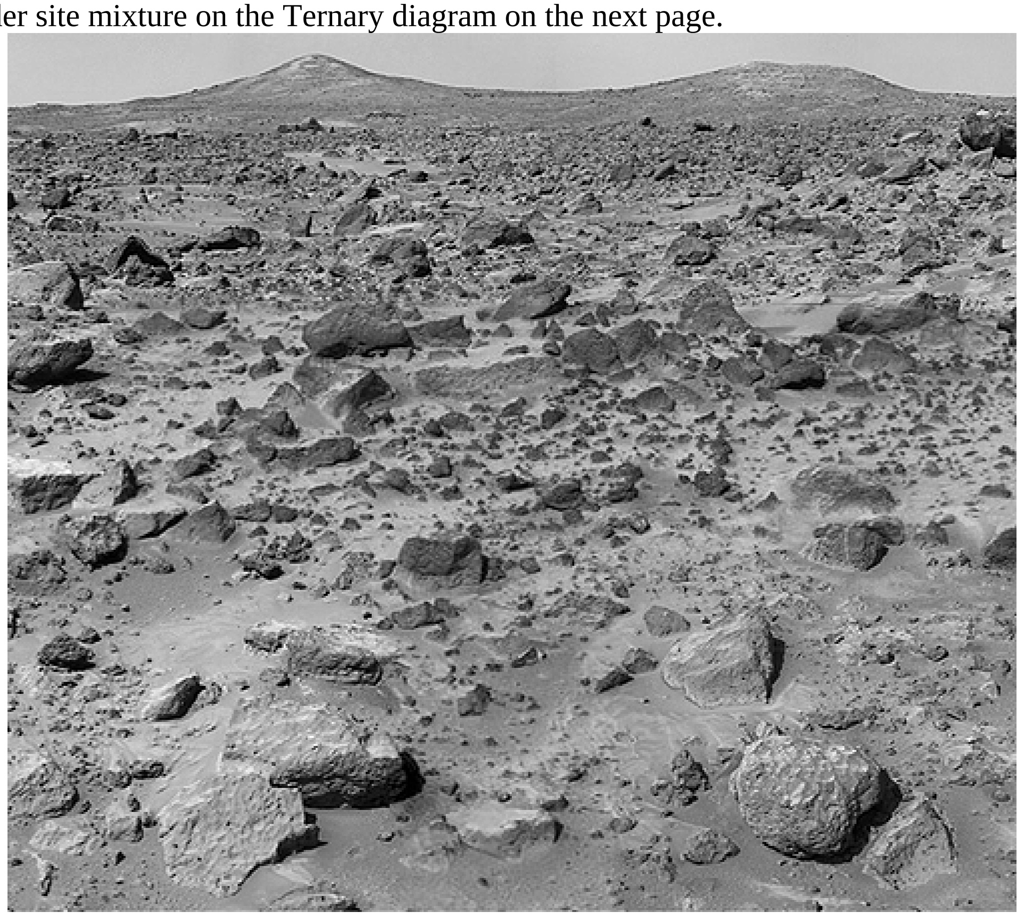
PLANETARY GEOLOGY, Fall 2003
Geology 20B, Grosfils

LAB 8: Homework Assignment, due October 29th

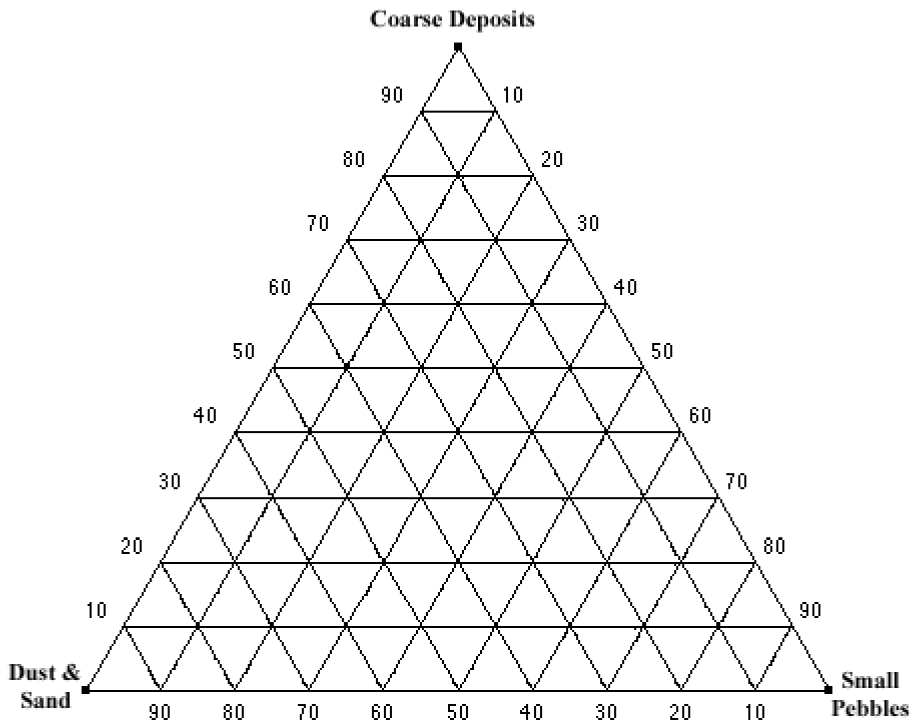
On July 4th, 1997, Mars Pathfinder landed at the mouth of Ares Vallis, a large channel that drains into the Chryse Planitia basin. While there remains a great deal to debate about the origin of the channels, one of the leading hypotheses at present is the idea that these features are the result of catastrophic flooding. If this is correct, then the plains where Pathfinder landed may be rich in debris eroded out of the Martian highlands across which the Ares Vallis channel passes, providing a golden combination – a relatively safe landing site which still provides access to a wide variety of different rock types. [If you would like to learn more about the many Pathfinder results, explore the April, 1999 and January, 2000 issues of the journal *Journal of Geophysical Research – Planets* (the green one) in the library.]

For the sake of this lab assignment you will hypothesize that the Ares Vallis and associated deposits were indeed produced by catastrophic flooding, and will use the information at your disposal to learn all you can about the putative flooding event.

1. Using images taken by the lander's camera (see below) as well as thermal remote sensing satellite data, it has been estimated that the surface of the landing site and immediate vicinity is best described as: 16% semi-rounded large pebbles, cobbles and boulders (>3 cm and <7 m is the range observed, but some/all of these could also be derived from impact events), 25% small pebbles and lag deposits (deposits formed when wind removes fine particles, leaving coarser grained material behind), and the remaining 59% is covered with sand and dust. Using these data, plot the Pathfinder site mixture on the Ternary diagram on the next page.

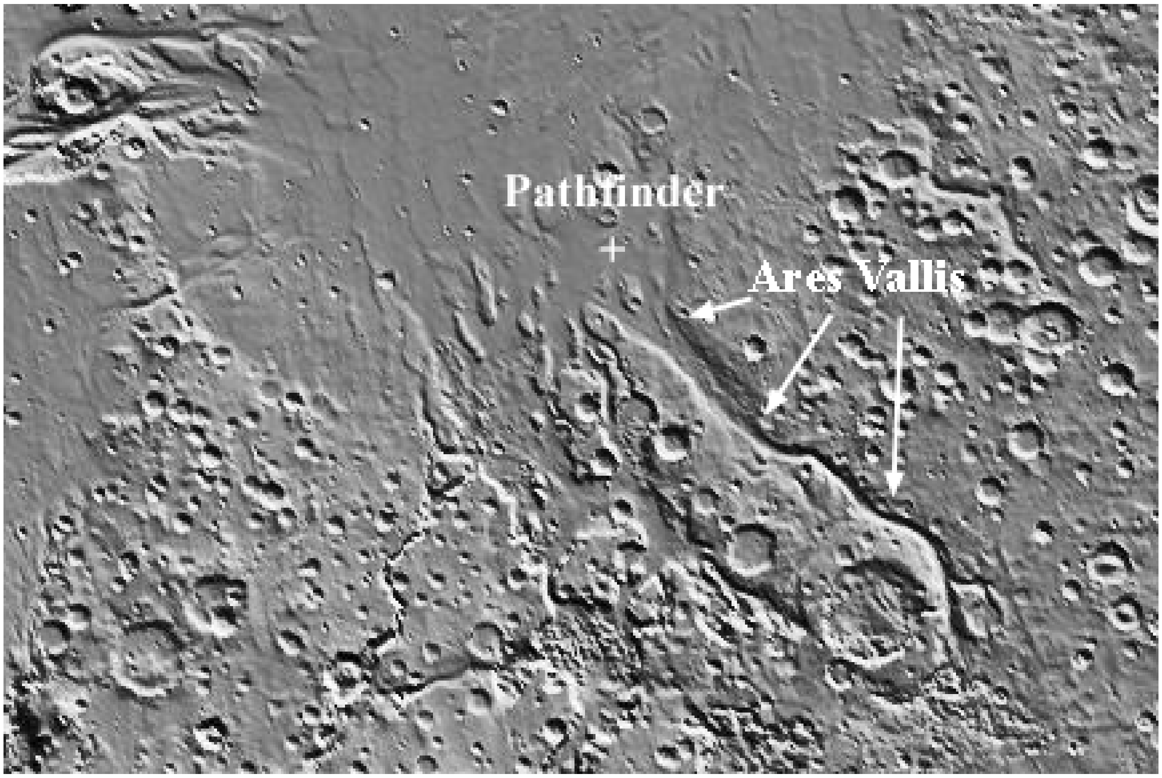


Surface image taken at the Pathfinder landing site. Large rocks in foreground are ~30-40 cm across.



2. Using Figure 1, Table 1 and the Pathfinder site materials description provided above, provide a reasoned, well-supported explanation for what you estimate as the water velocity necessary to carry the *average* sized detrital particles to the Pathfinder site where they were deposited. Be sure to document your work, showing for instance how you calculated the average size fraction, etc. A range of answers will be accepted provided that the reasoning and support for your argument are well laid out, quantitative where possible, and self-consistent.

3. In the coarse 1°x1° MOLA grid from Mars Global Surveyor, part of which is shown below (note, this is raw topo *data*, **not** a photographic *image*, and the area show is ~540 km wide!), it is evident that Ares Vallis is a long, gently sinuous channel which (a) varies in width and depth along its length, and (b) tends to have a fairly rectangular cross section – this is most obvious at the north end of the channel, but is also true for the upstream portions of the channel as well. For the southern parts of the channel, the width is approximately 70 km and the present depth is ~1 km. Use this cross section and your result for velocity from problem #2 above to estimate the discharge out of Ares Vallis required to deposit the sediments observed at the Pathfinder site; we did a similar calculation in class. Again, be sure to show all your work, and watch your units!



To do some investigating of MOLA topography and other datasets at a regional scale, check out the following web site: http://marsoweb.nas.nasa.gov/globalData/.

4. Another way to estimate the discharge is to use the **Manning Equation** (see attached handout **–** you will want to **use Equation <u>3-14B</u>** not 3-14A) to obtain the velocity; this is done quite commonly for streams on Earth, even though it often yields only rough results. In this equation the volume of water need not equal the actual channel volume – i.e., it allows that the channel might have been cut by a series of shallower floods rather than a single "filled to the brim" event. In order to use the Manning equation, you need to know three things – the cross sectional shape of the channel and the depth of the associated flow, the slope of the channel's floor, and the "Manning coefficient" which is empirically derived. You already know the shape of the channel, and independent evidence (height of teardrop-shaped islands in the channel) suggests that the flow depth during the last flood event was between 10 and 100 m. The slope of the channel bottom is known to be 0.01° from south to north, i.e. the bottom drops approximately 1 m in elevation along every 6 km of length. The Manning coefficient must be estimated from images. Consider the Pathfinder site image presented earlier – would you expect the roughness in the main channel to be rougher or less rough than what you see in this photo? Why? Using the Manning equation, the Pathfinder surface image provided below, and the data provided elsewhere in this question,

    a. Estimate the range of flow velocities in the channel.
    b. Estimate the associated discharges for the channel.

5. Several groups of scientists have attempted to estimate the discharge rates for Ares Vallis and the other channels which appear to drain into the northern lowland plains. This is not simply an academic exercise, as the volume of water which the channels can disgorge can be compared directly with the volume of water required to fill the purported northern ocean on Mars. This comparison is ongoing. For Ares Vallis, peak discharge estimates are approximately 7×10^7 m^3/s. Explain why you feel your answer does or does not support this value – if your answer is different, what factors might we have failed to consider (and what influence would you expect this to have?), and if your answer is similar to the one provided above, do you believe it – why or why not? Please attach an additional page if necessary.