A new frontier in space exploration

Dr Gordon Osinski draws parallels between craters left on Earth by asteroids and comets billions of years ago to construct a better understanding of distant planets. Here, he explains how this novel research evolved

First, can you outline your current research interests in the field of planetary geology?

My research interests are diverse and interdisciplinary in nature. My main area of research focuses on understanding impact cratering as a planetary geological process, on the Earth, Moon and Mars. My research covers the mechanics of impact crater formation, the generation of impact melts, emplacement of ejecta and post-impact processes such as impact-associated hydrothermal activity. Fieldwork forms the basis of much of my research, coupled with the application of cutting-edge micro-analytical imaging and analysis of samples. Satellite data is used extensively to guide fieldwork and to study the Moon and Mars.

My research also covers the fields of astrobiology and planetary materials. My interest in astrobiology stems from my work on impact craters; there is a growing body of evidence that impact craters, once formed, represent protected niches that are more favourable to life than surrounding terrains.

With respect to planetary materials, I am increasingly working on meteorites from asteroids, the Moon and Mars as probes in to the processes that operate on these bodies.

To what extent do you believe we can explore other worlds by exploring our own?

This mantra has become one that drives my research. I am a firm believer in field-based research and teaching. Indeed, field courses are one of the best pedagogical techniques for understanding the physical sciences. Students are given the opportunity to see real rocks, environments and relationships rather than through the 'eyes' of a book. This can also be translated to research, particularly for Mars, which is Earth-like in so many ways. Essentially, our interpretations of Mars can be guided, and potentially tested, by carrying out investigations of environments on Earth that are similar in some respect – whether that be their geology or environment, both past and present.

Why is the geology of celestial bodies so important to science and society?

There are so many answers to this question. There are, indeed, scientific, technological, political and even economic reasons, but in the end humans have always explored, driven by our curiosity and thirst for knowledge. Planetary exploration represents the high frontier of exploration. No other form of exploration fires the public imagination or has played such a dominant role in recruiting talented individuals to science and engineering careers over the last 40 years. Indeed, developing the technology required for planetary exploration missions represents one of the most challenging engineering opportunities of our time and has resulted in countless new products and technologies that have revolutionised life on Earth.

The Mars rover landing has generated a lot of interest in your field. What do you hope NASA will discover from the Mars mission?

The successful landing of the Mars Science Laboratory Curiosity rover was a huge engineering success and has definitely generated a lot of excitement. It has already made some key discoveries that point to Mars being habitable for life in the past – the goal of this mission is not to find evidence for life but to seek out signs that Mars was, or is, habitable. Some of the evidence already found include conglomerate rocks, which can only be formed in fast flowing water, like streams and rivers, and minerals such as clays, which require water for their formation on Earth.

Could you explain why impact cratering is such an important process?

It can be argued that impact cratering is the most common geological process in the Solar System. All planets, moons and asteroids with solid surfaces have been bombarded by objects from the day they were formed and will continue to be struck until the end of the Solar System. The same cannot be said of other major processes, such as volcanism and plate tectonics. It has become clear in recent years that impact events have shaped the geological and biological evolution of Earth and generated some of the planet's most important economic resources.

Finally, how do you encourage collaboration across the disciplines?

Collaboration across disciplines is often tough to achieve and one must be proactive about it. To this end, I have established Canada's first training programme in 'Technologies and Techniques for Earth and Space Exploration'. This programme brings together industry, academia and government, and centres on the themes of planetary exploration, mining technology and robotics. It integrates mechanical and electrical engineering with biology, geology and astronomy, in the pursuit of establishing a world-class research and training programme.

Geology of the Solar System

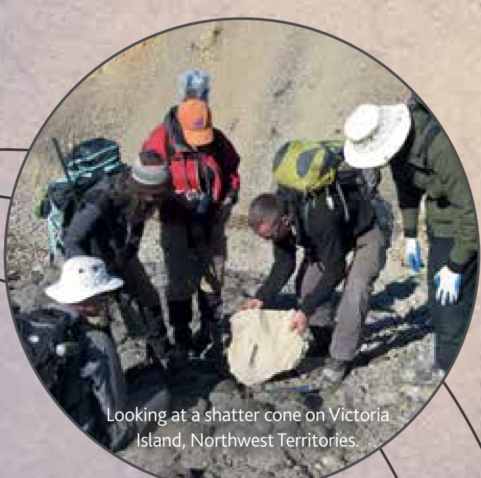
The Centre for Planetary Science and Exploration at the University of Western Ontario push the frontiers of space exploration not only in their research but also through their approach to teaching

FROM PHILOSOPHERS TO modern day scientists, the stars and Solar System have always played an important role in cultures around the world. The night sky helped us to navigate before maps or GPS and provoked questions about how the conditions on Earth came to be right for life to flourish. Our ambition to explore the Universe has spawned incredible technological progress during the Space Race era and continues today, driving forward discoveries in space exploration.

The 2012 Mars Science Laboratory Curiosity Rover landing marked one of the latest chapters in the quest to explore our Universe. Mars bears the marks of life's crucial ingredient: water. By learning more about the Red Planet, we can discover more about the potential for life beyond Earth. Some clues about this otherworldly potential, however, can be found somewhat closer to home. Canada, a seemingly unlikely candidate, has been the source of great fascination for Dr Gordon Osinski and his colleagues at the University of Western Ontario's Centre for Planetary Science and Exploration. Exhibiting parallels to its distant relatives, the Earth provides a tangible document of the evolution of our Solar System and the varied landscape of Canada, in particular, is often touted as possibly a close geological resemblance to other planets. Drawing on expertise from two seemingly disparate subjects, Osinski and his team present a new multidisciplinary research project that is inspiring the next generation of scientists.

GLACIERS, CRATERS AND VOLCANOES

Osinski plays a leading role in numerous research groups and initiatives. His academic career began with a degree in Geology, which satisfied both his love of the outdoors and his passion for science.



Looking at a shatter cone on Victoria Island, Northwest Territories.

It was not until his PhD that his childhood interests became somewhat more of a career choice: "During my PhD I became re-exposed to planetary science and was energised at the almost unlimited potential for new discoveries," recalls Osinski. The basic premise of Osinski's work that has evolved since his time in academia is that in order to understand the geology of other planets, we must first understand that of our own. Taking the Earth as his reference point, this ethos has underpinned his novel approach to revealing more about the stars.

Canada provides a unique geography and climate for planetary research, which has enabled the country to make crucial contributions to international space exploration efforts. In particular, a number of regions are geologically similar to Mars and are known to the scientific community as Mars analogue sites. Including craters made by the impact of asteroids in polar deserts, hot and cold springs and deep underground mines, Osinski takes full advantage of these idiosyncrasies. Dedicating most of his field research to these remote parts of Canada, he uses data collected from ground work and remote sensing observations, and collates them with a range of geochemical data to draw comparisons of the geology of both the Moon and Mars.

THE FIELD IS THE CLASSROOM

Osinski's current research is a prime example of this approach. He is in the process of carefully studying how glaciers develop in the Canadian Arctic and examining the different landforms they create with their slow-moving but highly destructive force. By comparing his findings with detailed images of similar landforms on Mars, he can use his knowledge of the history of Canadian glaciers to better interpret its geology. The same methods can be used with volcanoes and impact craters to give a clearer picture of how a planet – be it Earth or Mars – formed and evolved.

Osinski conducts these studies within a research group, called the Centre for Planetary Science and Exploration (CPSX) which he co-leads. CPSX has brought together scientists from different fields with the goal of making the University of Western Ontario a hub in planetary exploration and space systems design. For Osinski, one of the most important aspects of CPSX work is the effort made to reach out to young scientists and provide them with the training and inspiration necessary to lead the way in space exploration. As such, the only graduate programme in planetary science currently available in Canada is that offered by the Centre.

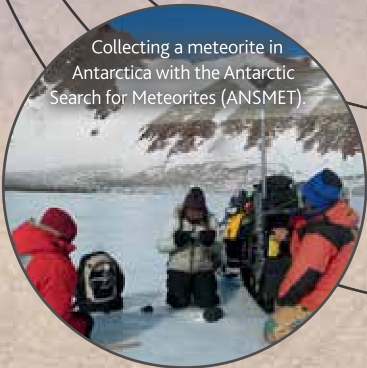
TECHNOLOGIES AND TECHNIQUES

In fact, the programme entitled 'Technologies and Techniques for Earth and Space Exploration', funded by Canada's Natural Sciences and Engineering Research Council of Canada, was the first of its kind. It equips students with a wide range of skills and enables them to familiarise themselves with the latest technologies in space exploration, from robotics to analytical instrumentation. Osinski is highly committed to training his students and believes they should have first-hand experience with cutting-edge research projects and exposure to a wide range of interrelated disciplines, from philosophy to geography, mathematics to biology. "I am passionate about my research and derive tremendous inspiration from fieldwork, which is often carried out in remote corners of the globe," enthuses Osinski. "I am convinced that the secret to being a good teacher is to teach with the same energy and enthusiasm that I dedicate to my research."

The future of space exploration depends on passing existing knowledge onto budding scientists to fill the jobs of tomorrow and inject the knowledge necessary for innovation and discovery. CPSX therefore offers students the exciting opportunity to participate in simulated space missions. These replicate almost every aspect of preparation and execution involved in a real mission but investigate impact structures on Earth, such as Mistastin Lake in Labrador. These projects not only train the next generation of space explorers, they allow researchers to test and develop the necessary techniques and technologies for successful future missions.

TO MARS VIA THE MOON

The Canadian Lunar Research Network (CLRN) was developed in response to the Canadian Space Community's goal to send human beings to the Moon and, eventually, Mars. Hosted by CPSX and chaired by Osinski, it brings together experts from a variety of organisations across Canada. Any missions to Mars will have to use the Moon as a stepping stone, so widening our knowledge and understanding of its structure and surface is essential to facilitate future missions and develop new technologies. One such project aims to analyse lunar dust and understand more about how it affects equipment that might be used by astronauts or robots such as the Mars Rover. Using microbeam analytical techniques, such as scanning electron microscopy, the team will be able to discern the physical and chemical



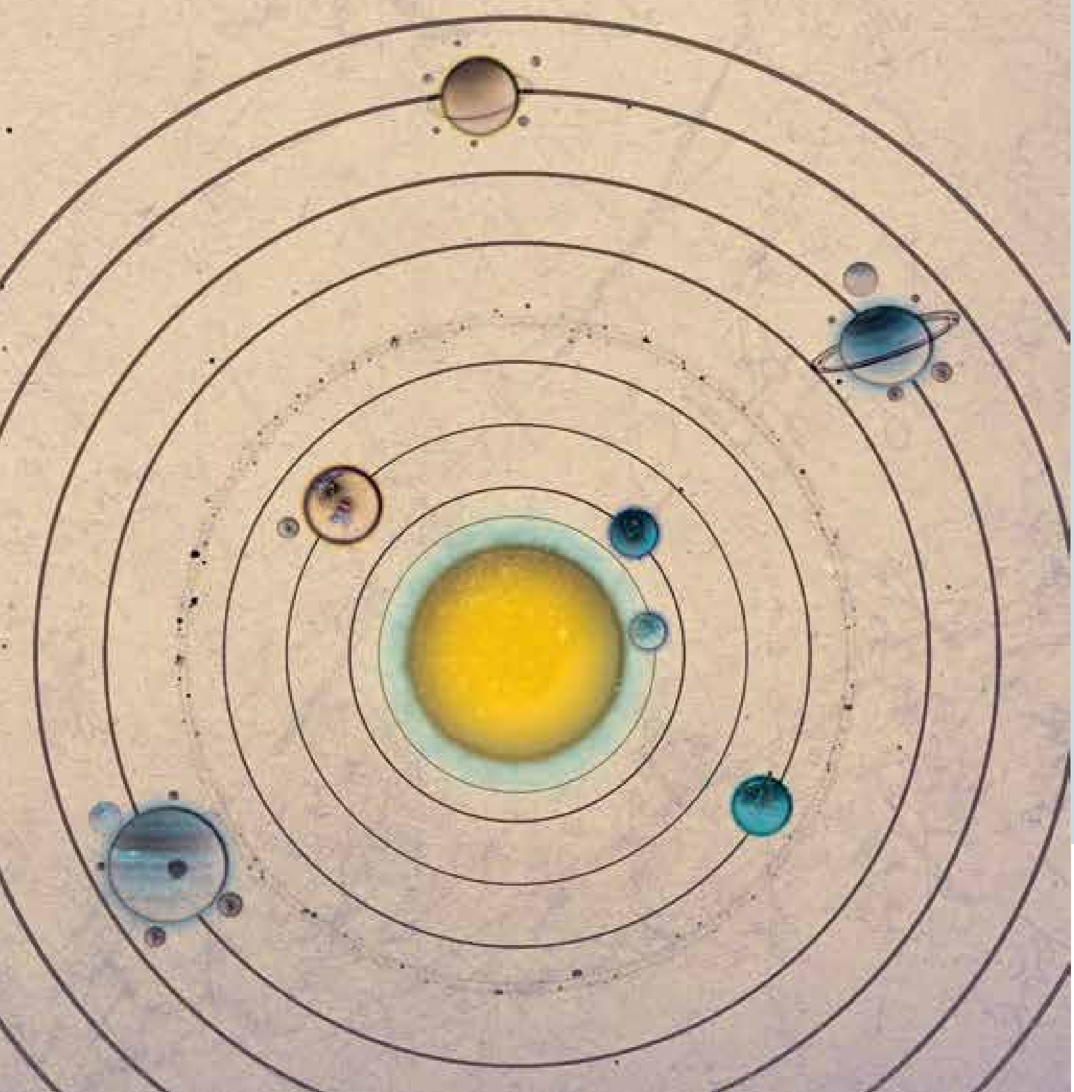
Collecting a meteorite in Antarctica with the Antarctic Search for Meteorites (ANSMET).

Embarking for Arctic fieldwork. Dr Osinski (**second from left**), his students and Canadian astronaut, Jeremy Hansen (**right**).

properties of moon dust. This knowledge will be incorporated into plans for moon landings to make missions safer.

New knowledge about the Moon is not just useful for astronauts and space programmes. Discoveries about its structure could in fact shed light on the early history of our planet and the origins of life. Lunar impact craters represent unique opportunities to sample the subsurface of the Moon. These ejecta deposits are essentially samples from different layers of the Moon and CLRN members analyse their composition using remote sensing techniques to determine how deep they were once buried. They therefore hold the key to unlocking the geological history of the Moon and the team aim to develop a robotic investigation to collect data from across its surface with no need for human supervision.

Such notions may seem futuristic but much of the work conducted by Osinski and his colleagues is of this nature, and very much a reality. Ambitious, cutting-edge and designed to lead the way in space exploration technology and research, their work is at the forefront of the global drive for new and innovative ways to explore our Solar System and beyond.



INTELLIGENCE

PLANETARY GEOLOGY

OBJECTIVES

- To further our understanding of the Earth and of the Solar System through comparative planetary geology
- To train the next generation of scientists and engineers
- To bring the excitement of planetary science to the public

FUNDING

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GORDON OSINSKI is the NSERC/MacDonald, Dettwiler and Associates Ltd/Canadian Space Agency Industrial Research Chair in Planetary Geology in the Departments of Earth Sciences and Physics and Astronomy at the University of Western Ontario, Canada. He holds a PhD from the University of New Brunswick (2004) and a BSc (Hons) from the University of St Andrews (1999), Scotland. Osinski's research interests are diverse and interdisciplinary in nature. His main area of research focuses on understanding impact cratering as a planetary geological process, on the Earth, Moon and Mars. He has published more than 85 papers in peer-reviewed journals and special papers, and has given over 70 conference presentations.

For this research on impact cratering, Osinski was awarded a Canadian Space Agency Fellowship in Space Science (2007), an Ontario Ministry of Research and Innovation Early Researcher Award (2009), the Nier Prize of the Meteoritical Society (2009), an international award for young scientists and an NSERC Discovery Accelerator Supplement award (2013). He is also Associate Director of the Centre for Planetary Science and Exploration, the Principal Investigator of the Canadian Lunar Research Network, an Affiliate member of the NASA Lunar Science Institute and the founder and first Chair of the Planetary Sciences Division of the Geological Association of Canada.

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