



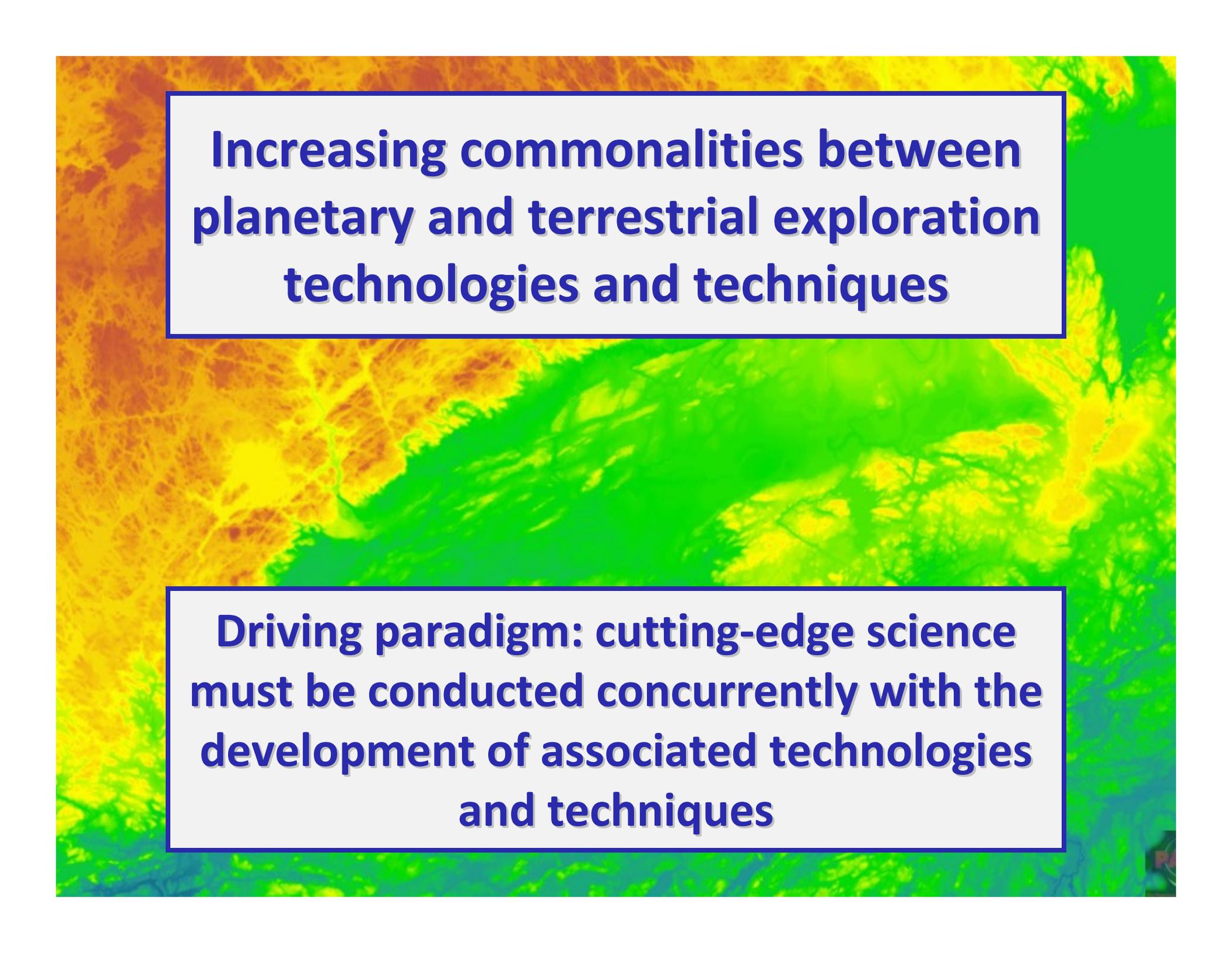
Commonalities of Earth and Space Resource Exploration Technologies and Techniques

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Increasing commonalities between planetary and terrestrial exploration technologies and techniques

Driving paradigm: cutting-edge science must be conducted concurrently with the development of associated technologies and techniques

EXPLORATION – To boldly go ...







A Revolution in Field Geology

Gigapan – “Epic Pro”



- Creates large panoramic images



3D Scene Modeler (stereo camera)

Sub-m-scale 3D modeling.



Iris-3D LIDAR

- Maximum range ~1 km
- Provides scale and range data



XRF: Bruker Tracer III SD

- Can determine general composition of major and trace elements (Mg to Pu).



GPR:

Noggin Plus 250MHz

- Depth of penetration 5-10m max.





Geological Prospecting Tools

Technologies required for conducting geological fieldwork:

- **Tech 1:** Access to locations of interest (e.g., spacesuit, rover, excavation equipment).
- **Tech 2:** Surface characterization (e.g., microscope, stereo camera, laser camera).
- **Tech 3:** Subsurface characterization (e.g., ground-penetrating radar).
- **Tech 4:** Geochemical characterization (e.g., X-Ray Fluorescence, X-Ray Diffraction).
- **Tech 5:** Sampling tools (e.g., hammer, drill).
- **Tech 6:** Mapping tools and software (e.g., PDA's, tablet PC's, GIS).

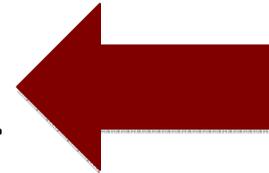
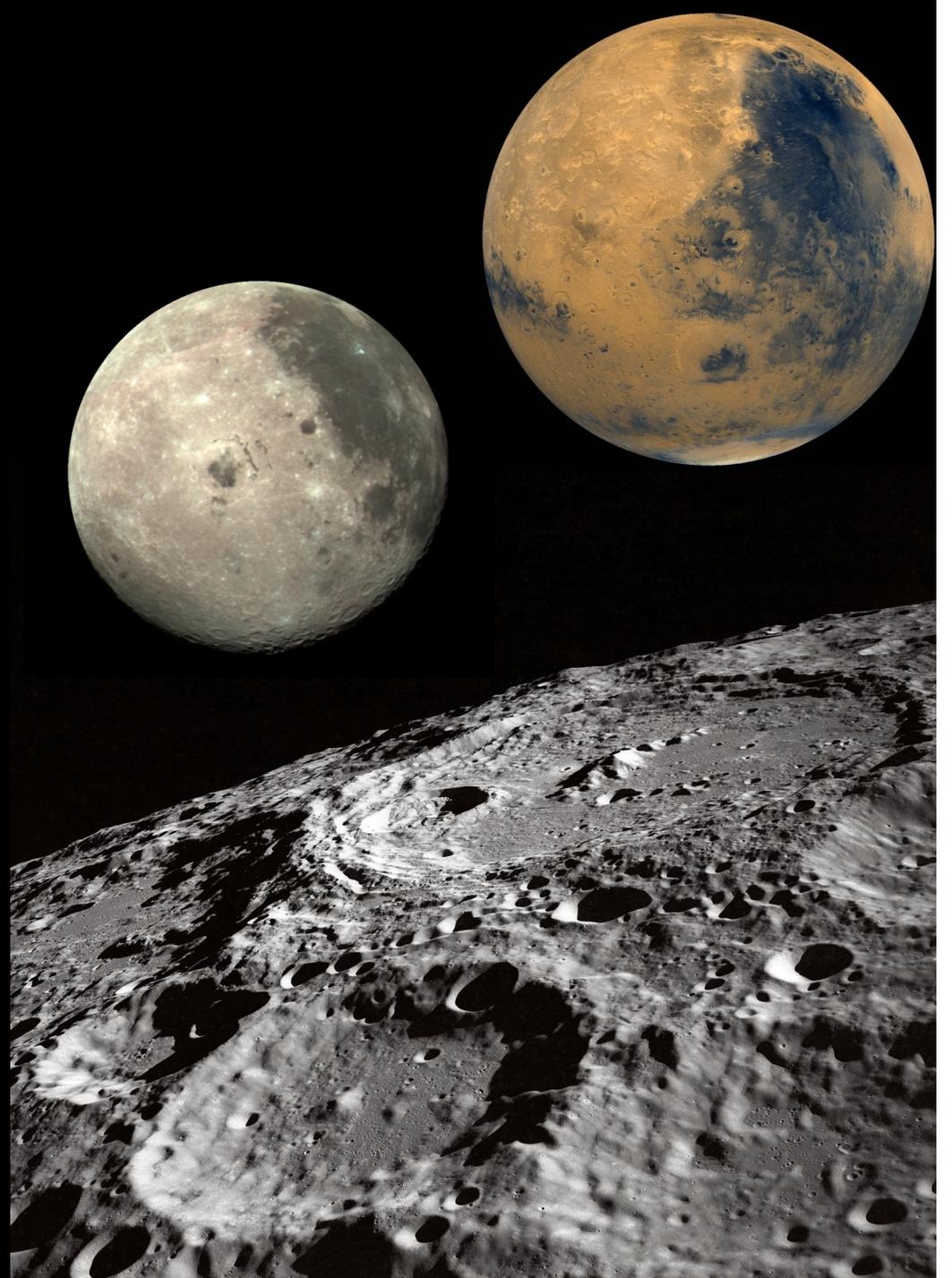
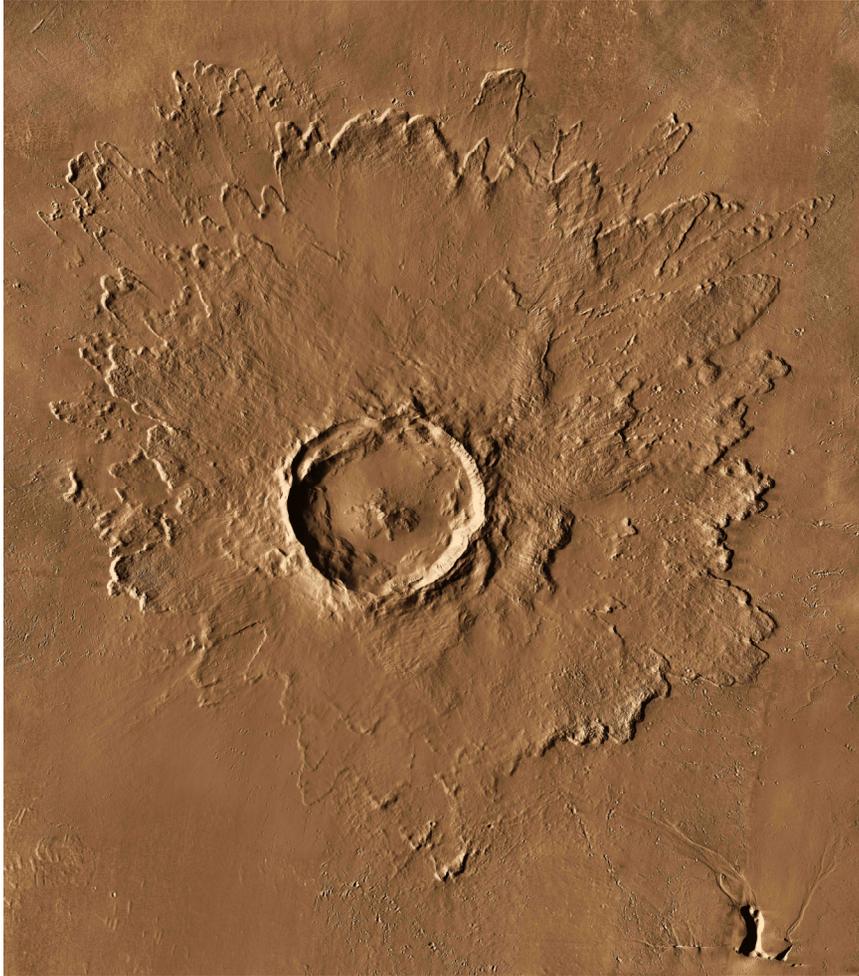


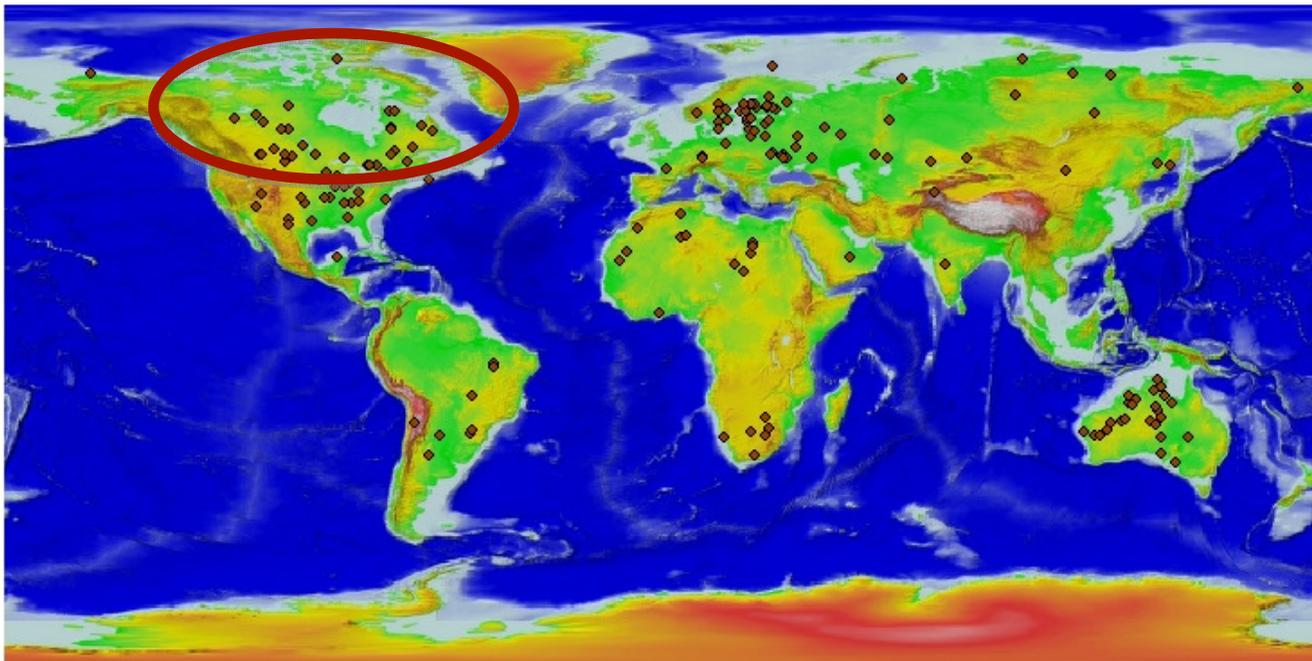
Image: NASA / Apollo 16 / John Young





Exploration of Canadian Impact Craters

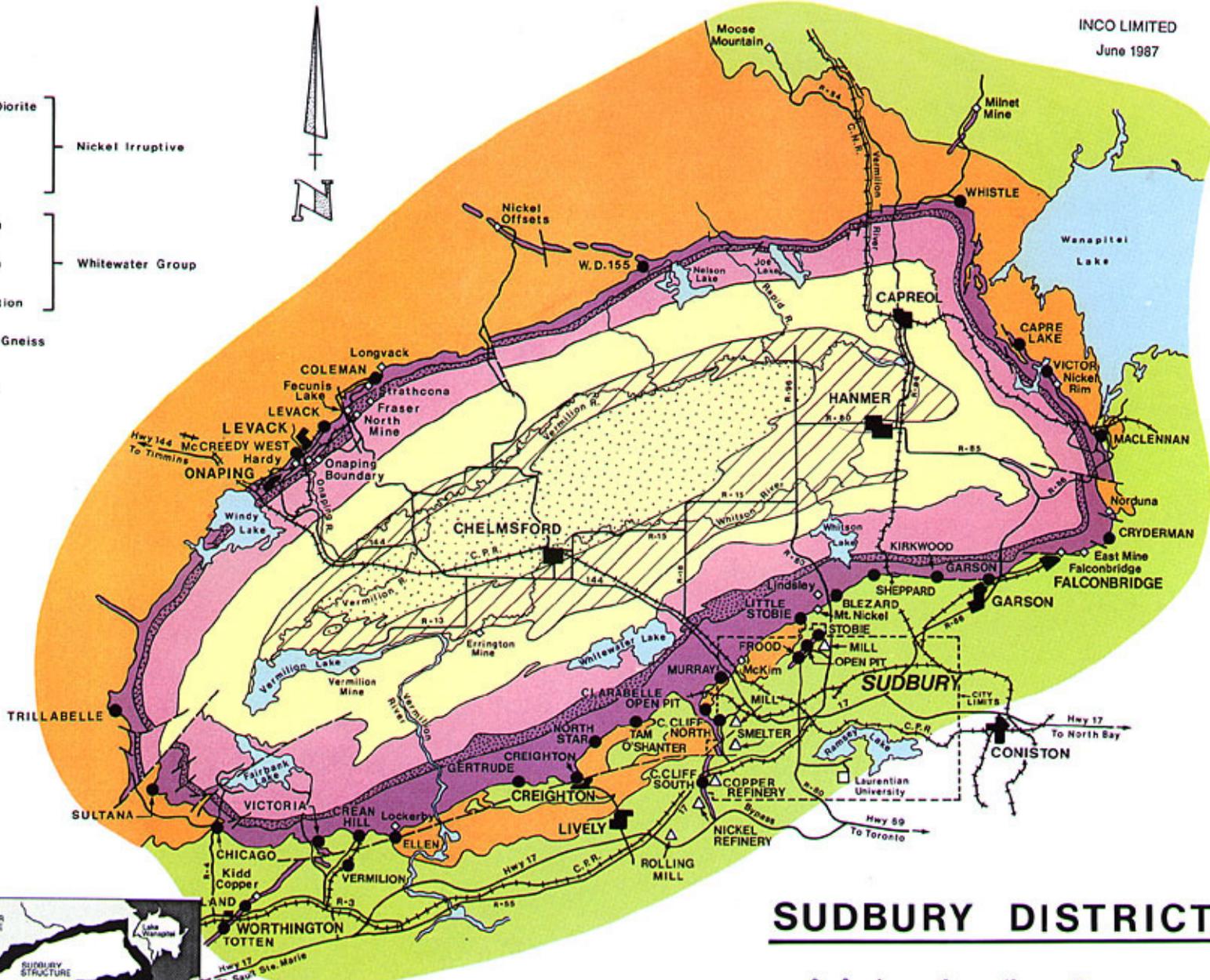
- ~30 impact structures in Canada.
- Less than half well-studied (or studied at all!).
- One-third of craters on Earth are associated with economic resources



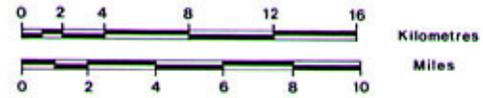
DEM image: ESRI; Impact crater locations from Earth Impact Database:
<http://www.unb.ca/passc/ImpactDatabase/index.html>

-  Norite and Quartz Diorite
 -  Quartz Gabbro
 -  Micropegmatite
 -  Onaping Formation
 -  Onwatin Formation
 -  Chelmsford Formation
 -  Granite and Granite Gneiss
 -  Greenstones and Sedimentary Rocks
- } Nickel Irruptive
- } Whitewater Group

-  INCO Properties
-  INCO Reduction Plants
-  Mines of other Companies
-  Faulting
-  Highways
-  Regional Roads
-  Railways

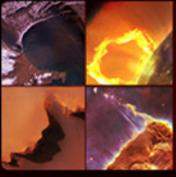


SUDBURY DISTRICT





Apollo 16 geologic training-exercises in Sudbury, Ontario, Canada 7-9 July 1971; (a) Charles Duke (left) and John Young studying traverse map prepared for them during geologic traverses at Sudbury; NASA photo S-71-39840. USGS Open-File Report 2005-1190, Figure 088a.



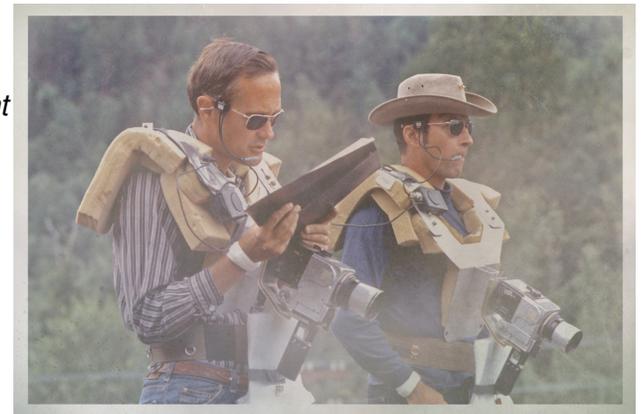
Training in the Footsteps of Apollo

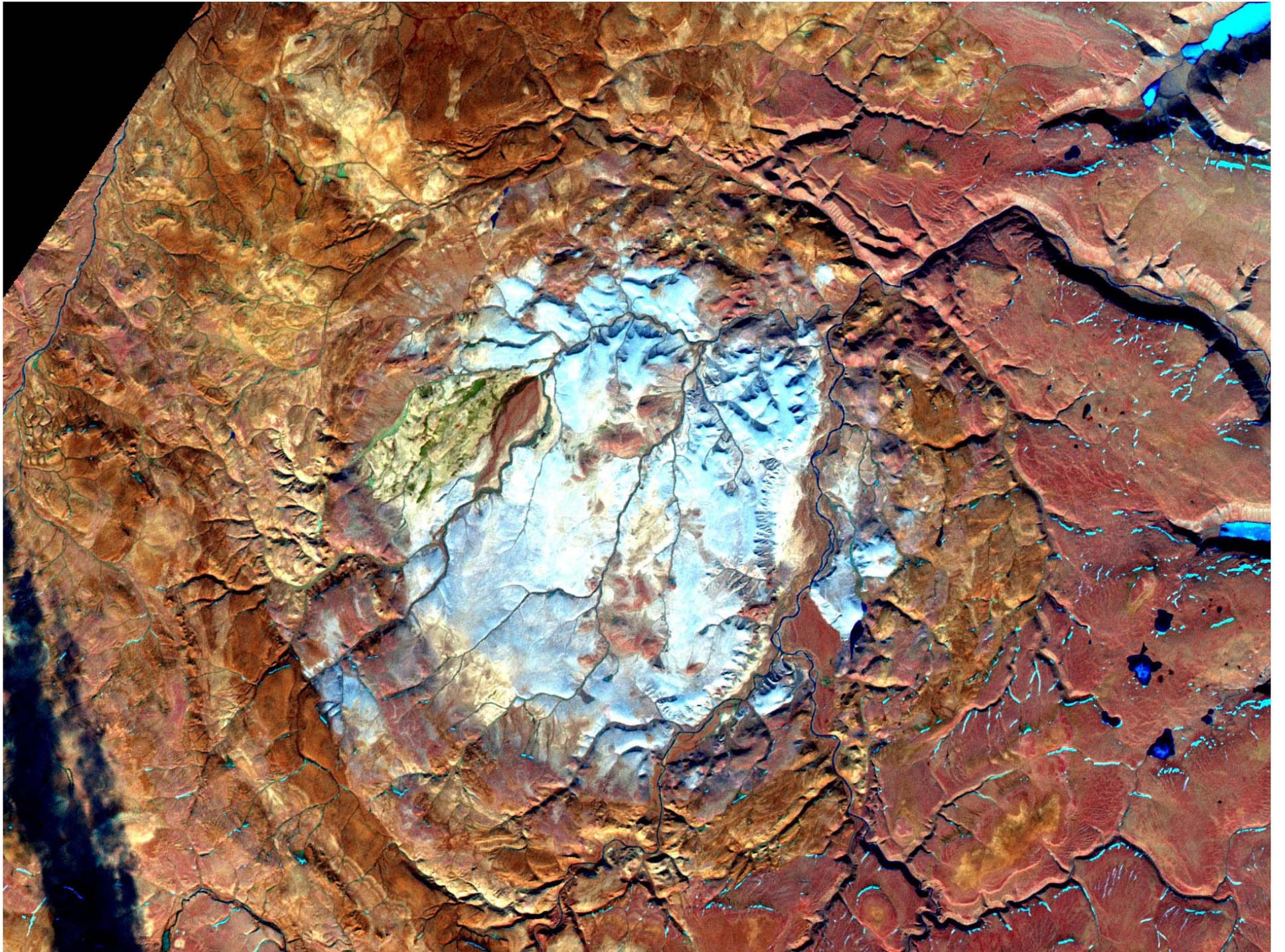
- NLSI (through the LPI Center for Lunar Science and Exploration [CLSE]) and its international partner, the Canadian Lunar Research Network, organized a Field School at the Sudbury Impact Structure as a week long classroom and field training program based in Sudbury, Ontario, October 1-5, 2012.
- The program follows the immersive training and education given to Apollo astronauts to introduce students to impact cratering processes and observe, in the field, the attributes of an immense impact basin.
- Skills developed prepare students for thesis studies in impact cratered terrains, whether they be on Earth, the Moon, Mars, or some other solar system planetary surface.
- This field training will lead to further collaborative work between US and Canadian scientists that will greatly enhance the productivity of our lunar science and exploration programs.

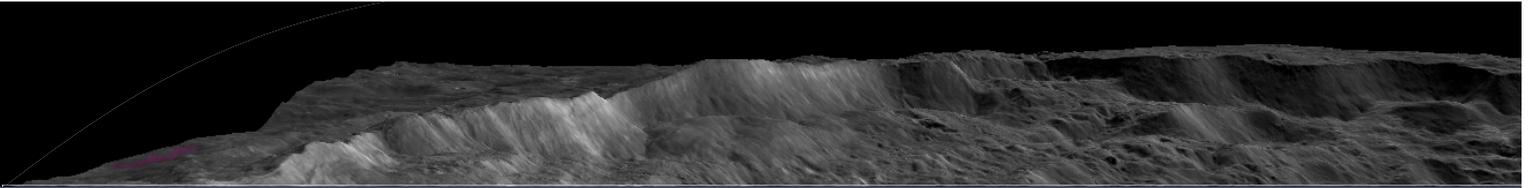


Top: Students examine the Onaping breccia that was produced by the Sudbury impact event 1.85 billion years ago (also studied by Apollo astronauts in the latter stages of the Apollo program, see below), October 2, 2012. The immense Sudbury Igneous Complex was the central impact melt pool produced by that impact event. Credit: Kring/LPI

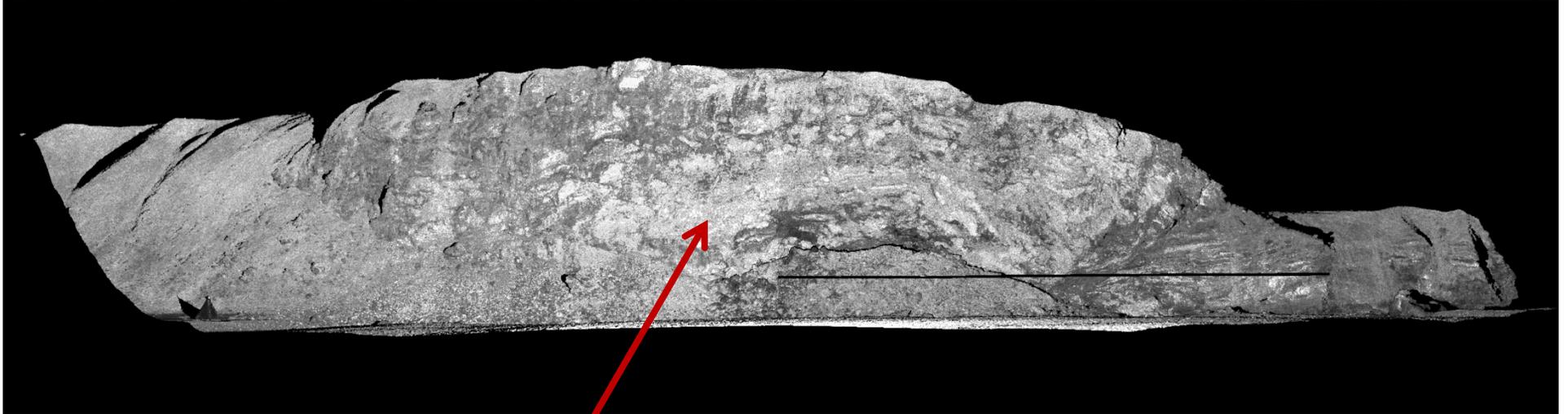
Bottom: Apollo 16 geologic training-exercises in Sudbury, Ontario, Canada July 7-9 1971; Charles Duke (left) and John Young studying traverse map prepared for them during geologic traverses at Sudbury. Both astronauts have electric Hasselblad cameras, similar to the ones they would use on the Moon, mounted on their chest plates. Credit: NASA







Example: Lidar as a Prospecting Tool

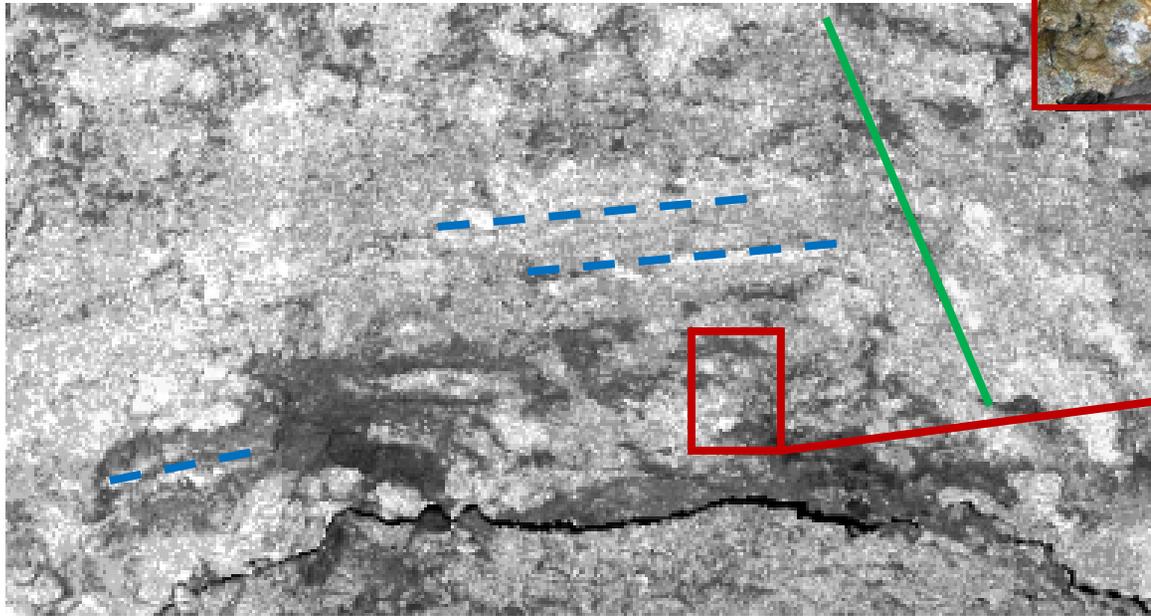


High intensity zone = increased mineralization



Layering

Fault

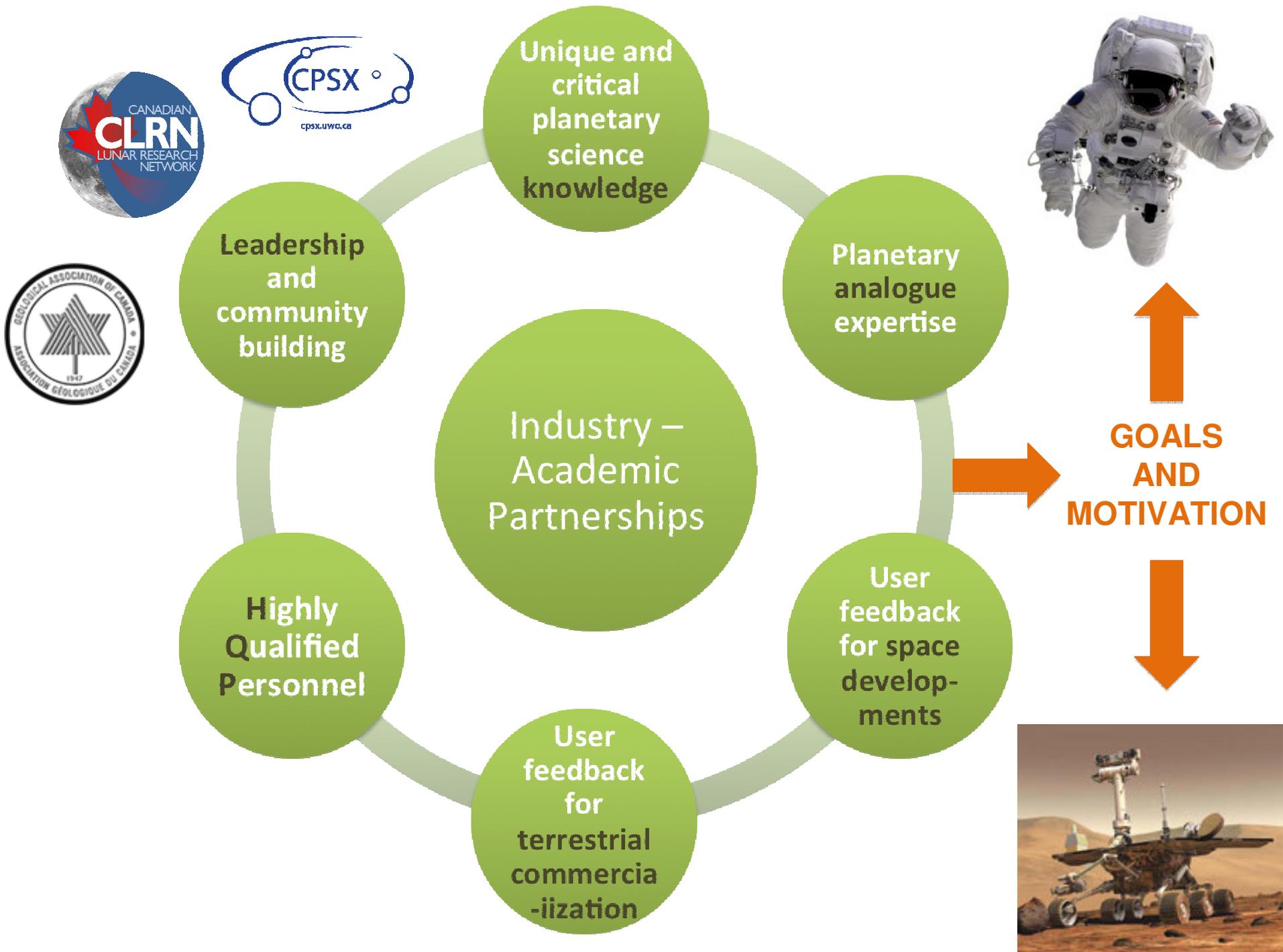




Bringing Together Scientists and Engineers

- 1) To develop geological exploration **strategies and techniques** for robotic and human Moon–Mars–Asteroid missions.
- 2) Develop instrumentation (e.g., geological **prospecting tools**) for future planetary missions and terrestrial applications.
- *Addressing these themes is critical for ensuring the involvement of Canadian industry and academia in **future exploration missions**.*







NSERC CREATE in Earth and Space Exploration

- **Theme 1:** Earth and Planetary Materials Research.
- **Theme 2:** Mechatronic Tools for Materials Handling.
- **Theme 3:** Imaging and Analysis Instrumentation.
- **Theme 4:** Exploration Surface Systems.

Project Title:

Technologies and Techniques
for Earth and Space Exploration

PI:

Dr. G. R. Osinski

Funding:

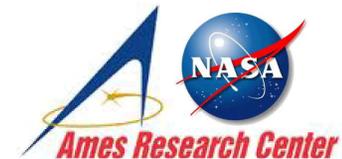
\$1.6 million over 6 years

Website:

<http://create.uwo.ca>



**NSERC
CRSNG**



**CLEARPATH
ROBOTICS™**



BARRICK

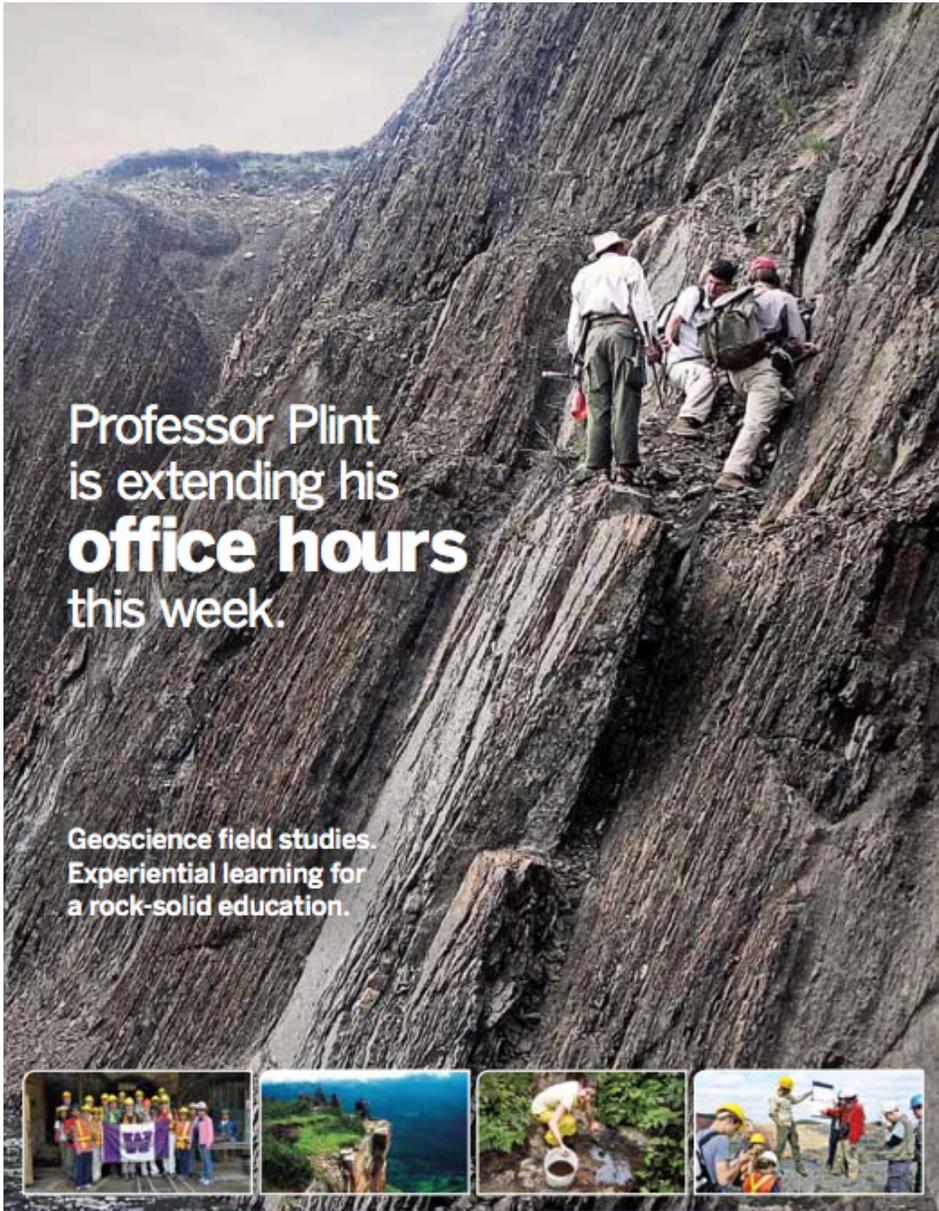




Bringing Together Earth and Space Scientists

- With research extraction from other planetary bodies now on the horizon, there is a need to train a next generation of scientists literate in both fields



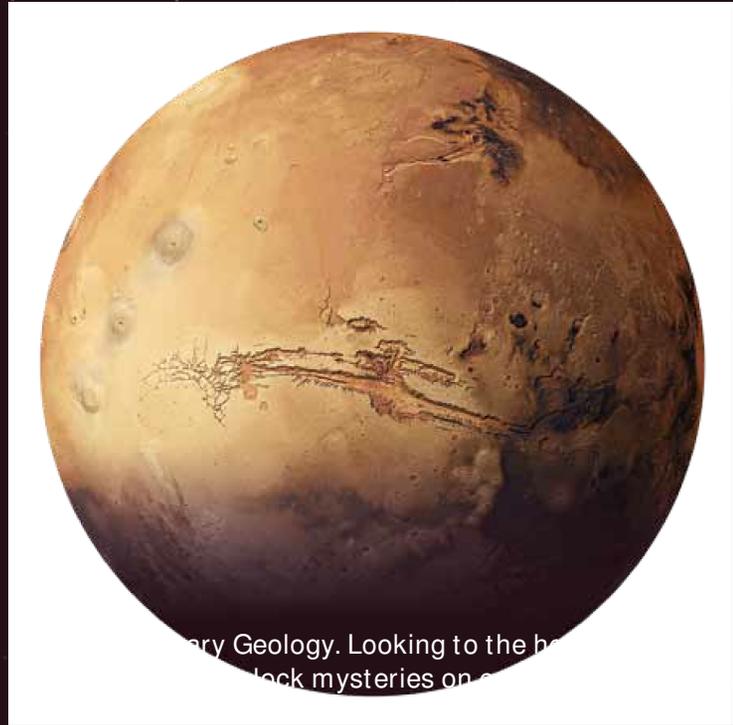


Professor Plint is extending his **office hours** this week.

Geoscience field studies. Experiential learning for a rock-solid education.



Some of our labs are **untouchable.**



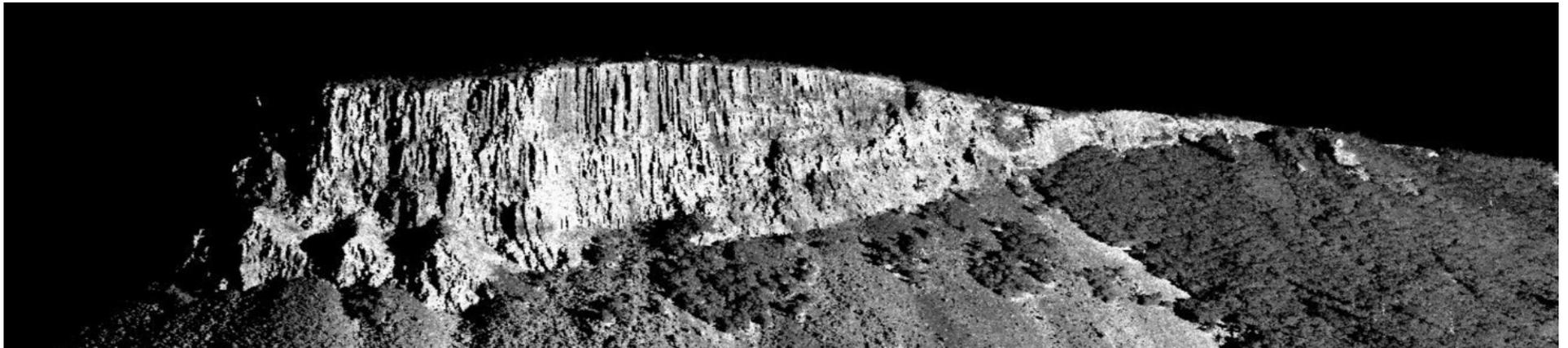
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lock mysteries on e





Concluding remarks

- There are increasing **commonalities** between **Earth** and **Space** resource exploration technologies and techniques.
- There is a need to bring **together**:
 - Scientists + Engineers.
 - Earth + Space researchers.
 - Universities + Industry + [Government].
- **Canada** is well-placed to lead the charge!



Questions?

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