Understanding the Red Planet

Dr John Grant and **Sharon Wilson** speak to *International Innovation* about their innovative research into Martian climate history and geology

Could you summarise your respective academic backgrounds and explain what sparked your interests in geology and, more specifically, the planet Mars?

JG: I am a geologist who became interested in geology and geomorphology while growing up along the shores of Lake Champlain in northern New York State, USA. I developed an interest in Mars as a child after reading science fiction, which grew into a fascination after the Viking landings occurred. I attended the State University of New York College at Plattsburgh, receiving my Bachelor's degree in Geology in 1982 with magna cum laude. I then earned a Master's and PhD, both in Geology, at the University of Rhode Island and Brown University, respectively.

SW: I am a geologist who grew up in Wisconsin and found geology to be the perfect field in which to combine my interest in mathematics and science with my love of exploration and the outdoors. After analysing the geochemistry of mafic rocks in Vermont during college, I studied the aqueous alteration minerals in a meteorite from Mars during an internship at the Natural History Museum in Washington, DC. From that point on, I have been captivated by the geology and climate history of Mars.

How has your collaboration with one another contributed to the overarching goals of your research and what impact do you hope your work will have?

JG&SW: We have broadly similar research goals. Simply put, we are a team and work very well together, with the efforts and queries of one complementing those of the other. Ultimately, we would like to build a more robust understanding of the evolution of water-related activity on Mars and how it relates to the occurrence – both in time and location – of habitable conditions on the planet.

Can you outline some of the channels through which you collect data on planetary and terrestrial geology and geophysics, and the challenges associated with managing these processes?

JG: Data used in our planetary research come from past and ongoing missions (mostly NASA). These data are readily available via the Planetary Data System (PDS) in the US and can be obtained online from a variety of sources. In addition, my participation in three ongoing Mars missions – the High Resolution Imaging Science Experiment (HiRISE) camera on the Mars Reconnaissance Orbiter (MRO), Spirit and Opportunity Mars Exploration Rovers (MERs), and the Curiosity Mars Science Laboratory (MSL) – means I am involved in the targeting and collection of various data from Mars that can sometimes be used to support my research.

One of the challenges with managing data collection is that mission operations are time-consuming and involve lots of careful planning. The benefits are that the resultant data are then available for many people and for all time.

Have your findings into water-driven activity on Mars been well-received and what impact will this have on future research into habitability?

JG: I believe our research results have been well-received by the planetary science community and are held in high regard. Although our recent research concerned relatively young (by Martian standards) alluvial fans, many of our studies have related to older features and have contributed to a better understanding of the role of water in shaping the surface and potentially habitable environments on Mars. In the case of alluvial fans, their late activity points to local settings on Mars that may have been characterised by habitable environments a fair bit later in Martian history than has been thought.

Will you be participating in any special events or programmes this year? How important are outreach activities in your current roles?

JG: Beyond numerous and frequent mission operations activities, I participate in a number of outreach activities and give regular talks and colloquia related to my research and mission involvement. These activities are central to the activities of the Smithsonian. For example, in recent months I gave the keynote speech at the USA National Space Grant College and Fellowship Program conference, presented a talk at the Geological Society of Washington, gave presentations to local elementary school students, and delivered several presentations at professional conferences.

In terms of special events, I am the curator for an exhibition at the Smithsonian National Air and Space Museum entitled 'Spirit and Opportunity: 10 Years Roving Across Mars', which opened in time for the 10th anniversary of the rover landing on Mars and will remain open until the mid-August 2014. I am also the co-chair of a committee looking into landing sites for the next rover to Mars, which is expected to launch in 2020. The first of multiple workshops related to selecting the landing site for that mission was held in May this year.

Conditions right for **life on Mars?**

A group of researchers based at the **Center for Earth and Planetary Studies** in the **Smithsonian National Air and Space Museum**, USA, is uncovering new possibilities about the history of the Red Planet's habitability

THE STUDY OF other planets is vital as it informs our understanding of the Earth. The iconic Red Planet, with one of the more hospitable climates of all the planets in the Solar System, has become a focal point of investigation for planetary scientists. But images collected of Mars, familiar to many, depict a hostile and seemingly uninhabitable red desert. Conditions on the planet – characterised by low temperatures, low pressure and extremely little or no liquid water on the surface – do not appear to be conducive to sustaining life today.

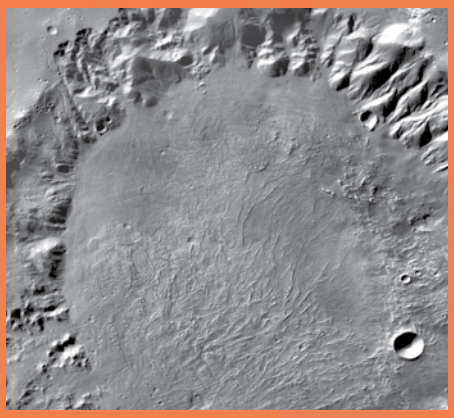
However, many scientists postulate that Mars may once have harboured primitive, bacteria-like life. Early in its 4.5 billion-year evolution, scientists believe that the Earth's second-closest neighbour had a thick atmosphere that was warm enough to support lakes or even oceans of liquid water. Indeed, the large eroded craters, outflow channels and other geologic features seen today provide evidence that liquid water once flowed on the surface of Mars. A fuller understanding of the history of water on the Red Planet is crucial for deciding whether ancient lifeforms may have lived on Mars in the distant past.

INNOVATIVE RESEARCH

Dr John Grant and Sharon Wilson, both based at the Center for Earth and Planetary Studies (CEPS) in the Smithsonian National Air and Space Museum, Washington, DC, USA, are two leading researchers in the field of geology and climate history on Mars. Grant has held several professorial posts at academic institutions in the US, as well as authoring and contributing to a huge number of articles in many high-profile industry publications. Meanwhile, Wilson's investigations at CEPS have been highlighted in the Smithsonian Channel's Women in Science Month.

CEPS research focuses on the geologic evolution of the Earth and other planets. Its overarching objective is to further understanding of the evolution of habitable worlds, approaching the problem from multiple angles: terrestrial fieldwork, detailed characterisation of geological processes and mapping of planetary surfaces.

Researchers from the Center are also heavily involved in ambitious space missions; for example, they have made leading contributions to four Mars missions, one lunar mission and one mission to Mercury. CEPS scientists – most of whom are geologists or geophysicists – are also responsible for educational outreach to members of the public in the form of curating permanent and temporary space exhibitions at the Air and Space Museum.



This 43 km-diameter crater in Margaritifer Terra (27.8 S, 332.6 E) contains alluvial fans, especially well-developed in the lower left (southwest) quadrant, and sourced from well-developed alcoves in the interior crater rim. Subframes of CTX images B01_009999_1519 and P21_009432_1520 (6 m pixel-scale). North is towards the top.

EVOLVING KNOWLEDGE

Grant, Wilson and colleagues use cutting-edge technology to make observations about the surfaces of planets. For example, the Context Camera (CTX) on the Mars Reconnaissance Orbiter (MRO) provides grey images at a ~6 m pixel scale as it orbits around the planet. The High Resolution Imaging Science Experiment (HiRISE) camera on the MRO – for which Grant serves as a co-investigator – collects images with a pixel scale of ~26 cm that are about 6 km wide.

The research team has used the data provided by these cameras to locate alluvial fans on the surface of Mars. These fans – water-lain deposits of sediment at the juncture of steep, confined slopes and lower, flatter terrain – are important landmarks that provide crucial information about climate history and geomorphic activity. While alluvial fans have been recognised on Mars for several decades, it is only in the past 10 years that significant technological advances have facilitated their analysis in greater detail: "These newer data enable the assessment of morphometry – that is, 'appearance' – in ways comparable to those used on Earth, thereby enabling statements to be made about their evolution," explains Grant.

RETHINKING HABITABLE HISTORY

Alluvial fans are widespread on Mars and are known to exist across a range of different latitudes and longitudes on the planet. Grant, Wilson and their collaborators have studied them in order to characterise both the size and style of the runoff of water involved in their formation. As noted in their research papers over the past few years, many of the Martian alluvial fans are extremely well-preserved, with relic drainage channels as narrow as several metres still apparent. The remarkable preservation of these alluvial fans – as well as other small-scale features – contrasts with the degraded appearance of the craters in which they are found, suggesting sedimentary deposition occurred somewhat later in Martian history.

Interestingly, analysis of various water-lain deposits and eroded rocks on Mars provides evidence to suggest that most water-related activity occurred early in the planet's evolution.

The young alluvial fans discovered by the team substantially post-date the time when most water activity was thought to be occurring on the surface of Mars during the planet's first 1-2 billion years

However, while it is generally held that the climate after that period became drier and less habitable, Grant and Wilson's research crucially shows that the latest activity on some of these fans reflects runoff of water later than previously thought. This suggests conditions on Mars in some local areas may have been wetter much later in the planet's history than originally hypothesised: "Therefore, our results intimate that potentially habitable environments were not limited to the earliest periods of Martian history," Grant discloses.

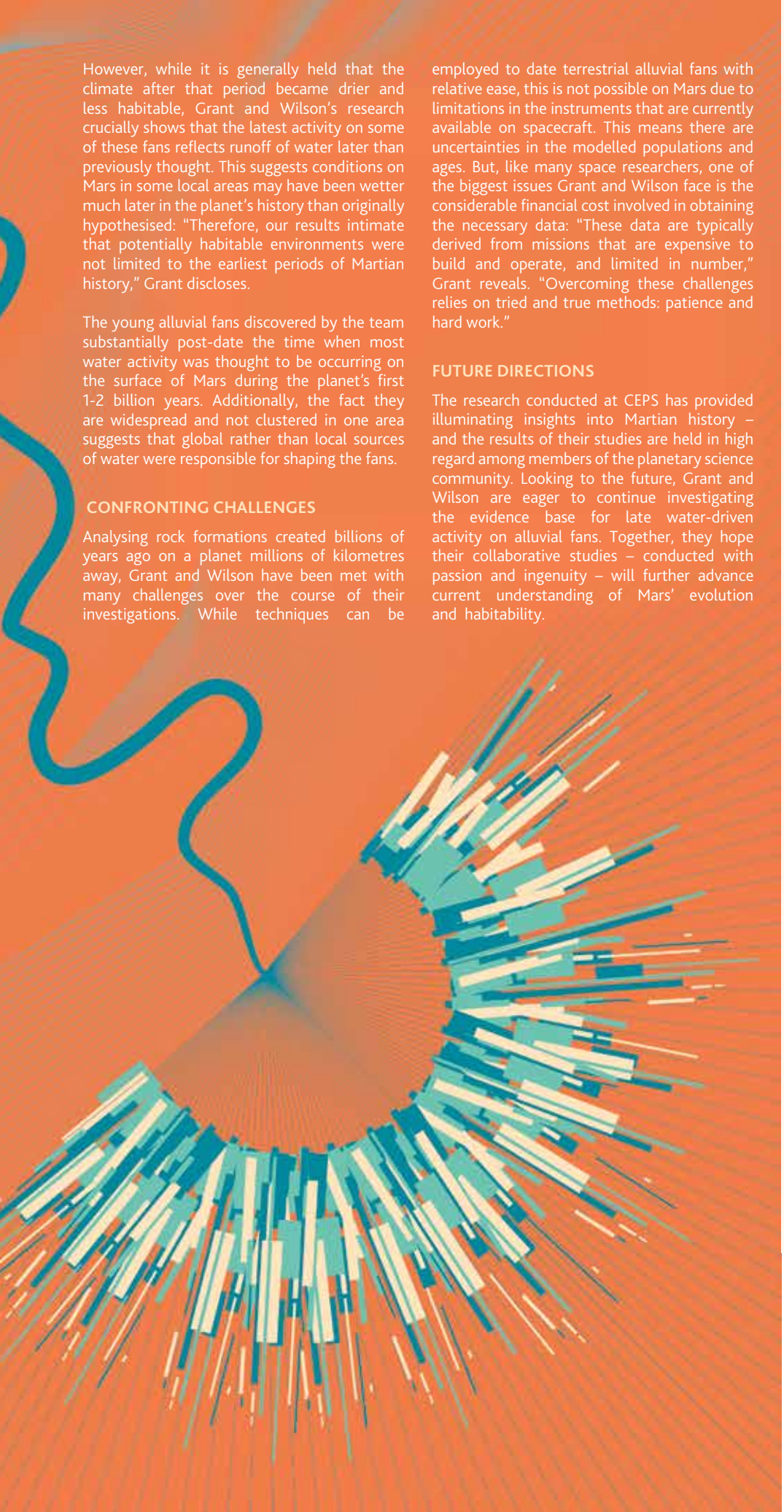
The young alluvial fans discovered by the team substantially post-date the time when most water activity was thought to be occurring on the surface of Mars during the planet's first 1-2 billion years. Additionally, the fact they are widespread and not clustered in one area suggests that global rather than local sources of water were responsible for shaping the fans.

CONFRONTING CHALLENGES

Analysing rock formations created billions of years ago on a planet millions of kilometres away, Grant and Wilson have been met with many challenges over the course of their investigations. While techniques can be employed to date terrestrial alluvial fans with relative ease, this is not possible on Mars due to limitations in the instruments that are currently available on spacecraft. This means there are uncertainties in the modelled populations and ages. But, like many space researchers, one of the biggest issues Grant and Wilson face is the considerable financial cost involved in obtaining the necessary data: "These data are typically derived from missions that are expensive to build and operate, and limited in number," Grant reveals. "Overcoming these challenges relies on tried and true methods: patience and hard work."

FUTURE DIRECTIONS

The research conducted at CEPS has provided illuminating insights into Martian history – and the results of their studies are held in high regard among members of the planetary science community. Looking to the future, Grant and Wilson are eager to continue investigating the evidence base for late water-driven activity on alluvial fans. Together, they hope their collaborative studies – conducted with passion and ingenuity – will further advance current understanding of Mars' evolution and habitability.



INTELLIGENCE

THE SURPRISINGLY WET LATE CLIMATE ON MARS

OBJECTIVE

To add to the growing body of evidence suggesting late water-driven activity on alluvial fans, which points to sources of water sufficient for enabling runoff later in Martian history than has previously been widely thought.

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DR JOHN GRANT received his Bachelor's degree, magna cum laude, in Geology in 1982, followed by a Master's and Doctorate in Geology at the University of Rhode Island (1986) and Brown University (1990), respectively. After a two-year position at NASA Headquarters, where he served as Program Scientist, he then accepted his current position of Geologist at the Center for Earth and Planetary Studies at the Smithsonian National Air and Space Museum in 2000.

Grant has had a strong connection to the classroom, beginning as a lecturer at Brown University in 1990. Since then, he has held several professorial posts at both Rhode Island College and the State University of New York College at Buffalo, where he was Associate Professor in Earth Sciences and Science Education.

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