertising listed on most of the websites belonging to the state science teacher associations (including Western Australia, Tasmania, Victoria and Queensland) and other sites that are relevant to education such as the 'Victorian Space Science Education Centre' and 'Astronomy WA', along with email alerts sent through the 'CSIRO Science by email' and 'astarix'.

The final group selected consisted of 6 selected Australian Teachers (3 from Tasmania, 1 from New South Wales, 1 from Queensland and 1 from Victoria), being guided by Mark Gargano, Education Director, Mars Society Australia, Inc. (Based out of Western Australia.) In addition to the 2 US teachers that were selected by the US Spaceward Bound crew and participated in all planning sessions, activities in the field and post-expedition discussions and surveys.

A part of the Australian host-educator role was to get all the educators thinking and working together prior to the expedition, a copy of training sessions coordinated by the MSA Education Director can be located at; http://quest.nasa.gov/projects/spacewardbound/australia2009/info.html

Participating teachers had a range of tasks that needed to be completed between 13 June and 3 July, these were formulated by Mark Gargano, with guidance from Dr Liza Coe. This began with an overview of Spaceward Bound, which included examining a couple of published papers relating to Spaceward Bound and thinking about classroom techniques and practices, a bit of self-analysis of approaches to science, and highlighting the differences between being in control as the teacher to being a member of a field research group. From here the teachers considered the necessity of simulated or analogue training and how this links and provides essential data for scientists. It was very important for the teachers to read the background theory and to consider the 'follow the water' principles, which after looking over key readings, were able to chat at length with the other education team members, via email the meaning and relevance of these studies. The aims of the 6 main preparation sessions were to draw the teachers into a research culture, applying their subject knowledge to the background reading and getting the diverse group all communicating together, gaining insights from each other's interests and experiences, but with the main goal to ensure that the teachers were able to actively engage in and support the scientific operations.

The key is to get teachers to prepare for working in the field as a researcher, not in charge of or in control of a group of 30 students. Attending teachers need to consider the science and questions being asked, in addition to considering how this research will be useful for classroom practices.

The format of the exercise is for teachers to join research groups of their interest, and then after a day in the field spending perhaps an hour or two discussing and processing this information as a group. It is in this format that it is usual for class room techniques to become more evident, that is 'how will this be translated to students?"

Exercises and programs relating to exercises from Spaceward Bound Australia have been trialled and implemented in a number of schools and are now a regular part of the program in Year 7 to 12 classrooms, although most of the applications are appearing more relevant at the Middle School (Year 7 to 10) level. Many of the attending educators have taken examples of the field exercises and utilized the learned skills and data within existing programs, with links to remote sensing, infra-red thermography, hypolith growth and colonized quartz, microbe from soil analysis and growth monitoring on sterile plates. As a bonus, the teachers also participated two astronomy sessions using the Celestron 14-inch (360mm) Schmidt-Cassegrain (SC) astronomical telescope in the Sir Mark Oliphant Observatory.

As an additional benefit, the teachers were trained in Infra-red thermography techniques. 3 teachers participated in a low-level flight and the remainder were a part of a ground team, with both teams in contact via two-way communication, the aim was to use the thermographic techniques to be able to detect the location of surface and sub-surface hot springs. This technique had been used in the Mojave and the Atacama desert to identify the location of caves and lava tubes and distinguish these from simple shaded areas. So as an extension science exercise, after securing flight time, the thermography team, including teachers created a series of experiments to test any findings. Scientific findings have proved highly successful, with a paper linked to this research published and associated presentations.

Therefore, some of the aims of equipping teachers with fresh skills and being able to get students to practice these techniques after instruction and for teachers to know what is the latest in research has been highly effective. A number of the teachers involved, had not participated in field research since their initial degree training and as well as enrichment, generated a new experimental skill set and fresh ideas for new classroom and laboratory approaches with Middle and Senior School. Using a rotation method teachers participated in field work and sampling, measuring data in-situ, analysing hot spring systems, DNA extractions and sterile plate productions in the laboratory, instructed in and utilised thermographic techniques and with several becoming very adept at analysis of imagery. Thus upskilling teachers with authentic research techniques and laboratory activities that link directly to secondary schools. Within at least 4 education centres (St Joseph's School, The Armidale School, Oatlands District High School and the Victorian Space Science Education Centre) programs have been developed up to several weeks duration where themes such as the 'Search for Life' and 'Follow the Water' have been incorporated. This includes at St Joseph's School where a dedicated Space Science school based elective has been created and the advanced Year 10 Science students partake in a 'Student Spaceward Bound' to investigate historical, technological, cultural aspects of space science as well as conducting field research and collecting samples following the format and techniques taught on Spaceward Bound. This information has been shared through various networks in Western Australia, with additional teachers and schools, not directly involved in Spaceward Bound incorporating aspects of this program including examining areas incorporating stromatolites, impact craters and examining hypolith growth at various different sites in the field while on day trips.

The sharing of experiences and content has occurred at many conferences, including Astronomy WA Space Camp, the Conference of the Science Teachers Association of WA, the Australian Mars Exploration Conference, the WA Catholic Education Head of Science Department development days, Future Science and the 2009 International Science Education Conference in Singapore at the end of last year. In 2010 there are a number of presentations being conducted around Australia by the Spaceward Bound teachers (Alumni), including at least one session or workshop at the Conference of the Australian Science Teachers Association in Sydney in July and a teacher workshop at the Conference of the Science Teachers Association of Western Australia (CONSTAWA) and activities run for many teachers through the Victorian Space Science Education Centre.

The Educational program of Spaceward Bound is crucial and participating teachers have all been able to gain knowledge and expertise in field techniques and apply them to the diverse field of space science and enhancing science education creating an exciting experience for those students involved. Teachers involved are still in contact and have shared class activities, programs and experiments that are linked to the Spaceward Bound experience. This is a part of the associated aspects of being brought into the Spaceward Bound Alumni, that you engage in a change in your classroom. Through an increase in knowledge and field experiences, depending on year groups taught and school processes, teachers aim to increase the awareness of the searching for life here in remote locations and making that connection for their students to the missions that are being conducted by NASA and ESA, thus making it real science for the students and the teachers.

7.0 Expedition Costs

The expedition costs are summarized in the table below.
All up the total expenses was $23,340 or nominally $865 per person.

The expenses are from Adelaide to Adelaide as described in the program in section 2. The expenses excluded the travel costs for people flying to and from Adelaide prior and post the expedition.

The income for the expedition was divided proportionally between MSA and NASA Spaceward Bound. The expedition support staff costs were equally shared between the two partners. The table lists the contributors to MSA's income. The CSIRO were the primary contributors.

SBA 2009 Cost Summary

Item	Detail	Expenses
Insurance		$897
Catering	Purchase Food for self catering	$2,935
Hardware	Catering equipment	$1,018
Fuel		$1,692
Accommodation	Including Adelaide, Arkaroola, Marree and Lyndhurst	$9,221
Vehicle Hire		$6,429
Sundry Items	Helicopter flight for Teachers Science Equipment Expedition Badges	$1,148
TOTAL Expenses		**$23,340**

Income	Income
The Australian Contribution:	
CSIRO	$5,000
MSA	$3,000
ANU	$1,400
MSA Fund Raising	$600
VSSEC	$300
	$10,300
NASA Contribution:	
NASA Spaceward Bound	**$13,040**
TOTAL Expenses	**$23,340**

Finally other major in-kind contributors are:

The University of South Australia:	Providing approximately $30,000 of Lab equipment; and
University of New South Wales	Providing approximately 3,000 of Lab equipment.

APPENDIX

Spaceward Bound Australia 2009:
Table of Scientist Expedition Research Work

Scientist	Affiliation and Contact Details	Science Activity Description
US Scientists		
Dr Chris McKay	Astro-biologist, NASA Ames Research Center chris.mckay@nasa.gov	Studies of life in extreme environments. In particular the survival of cyanobacteria under translucent desert stones. We will map the percent of translucent stone colonized over the moisture transect to compare with similar work from the Atacama and the Mojave deserts. Connection of desert landscapes to Mars with particular emphasis on Astrobiology.
Dr Jennifer Heldmann	Planetary Scientist, NASA Ames Research Center jennifer.heldmann@nasa.gov	The past and present distribution of water on Mars in all three states is of prime interest to researchers interested in the history of the martian environment, the past and present possibility of life, and the availability of resources for human exploration. A useful method for improving our understanding of martian hydrologic systems is to study analog systems on Earth that occur in Mars-like environments. The Arkaroola region in Australia is recognized as a valid Mars analog given the diversity of sites that provide useful analogs for martian rocks, environments, and processes. There are a number of permanent or semi-permanent water sources in the Arkaroola area that will be studied as Mars analogs. These springs or waterholes include radioactive hot springs, weakly radioactive cold springs, warm springs, and pools in creek beds. The physical and environmental conditions sustaining these water sources in the arid Arkaroola region will be investigated.
Dr Penny Boston	Microbiologist Associate Professor of Cave and Karst Science Dept of Earth & Environmental Science New Mexico Tech pboston@nmt.edu	Studies of microbial life in extreme environments. Survival of microbe in subsurface environments. Biomineralization by microbes and the traces they leave behind as possible indicators of past life on Mars.
Mike Spilde	Manager, Microprobe/SEM Laboratories Institute of Meteoritics University of New Mexico	My primary field of study is mineralogy, with an emphasis on microbeam techniques (SEM, TEM, electron microprobe, and X-ray microprobe). My research is focused in several areas: 1) The use subsurface terrestrial environments (particularly caves and lava

	Albuquerque	tubes) as analogies to the subsurface of Mars in the search for life, 2) The study of biogenic minerals, particularly manganese oxides, and 3) Cave geology and mineralogy
Elaine Bryant	Soil microbiologist, San Jose State University Elaine P. Bryant epbryant@earthlink.net	The project will identify how bacterial and Archaeal communities in the top 7-8 cm of soil change due to the availability of liquid water. My previous research has focused on a precipitation transect through the Mojave Desert, encompassing a precipitation gradient from 23cm annual precipitation to 9 cm annual precipitation. I used two culture techniques and two molecular techniques to compare microbial communities from 7 sampling sites in order to alleviate shortcomings of the individual techniques. I intend to inoculate viable count plates, which should quantify the culturable microorganisms at sample sites, and will be inoculating Biolog sole-carbon-source microplates. The Biolog plates offer communities of bacteria 95 different carbon sources. The pattern of usage at the different sample sites is indicative of the physiological characteristics of the bacteria at those sites. The microbial communities can be compared using multivariate analysis. The project will also extract DNA from the microbial communities in order to create clone libraries for sequence and identification purposes and to perform Denaturing Gradient Gel Electrophoresis. DGGE allows a side-by-side comparison of the taxonomically distinct organisms at each site. This presents a snapshot of organisms which are located at many or all sites, as well as indicating more selective organisms located at only one site.
Shannon Rupert	Ecologist University of New Mexico, Department of Biology srupert@unm.edu	Ecology, carbon cycling, and nutrient dynamics in extreme environments on Earth that are analogs for Mars. Place-based education. Springs and waterholes on Arkaroola and Wooltana were investigated in 2004 as part of Expedition Two. At that time, streams had not flowed in seven years. Streams flowed again for the first time in 2009. Study sites will be revisited and water quality and vegetation characterized. A new investigation will look at microbial ecology in subsurface environments. Place-based education looks at local cultural heritage and incorporates traditional ecological and scientific knowledge in science studies. This has mainly been done at the K-12 level, but my work incorporates place-based education at the college level. Scientists and teachers will be invited to interact with local experts while we are in the field.
Dr Adrian Brown	Planetary Scientist, SETI Institute, NASA Ames Research Center abrown@seti.org	Multispectral and hyperspectral instruments such as TES, THEMIS, CRISM, and OMEGA are essential tools in the mapping of the surface mineralogy of Mars. My planned SBA research activities will revolve around remote sensing of Arkaroola using the HyMap airborne hyperspectral dataset and demonstrations to the teachers who are present. The resulting data will be linked to the results from the CRISM dataset on Mars.
Dr Rosalba Bonaccorsi	Astro-biologist, NASA Ames Research Center/ SETI Institute	I plan to identify mars analogs for MSL11 landing sites candidates, and test hypotheses on preservation of organics/ total/viable and Gram negative biomass in clay minerals deposits vs. hematite-rich materials/ironstones. These objectives will be addressed by

	rosalba.bonaccorsi-1@nasa.gov	using ATP luminometry and LAL (Lymulus Amebocite Lysate) assays in the field. We will also test feasibility/potential of applying these assays under extreme field conditions. Data obtained from SBA09 will be compared with ATP, LAL and CN data obtained from other desert/Mediterranean regions (Rio Tinto, Atacama, Death Valley, and the California coast).
Australian Scientists		
Dr Paulo de Souza	Physicist CSIRO Tasmanian ICT Centre Research Director Paulo.Desouza@csiro.au	Remote characterisation of the mineralogy and chemistry of the Martian surface is a key role for unmanned exploration. It will also be a requirement for both hand-held and laboratory-based instrumentation on manned missions. Techniques include laser-induced breakdown spectroscopy (LIBS), X-ray diffraction, X-ray fluorescence (XRF), infrared spectroscopy, and Mossbauer spectroscopy. In this project there will be laboratory characterization of samples collected by geologists in the field using different techniques such as XRF, LIBS, and Mossbauer spectroscopy and instruction of students and teachers into their use and significance on the Earth and Mars
Dr Vic Gostin	Geologist (ret) Geology & Geophysics, Adelaide University	Search for Ancient Life. The search for water and for the presence of life, is one of the leading aims of planetary exploration. Investigation of the sedimentary record, including any preserved fossils, is key to understanding the evolution of planetary environments. Therefore it is imperative to distinguish actual fossils from inorganic structures such as those formed by chemical precipitation, physical deformation, or worm-like curved mudcracks. Arkaroola has excellent outcrops of Precambrian limestones and organic-rich shales that have preserved stromatolites and sponge-like fossils, as well as microfossils. Some of these will be examined in the field. In addition, other specimens of reputed fossils and pseudo-fossils will be available as a comparison. The question of biogenic vs non-biogenic origins continues to be a hot research topic, and is most relevant to the exploration of the Martian environment.
Eriita Jones	Planetary Science PhD student, Mount Stromlo Observatory, ANU Canberra eriita@mso.anu.edu.au	Potential groundwater discharge sites have been identified on Mars and are a plausible explanation for a range of surface features. To investigate features in the desert at Arkaroola that form from subsurface seepage and surface runoff and are visually similar (in morphology, not in scale) to features seen on the Martian surface. By understanding the controls on the formation of these features insight can be gained into whether the same mechanisms could have been involved in forming the 'visually analogous' features on Mars.
Reut Abramovich	Microbiology PhD student, Australian Centre for Astrobiology, University of NSW reut.sorek@gmail.com	(1) Radon and hot spring water, microbial mats and adjacent soil will be sampled at every site. We aim to carry out a culture-independent survey of archaeal, cyanobacterial and bacterial 16S rRNA, nifH genes and mRNA. This extensive study will allow us to estimate microbial diversity and identify diazotrophs (bacteria capable of fixing atmospheric nitrogen) which are an important niche in microbial communities and critical for nitrogen global productivity. We aim to sample multiple sites, at variable depths and times of day/night, to ensure that we obtain a comprehensive description of

		the bacterial diversity and gene expression. We would then compare microbial communities between sites in order to highlight common bacteria in this unique area and ascertain, if possible, their ecological roles. (2) I will also survey on Behalf of Carol Oliver participating teachers at various points over the next two years, beginning with pre and post field trip surveys to gather initial data on the learning and attitudes towards science research. During the field trip we will hold several focus group meetings with the teachers. We will then subsequently send questionnaires to the teachers to understand what in-class practices they have changed as a result of the field trip and the impact on their students. Several publications will be forthcoming – one on the field trip experience, and the other on the impact in the classroom over the next two years. We expect the data to influence future efforts in bringing teachers and researchers together on scientific field trips.

APPENDIX

Reference Maps