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Fostering links between environmental and space exploration: the Earth and Space Foundation

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Abstract

The links between Earth and space exploration occur across a broad spectrum, from the use of satellite technology to support environmental monitoring and habitat protection to the study of extreme environments on Earth to prepare for the exploration of other planets. Taking the view that Earth and space exploration are part of a mutually beneficial continuum is in contrast to the more traditionally segregated view of these areas of activity. In its most polarized manifestation, space exploration is regarded as a waste of money, distracting from solving problems here at home, while environmental research is seen to be introspective, distracting from expansive visions of exploring the frontier of space. The Earth and Space Foundation was established in 1994 to help further mutually beneficial links by funding innovative field projects around the world that work at the broad interface between environmental and space sciences, thus encouraging the two communities to work together to solve the challenges facing society. This paper describes the work of the foundation and the philosophy behind its programmes.

Keywords: Exploration; Space; Earth; Expedition; Environmental; Mars

1. Introduction

The community that focuses its efforts on the exploration of space has largely been different from the community focused on the study and/or protection of the Earth's environment, despite the fact that both fields of interest involve what might be referred to as 'scientific exploration'. The reason for this dichotomous existence is chiefly historical. The exploration of the Earth has been occurring over many centuries and the institutions created to do it are often very different from those founded in the second part of the 20th century to explore space (compare, for example, the National Space Society and the National Geographic Society, or the British Interplanetary Society and the Royal Geographical Society). This separation is also caused by the fact that space exploration has attracted people from mainly non-biological disciplines, primarily engineers and physicists, but the study of Earth and its environment is a domain heavily populated by biologists. In the political arena, decisions made about the Earth's environment are often totally separate from decisions taken about the exploration of space, and undertaken by separate organizations.

The separation between both communities is often reflected in attitudes. In the environmental community it is not uncommon for space exploration to be regarded as a waste of money, distracting from solving major environmental problems here at home. In the space exploration community it is not uncommon for environmentalists to be regarded as introspective people who distract from the more expansive visions of the exploration of space—the 'new frontier'. These are generalizations, but they are important perceptions that influence the degree to which both communities perceive themselves to be different from each other. These perceptions can also be negative in consequence because the full potential of both communities can be realized better when they work together to solve problems. For example, space explorers can provide the

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satellites to monitor the Earth's fragile environments and environmentalists can provide information on the survival of life in extreme environments that helps us better prepare for the exploration and study of other worlds. These are just two examples.

In the sense that Earth and space exploration both stem from the same human drive to understand our environment and our place within it, there is no reason for a dichotomy to exist. A more accurate view of Earth and space exploration is to see them as a continuum of exploration with many interconnected and mutually beneficial links. These links are most obviously manifested in field research, because that is where Earth and space exploration find expression.

In 1994 the Earth and Space Foundation was established for the purposes of fostering such links by direct practical action. The Foundation's primary purpose is to fund field research and expeditions that practically demonstrate and deepen the links between Earth and space exploration, thus encouraging the space and environmental exploration communities to act together to address the challenges facing human society.

2. The Earth and Space Foundation

> Humankind now faces the dual challenges of the environmental preservation of the Earth and the exploration of space. Both are essential to our quality of life and our future. Neither goal can exclude the other and success in either requires boldly advancing on both. By supporting and encouraging exploration that bridges these complementary goals, the Earth and Space Foundation seeks to promote and fulfil the vision of the Earth as an oasis, cared for a by space-faring civilization.
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> Foundation Mission Statement

The Foundation was established in 1994 as a registered charity in the UK (No. 1043871). Originally named the 'British Foundation for Non-Terrestrial Exploration' it was rechristened the following year as the Twenty-one Eleven Foundation for Exploration after a 501(c)3 non-profit corporation was established in California. The Foundation remains registered as a charity both in the UK and the USA. Each entity is presided over by a Board of Directors; there is also a Board of Advisors, although there is overlap in the Boards of the UK and US charities. The Boards are made up of professionals involved in environmental or space sciences who either have extensive scientific and/or field experience.

3. Examples of work the foundation has supported

The Foundation established its annual grants programme in 1995 and now has a permanent endowment that supports the annual grant giving effort. The purpose of the grant programme is to fund expeditions that enunciate the full breadth of links between Earth and space exploration and in so doing, encourage and contribute towards communication between the environmental and space exploration communities. By the year 2002 the Foundation had helped support over 40 projects worldwide.

The Foundation's work is supported by individuals and corporations who contribute to the overall grant endowment or set up specific endowments to support an annual grant named after them. For example, the Betty Adamson Expedition Award was specifically set up to support expeditions that demonstrate a sense of adventure slightly out of the ordinary.

Each year a panel made up from the Board of Directors and Advisors reviews the grant applications. External opinions may be solicited.

The Foundation supports projects in a number of different categories representing certain themes that link environmental and space exploration. These grant-giving categories are listed below, along with examples of projects that have been supported by the Foundation.

3.1. Environmental projects using technologies resulting from space exploration

Such projects include those using satellite communications, GPS, remote sensing, advanced materials and power sources.

3.1.1. Use of remote sensing

The river plains of Guinea and Sudan support vast savannah zones that are important rice production regions for this area of the world [1]. In 1997 the Foundation assisted the West African Rice Development Association (WARDA) in its efforts to use satellite remote sensing to map and characterize the flood plains. The remote sensing data was coupled with ground-truthed and low-flight information to build up maps of this vital food production region that are now being directly used to improve rice production and harvesting.

The people of Guatemala are faced with destruction of the forest on which their livelihood depends. Rather than rejecting economic progress and trying to save the forests on their intrinsic merit, one novel approach is to make the forests themselves valuable, although these schemes must be carefully assessed to be successful [2]. In 1996 the Foundation provided a grant to a group of expeditions that used remote sensing to plan ecotourism routes in the forests, thus providing capital to the local communities through the tourist trade. This approach is now making the protection of the forests a sensible economic decision.

3.1.2. Use of global positioning systems

Coral reefs are an enormous source of biological diversity and contribute a great deal to the health of the world's coastal regions. Yet globally they are under stress [3]. The Foundation provided Edinburgh University in Scotland with a grant in 2001 to use GPS systems to map completely new and uncharacterized coral reefs in Madagascar. The study is part of an ongoing effort by the University's Coral Awareness programme to study new coral reefs to understand the extent of their biological importance to local ecosystems and ocean health. At the end of the year the university had successfully established a multiyear mapping project in the region that is providing important information for conservation efforts.

Mongolia is a country of vast natural resources and wealth, but its people need to know how to manage and use this wealth successfully [4]. In 1997 the Foundation helped to fund two separate projects focused on this nation. The first project used GPS systems to map archaeological remains throughout the country that date back to the days of Ghengis Khan. The data retrieved are being used to better look after these historic resources and it is being used to plan tourist activity. The second project used GPS and remote sensing to map snow free areas in the country during spring. When winter ends, Mongolian herdsmen often have difficulty locating snow-free areas for grazing their livestock. In the past, searches were conducted on the ground. Now, as a result of this project using satellite remote sensing, information on where the snow has cleared is fed directly by satellite to herdsman across the country.

3.2. Use of data from extraterrestrial expeditions to help further our understanding of the earth's environments and the biosphere

How does gravity influence the evolution of life on Earth? In 1996 the Foundation provided a grant to help analyse small self-enclosed biospheres that had been returned from space after several months of microgravity conditions. The aquatic biospheres, containing shrimp and algae, grew on the Russian Mir Space Station and were returned to the University of Arizona in the USA for data analysis. Scientists have studied the data to learn more about the evolution of life on Earth and to help plan effective closed-loop life support systems for the human exploration and settlement of the Moon and Mars [5].

3.3. Astronomy at the interface between earth and space exploration/astroarchaeology

Projects include expeditions making astronomical observations from remote, difficult to access, Earth locations, archaeological field projects studying the development of early civilizations that made significant contributions to astronomy and space sciences, and field expeditions studying the way in which views of the astronomical environment shaped the nature of past civilizations.

The area which now forms part of the modern state of Syria—'the Fertile Crescent'—was the birth place of astronomy, accountancy, animal domestication and many other fundamental developments of human civilization. In 1996 the Foundation helped fund a large archaeology project by the Society for Syrian Archaeology at the University of California, Los Angeles in collaboration with the Syrian government that used GPS and satellite imagery to locate mounds or 'tels' containing remnants of early civilizations. The collections from these regions are being used to build a better picture of the nature of the civilizations that gave birth to astronomy.

3.4. Field research applying the Earth's environmental and biological resources to the human exploration and settlement of space

This may include the use of extraterrestrial 'analog' environments on Earth, as well as physiological and psychological studies in extreme environments.

Space 'analog' environments on Earth help us understand how to operate in the space environment or help us characterize extraterrestrial environments for future scientific research [6]. The diversity of such environments is large. In 1995 the Foundation provided a grant to an international caving expedition to study the psychology of explorers subjected to long-term isolation in caves in Mexico. The psychometric tests on the cavers were used to improve US astronaut selection criteria by the NASA Johnson Space Center.

In the Arctic a 24 km-wide impact crater formed by an asteroid or comet 23 million years ago has become home to a Mars-analog programme [7]. In 1998 the Foundation helped fund the NASA Haughton–Mars Project to use this crater to test communications and exploration technologies in preparation for the human exploration of Mars (Fig. 1). The crater, which sits in high arctic permafrost, is an excellent analog for the physical processes occurring on Mars, a permafrosted, impact altered, planet. Geologists and biologists are working at the site to help understand how impact craters can shape the geological characteristics, and possibly biological potential, of Mars.

3.5. Astro- and exobiology related fieldwork

Field research that assists in the search for life off the Earth and the study of the survival of life in extreme environments are the main elements here.

Dolphins demonstrate certain aspects of self-awareness and other attributes of intelligence. Earthtrust, an international environmental non-profit organization, runs Project Delphis, a programme that brings together computer scientists and biologists to try to unravel communication in this non-human mind [8]. In 1996 the Foundation provided a grant to help this project. The space related applications are two-fold. First, the link between biologists and computer scientists is key to many other areas of astrobiology, such as the development of technologies to search for life on Mars or Jupiter's moon, Europa. The collaborations that have been forged by the project have provided important lessons in how to establish interdisciplinary scientific studies. Second, unravelling communication in a non-human mind can help us develop the technology and approaches for seeking signals from extraterrestrial civilizations. The work has immediate benefit to the Search for Extraterrestrial Intelligence (SETI) and generally for developing methods to unravel complex electronic signals.

In 2001 the Foundation provided a grant to the Massachusetts Department of Environmental Protection to launch an expedition to the Antarctic led by Brian Duval. He is a specialist in snow algae. These micro-organisms live within the snow itself, gathering their nutrients from the tiny amounts of contaminants to be found in melt water and gathering their energy from sunlight. As well as understanding how these organisms make a living in such an unforgiving environment, Brian Duval is interested in snow algae as an analog to possible forms of life in extraterrestrial snow and ice covered environments [9]. So as well as providing direct information on how these organisms contribute towards productivity in the polar regions of the world, the work has interesting implications for exobiology, the search for life beyond Earth. The expedition returned with important new collections of these unusual extreme environment organisms.

Fig. 1. Scientists simulating space missions in extreme environments on the Earth can help prepare the way for the exploration of Mars. Here, in 2001, scientists see how the deployment of cosmic radiation dosimeters is hindered by wearing restrictive exploration suits. The simulation was just one activity of the NASA Haughton-Mars Project, which the Foundation helped to fund in 1998 (photo, Charles Cockell/NASA Haughton-Mars project/Mars Society).

3.6. Effects of the space environment and space exploration on the earth

This involves expeditions studying impact craters, environmental surveys of launch complexes, and approved meteorite collection expeditions.

The massive extinction 65 million years ago that wiped out the dinosaurs and three-quarters of all life on the planet may have been caused by the collision of an asteroid or comet with the Earth [10]. The Chixculub crater in Mexico's Yucatan Peninsula may be evidence of this devastating event [11]. In 1996 the Foundation helped to fund the Planetary Society to launch an expedition to study the 120-km wide crater. The expedition collected samples and undertook surveys of the crater that yielded powerful evidence that the crater was caused by the impact that triggered the Cretaceous–Tertiary extinction. The crater is now widely accepted as being associated with the extinction boundary.

3.7. Educational fieldtrips that improve public understanding of the links between environmental and space exploration

African countries are making rapid strides in economic development. In 1999 the Foundation provided a grant to Kevin Hand from the NASA Ames Research Center to assist him in his travels across Africa talking to schools about space research and education. His trip lead to the formation of Cosmos Education, a new US-based non-profit organization dedicated to space education in developing countries. By organizing the 'Under African Skies' conference, the Cosmos Education Foundation has helped African children understand how space research can be of direct benefit to their lives and their welfare.

The International Space University (ISU) is a multi-disciplinary graduate school that provides education in subjects as diverse as space law and space life sciences to more than 100 students from over 20 countries around the world each year [see e.g. 12]. In 2001 the Foundation provided a grant to send all ISU's summer sessions students to an environmental exhibit in Bremen, Germany. The exhibit highlighted new approaches to environmental protection and research. The purpose of the grant was to allow these future space leaders to become fascinated by environmental research and the study of the Earth's biosphere. It was a trip acclaimed by all those who took part in it.

4. Other projects and future projects

The Foundation seeks to establish a long-term continuity in its activities through two programs. The first program involves a series of awards for the future human exploration of Mars, a location with a diverse set of exploration challenges [13]. The awards, funded through a separate endowment, will honour the following human 'firsts' on Mars:

- landing on the surface;
- undertaking an overland expedition to the Martian South Pole;
- undertaking an overland expedition to the Martian North Pole;
- climbing Olympus Mons, the highest mountain in the Solar System;
- descending to the bottom of Valles Marineris, the deepest canyon on Mars.

The Foundation will offer awards for expeditions further out in the Solar System once these Mars awards have been claimed. The long-term awards demonstrate that the grants programme really has no boundary in what it could eventually support and they provide longevity for the objectives of the Foundation. The awards underline the fact that there is no contradiction in an organization supporting and encouraging the exploration of space and at the same time directly funding and supporting environmental research.

Fig. 2. The spirit of exploration that drives us to understand and protect the Earth's environment will drive us on similar extraterrestrial frontiers. Here, an explorer climbs the foothills of Olympus Mons on Mars in the painting 'Hard Science' held by the Foundation in its collection. Two and a half times the height of Mount Everest, it is the highest mountain in the Solar System. (Image copyright, Pat Rawlings, 1993.)

The Foundation's other long-range effort involves acquiring a collect of paintings and drawings that depict epic human expeditions on the frontiers in the Solar System. The Foundation holds the original of the 1993 Pat Rawlings painting, 'Hard Science', which depicts a suited explorer climbing the foothills of Olympus Mons (Fig. 2). In 2000 it commissioned a painting of explorers setting out for the Martian North Pole entitled, 'Farewell! Departure for the Pole!'. The Foundation also holds two paintings by Michael Carroll depicting explorers at the Martian North Pole.

These paintings are not only long-term assets, but they depict in visual format the expeditions and field research the Foundation will one day be funding, again providing substance to the long-term vision of continuity. They directly depict the common spirit that links the exploration of Earth and space.

As for future projects, the Foundation is keen to develop its activities. It plans to establish its own expedition programmes and launch education programmes which support the foundation's vision. These new directions will be dependent upon funding becoming available for specific projects.

5. Conclusions

The links between environmental and space exploration are broad and deep. The environmental and space exploration communities can work together to solve the challenges now faced by human society in both protecting and understanding our planet and exploring the frontier of space. The Earth and Space Foundation was established to fund field expeditions and practical research that bridge these two complementary goals, thus directly furthering society's advance on both fronts. Using the annual grants programme, by 2002 the Foundation had successfully helped support over 40 diverse projects worldwide which reflect the full breadth of these links. The success of its work demonstrates that its mission-statement vision of 'the Earth as an oasis cared for by a space-faring civilization' is a real, practical, objective. Its work will be continued through existing and future programmes and the support of its benefactors.

6. Further information

Further information can be found on the Foundation web site at www.earthandspace.org

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