# Using Extraterrestrial Activities in the Physical Geology Classroom to Encourage Critical Thinking

Michelle M. Selvans, National Air and Space Museum, Smithsonian Institution *and* Northern Virginia Community College (NVCC), selvansm@si.edu
Tracy K. P. Gregg, University at Buffalo, State University of New York
Erin Kraal, Kutztown University

Smithsonian *National Air and Space Museum*

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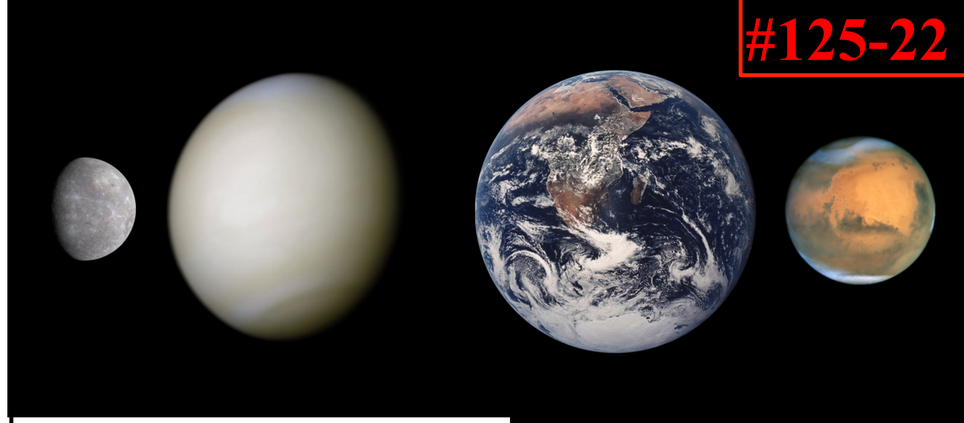


## WHY LOOK BEYOND EARTH FOR LEARNING OPPORTUNITIES?

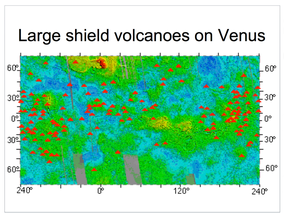
We use **extraterrestrial content** to familiarize students with basic geological concepts and processes. The Solar System's diverse geological settings provide a wealth of opportunity for teaching introductory geology. Volcanism on Io, weathering on Venus, impact cratering on Mars, and Lunar fault scarps (and quakes!) all provide students with low-stakes locations for learning the scientific process of discovery. Since landscapes beyond Earth are less familiar to introductory geology students than those of their home world, they cannot be expected to know as much about them up front. This frees them from concern over having *the right answer* and instead **encourages creative thinking**…an essential component of scientific inquiry!

***Recruitment benefits of extraterrestrial content: T. Gregg (#192-1), TUESDAY 8:30am.***

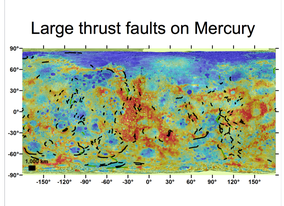
## OBSERVER ASSESSMENT: IN-CLASS ACTIVITIES

Given **global maps** of volcanism on Venus, thrust faults on Mercury, elevation on Mars, and all of these on Earth, they were asked **to determine whether other planets have plate tectonics**. In-class activities comparing Earth to Venus and Mercury were used during the Assistant Dean's observation (NVCC); he "liked the activity," which **"got [the students] thinking about larger concepts."**

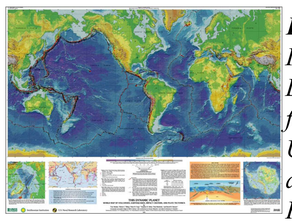
*This comment speaks to the effectiveness of using data from other planets to get students thinking creatively about a broad concept.*




**Small group discussion**
Compare volcanic activity on Earth and Venus: What global patterns do you see on each? What does this say about each planet?




**Think/pair/share**
Compare the locations of large thrust faults on Mercury and on Earth: What kind of forces are acting on the scarps? What does this say about Mercury?



***For the above activities:***
*I put out large versions of This Dynamic Planet (Earth map, from USGS/Smithsonian/ USNRL), and display the Venus and Mercury maps as PowerPoint slides.*

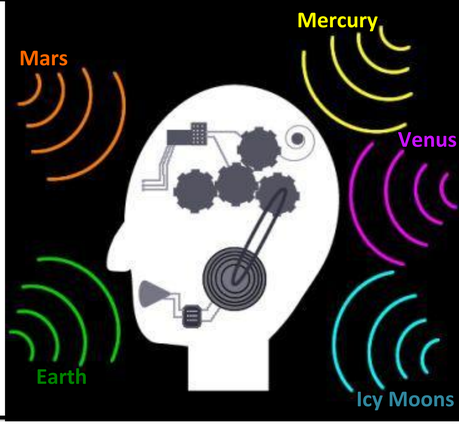
## STUDENT ASSESSMENT: IMPACT LAB

When asked to assess two (out of nine) labs in a Physical Geology course at Northern Virginia Community College (NVCC)**, ~30% of the students (5 out of 16) chose to comment on the Impact Lab** (modeled after material developed by NASA). This lab asked students to create and diagram several impact craters, calculate the effects of mass and speed on energy released during impact, and think about where in the Solar System they would find craters. There was general consensus that **it "was helpful in understanding how craters impact planets and what happens to the ejecta"** by being able to "compare visually the different craters we made" and see how "impacts change based on angle and speed." One student specifically commented that it **"would have helped even more to compare velocity and angle [of impact] by looking at actual craters on the Moon, Mars, etc."**

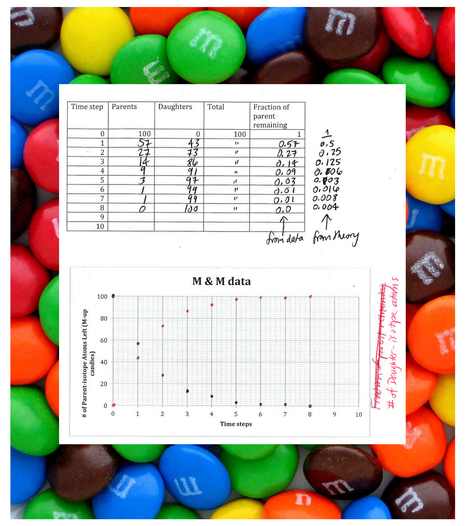
*These comments 1) demonstrate an understanding that impact cratering is a geologic process that happens throughout the Solar System, and 2) highlight the usefulness of working with examples from diverse settings.*

**Basic geologic processes…**
- **Volcanism**
- **Tectonics**
- **Impact cratering**
- **Weathering/erosion**

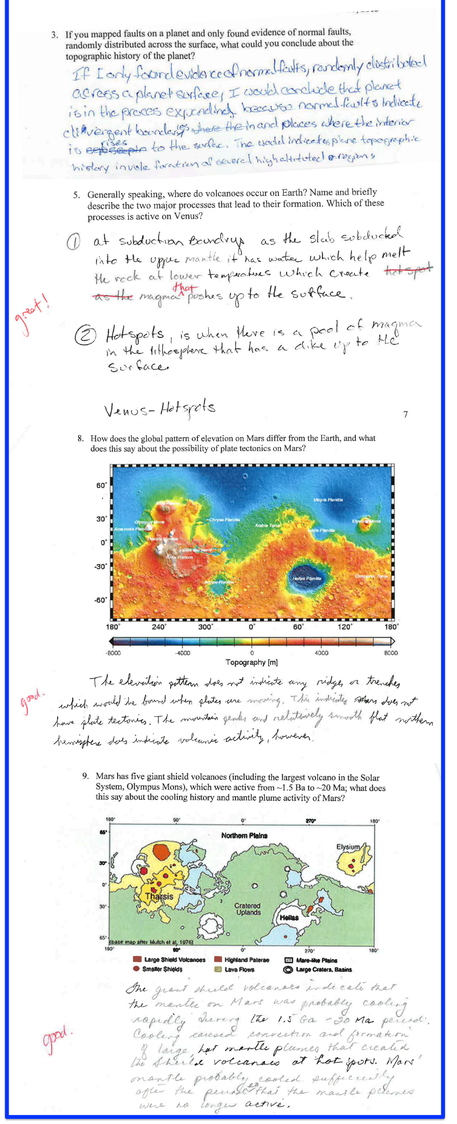
**…happen all over the Solar System!**
- **Mercury**
- **Venus**
- **Earth and the Moon**
- **Mars**
- **Satellites of giant planets**
- **Asteroids, Pluto/Kuiper Belt objects**




## Radioactive decay assignment (in-class)




## Exam questions




## Online resources and acknowledgements

*Many resources exist for teaching geology concepts using otherworldly settings. Dig around online, use materials presented here (**we're happy to share!**), and/or develop your own.*

- **Impact Lab**: adapted from NASA materials
- **Venus volcanoes map**: http://volcano.oregonstate.edu/oldroot/volcanoes/planet_volcano/venus/large_shield.html
- **Mercury map**: instructor's ongoing research (e.g., *Selvans et al.*, 2013, LPSC #2773)
- **Radioactive decay assignment**: developed by E. Kraal
- **Mars volcanism map**: (also OSU) …/planet_volcano/mars/Overview.html
- **HiRISE** (Mars) images: http://hirise.lpl.arizona.edu/katalogos.php
- **LROC** (Moon) images: http://lroc.sese.asu.edu/images/
- **This Dynamic Planet** map: http://pubs.usgs.gov/imap/2800/

*M. Selvans would like to thank T. Gregg and E. Kraal for the inspiration to introduce more planetary science content into her Physical Geology classroom, and conveners of* Measuring Student Success *(On The Cutting Edge virtual workshop, 2013) for assessment ideas.*

**"Your class rekindled my childhood fascination with space."**

**- Postbaccalaureate student preparing for geophysics graduate school**