FORMATION OF "AMBOY CRATER" ON EARTH, MARS AND THE MOON!

Comparative planetary geology requires understanding how geological processes are affected by changes in physical environment—each planet and moon provides an opportunity to refine our understanding of how physical geological processes operate. Volcanism is a great example of a major geological process highly susceptible to such variations. Today you will constrain how "Amboy Crater" would look if the same eruption happened on the Moon and Mars.

Useful Data and Equations

- Amboy: The average thickness of the lavas at Amboy is ~5 m and the surface area of the flow is ~60 km^2. Because the cone and lava flow were emplaced on a smooth surface with a slope of ~0.15°, the cone itself is off-center (i.e., not in the center of the approximately circular lava flow), and from the map the greatest linear distance the lavas had to flow was 8 km. The volume of the cone, approximated by taking a cone 450 m wide at the base and 150 m tall and subtracting from it a cone 250 m across at the base and 60 m tall, is ~11 x 10^6 m^3.
- Density of basalt: 2.7 g/cm^3
- Viscosity of basalt: 100 to 1000 Pa-s (1 Pa = 1 N/m^2)
- Earth's Gravity: 9.8 m/s^2
  Moon's Gravity: 1.6 m/s^2
  Mars' Gravity: 3.7 m/s^2
- Thickness a body of lava resting on a sloping surface must obtain before it will flow

$$t = \frac{\tau}{\rho g \tan\alpha}$$

[t = thickness (m) ; τ = yield strength (N/m^2) ; ρ = density (kg/m^3) ; α = slope (°)]

- Velocity at which a lava flow of thickness t will move down a slope

$$V = \frac{\rho g t^2}{3\eta}\sin\alpha$$

[V = velocity (m/s) ; t = thickness (m) ; η = viscosity (Pa-s) ; α = slope (°)]

TEAM A
What was the yield strength of the Amboy Crater lava flow when it was emplaced?

TEAM B
What can we say about the time required for the lavas at Amboy to flow the observed distance of 8 km?

--- WE'LL DISCUSS AS A CLASS, THEN ---

***Hint*: for the next part you will want to start by re-calculating the thickness (why?). Also, best to assume a circular flow with the cinder cone very close to one edge, like at Amboy**

TEAM A
If a lava flow of the same volume and with the same material properties (viscosity, density, yield strength) erupted on the Moon onto a surface with the same slope that is found beneath Amboy Crater, characterize the dimensions of the flow and the maximum time required for it to form.

TEAM B
If a lava flow of the same volume and with the same material properties (viscosity, density, yield strength) erupted on Mars onto a surface with the same slope that is found beneath Amboy Crater, characterize the dimensions of the flow and the maximum time required for it to form.

Now we'll examine the formation of the cone together using a freeware program, written by volcanologist Ken Wohletz, called Erupt (v.3), this time to explore how varying the gravity will affect the geometry of the resulting edifice. The program and detailed instructions for its use and abuse can be downloaded from the web site located at http://www.ees1.lanl.gov/Wohletz/Erupt.htm.

Question 1: To test the program, can it can create an Amboy-like volcanic cone on Earth?

Question 2: What will it look like if a cone with the same volume is erupted under otherwise identical conditions (i.e., only gravity gets altered) on Mars?

Question 3: Ditto for the Moon?

Question 4: What important parameters might we also need to consider modifying?

FOR FUN, LATER, TRY THE FOLLOWING—http://www.educeth.ch/stromboli/simulation/applet-en.html
Load the web page and then, using the cross section of Amboy from your first lab, try to constrain the launch angle and start velocity required to form Amboy Crater's cinder cone (~225 m radius, and top of arcuate path must clear 90 m height!) using spherical blebs 5 cm in diameter (~average clast size) with a density of 2.7 g/cm^3. At the same launch angle you identify, what would the launch angle have to be to hit the town of Stromboli?