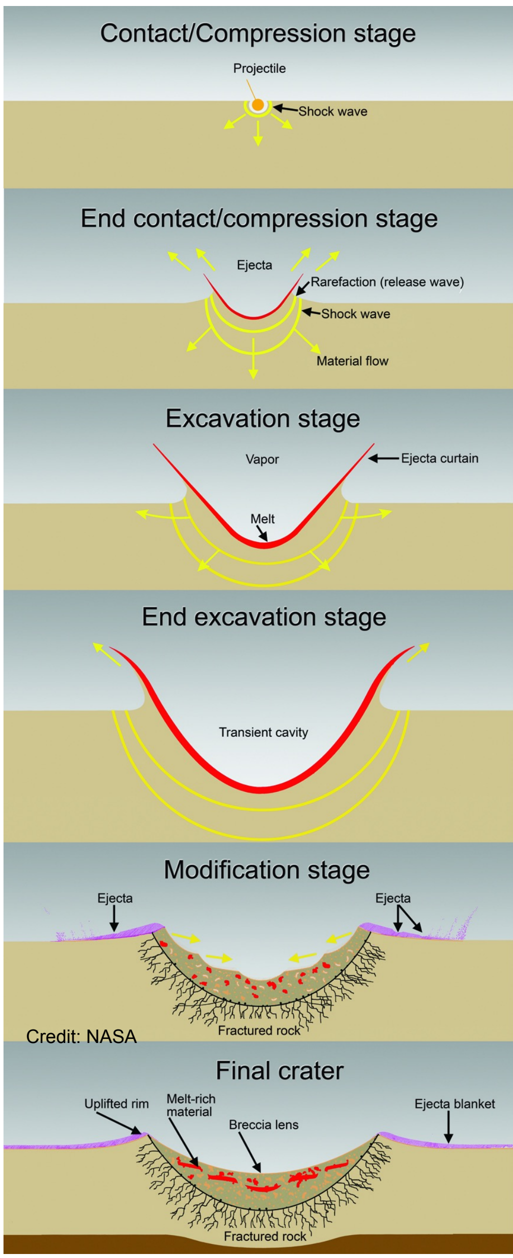
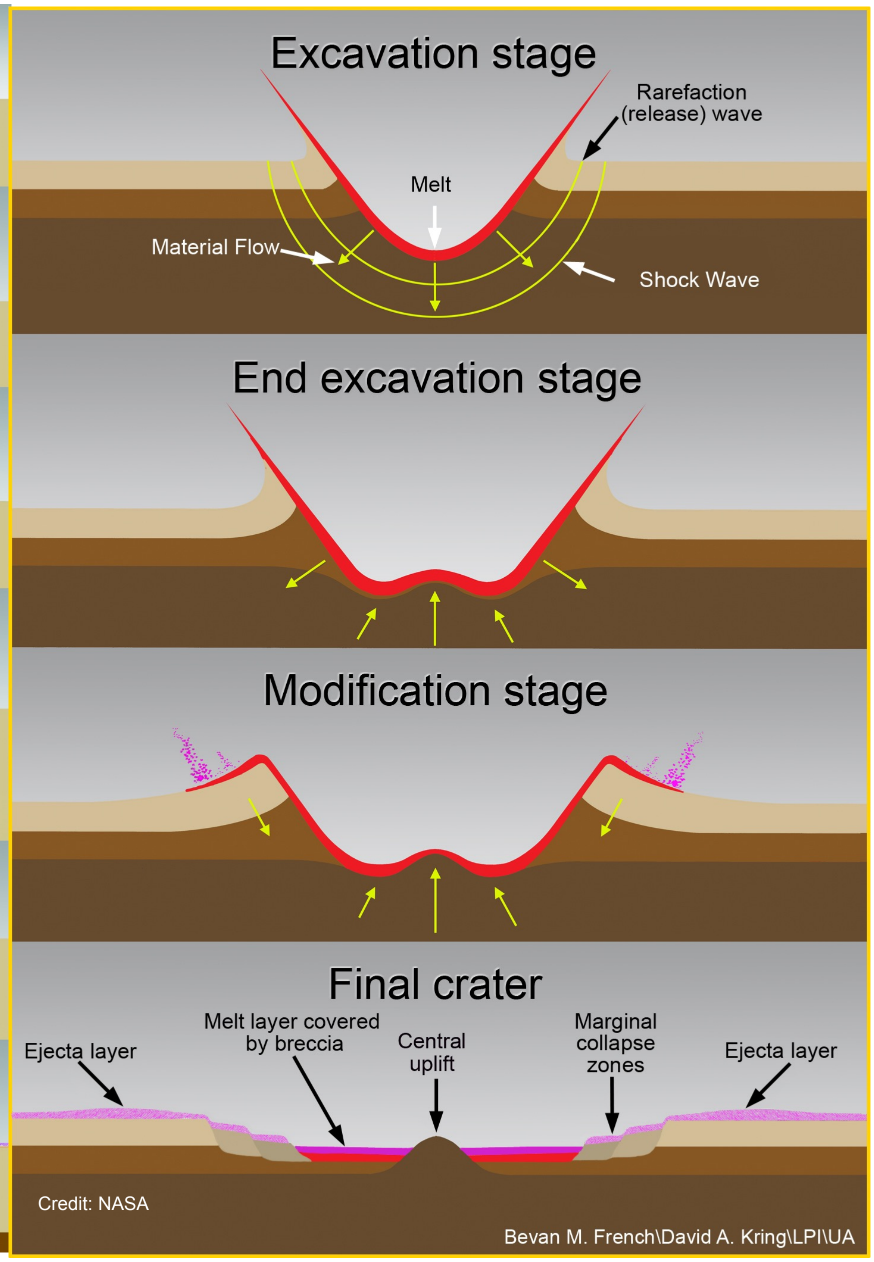
Somewhere, something incredible is waiting to be known.
Carl Sagan

Surface Carpentry

Greetings AST 111'ers. In this module we're going to look into what shapes planetary surfaces, surface carpentry.

There are four geological processes do surface carpentry: impact cratering, volcanism, tectonics and erosion. The first is obviously an externally driven phenomena, the middle two are driven by the thermal energy a planet's interior which we've already explored, and the last one is an interaction between the surface and a planet's atmosphere. Away we go!





The images above show an impactor coming in and making a crater. The left image shows the making of a simple bowl crater while the right image shows the making of a more complicated central-hump crater. When impactors come in on Earth, they're typically coming in between 10 - 70 km/sec, effectively 1 - 7 times the escape velocity of Earth. This packs enough wallop to vaporize solid rock. The word "crater" is Greek for "cup," because impactors make kind of cup-looking things. Craters are circular, almost no matter what the impact angle is, whether it's coming in head-on or inclines because they blast out material in all directions. So no matter what angle you're coming in at, in the end, you make a roughly spherical explosion, which is why all the craters look the same in that they're bowl or cup shaped.

Two rules of thumbs on craters. The depth of a crater is about equal to the size of the impactor. So if you have a 10 kilometer impactor coming in you're going to make a 10-kilometer hole. Second is the width of the crater is about 10 times the size of the impactor. So for a 10 kilometer impactor coming in, we make a 100-kilometer crater. Just looking the width and depth of a crater gives you a pretty good handle on the size of the impactor.

Credit: Wikipedia
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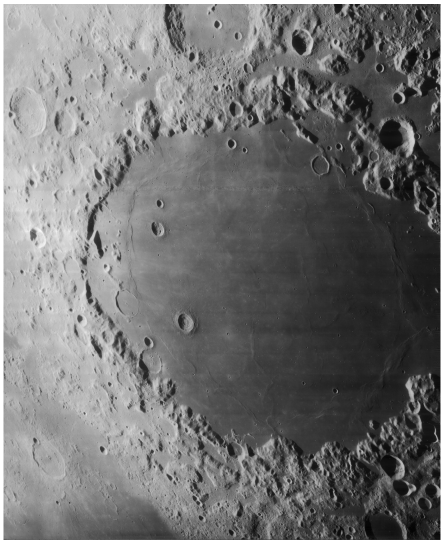
Volcanoes -- that's our second surface carpentry process -- happen when molten rock finds its way from the interior all the way up to the surface. Magma rises basically because its hot. Hot stuff is less dense than cold stuff. And surrounding rock is cold and thus denser. So molten rock wants to come up.

Of course you can help the molten rock rise by squeezing it like toothpaste out of tube. Here the squeezing action is from the pressure generated by tectonic forces.

Trapped gases that are in the interior also come up with the magma. That can give some dramatic explosions. It's like shaking a soda bottle and when you pop it open and all the gas comes rushing out along with the liquid. The image above is from the Rinjani volcano where not only is there molten rock - magma - but trapped gases being released. There is enough dust and soot rubbing against each other to create a significant electrical charge. Hence the lightning. Hey, if you ever get a chance to go to the National Volcano Park in Hawaii, check it out. It's an an active volcanic region and very awesome.

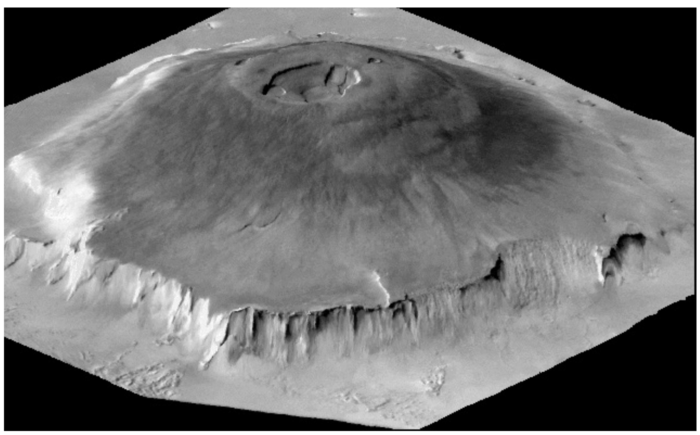
Volcanism is much more likely on a planet with high internal temperatures and a relatively thin lithosphere. These two are related as we talked about before. The bigger you are, the longer you're going to hang onto your internal temperature, the more active of geology you're going to have because you have relatively thinner lithosphere that you can move around.

thin runny lava flows
make flat plains



Credit: NASA

thicker lava flows
make shallow sloped
shield volcanos



thickest lava flows
make steep sloped
stratovolcanoes

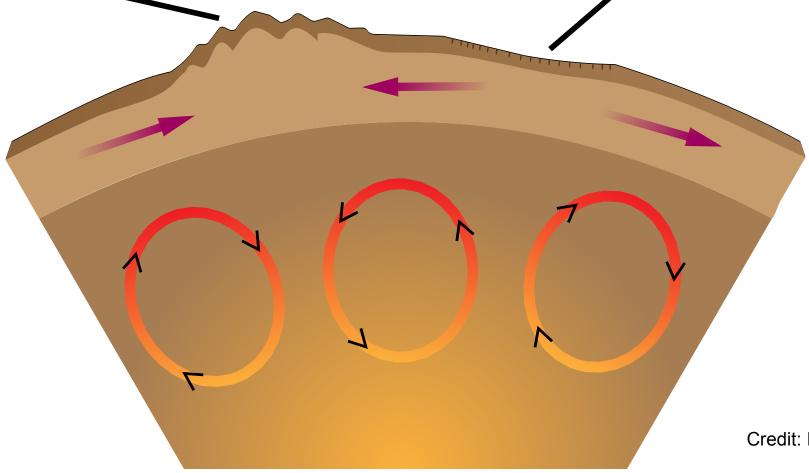
Credit: Wikipedia, Creative Commons

When molten rock comes out it can be a very thin runny kind of lava.The measure of easily something flows is called the viscosity. Water has low viscosity, honey has a high viscosity. So if you have low viscosity lava, very runny lava, then you'll make flat wide plains. You see this, for example, ton the Moon. All those dark areas on the Moon, called the Maria, were named because people thought they look like dark seas. Instead its been low viscosity lava that the moon spat out after an impact that then spread out. Like the image above shows.

On the other hand, if the viscosity of the lava is thicker, you can make things called shield volcanoes. They have shallow slopes. A prime example of a shield volcano, shown by that middle image above, is Olympus Mons on Mars. Here the lava doesn't get a chance to flow very far before it cools and solidifies. So you can get this build-up of shallow sloped shield volcanoes.

On the third hand, if the lava is really thick stuff and it can hardly flow at all before it cools off, then you get steep slopes and what are called stratovolcanoes. A good example of that on Earth is Mt. Hood in Oregon.

So we have those three different basic types of lava. You have a thin, medium, and thick types. The geological features that you see on the surface depend on that viscosity of the lava.

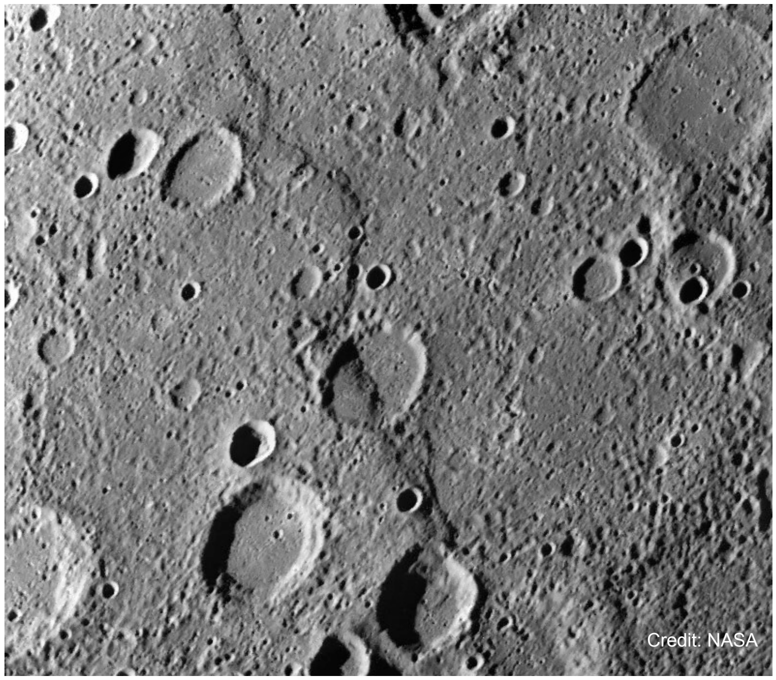


Onwards with tectonics. Often the greatest source of the internal stresses come from the convection cells in the mantle, the boiling motion going on inside the Earth. Just to review a little bit — what does convection do? Convection transports energy from A to B by making material physically move from hot to cold. So we heat up material at the bottom and move the material to the top where it cools off. Now cooler and thus denser, it falls back down to the hot region.

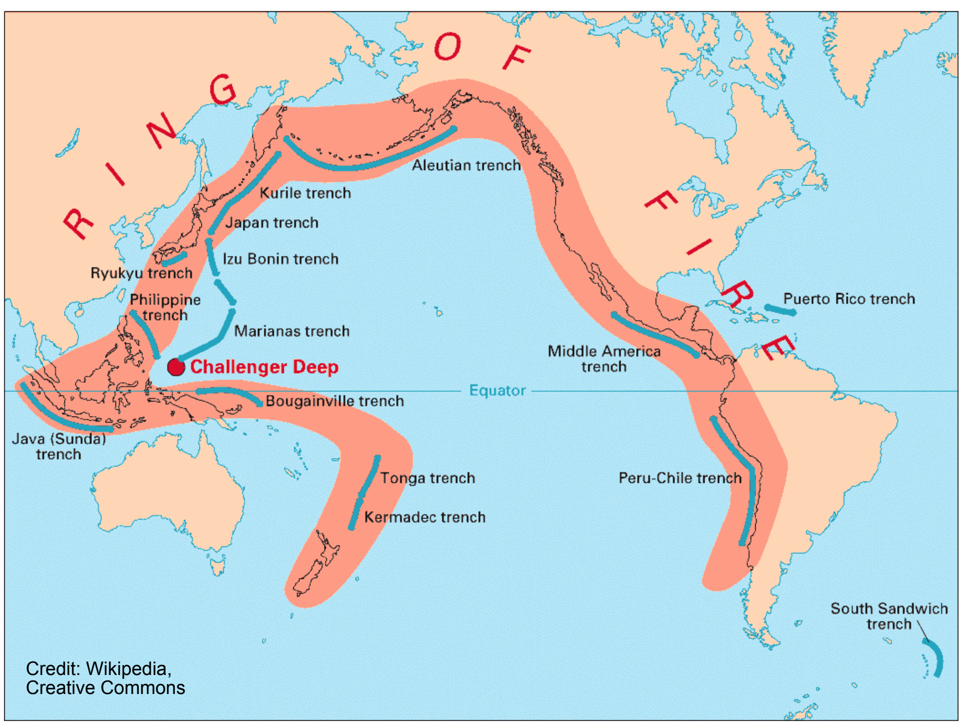
These convection cells can bang up against one another. Where you have two convection cells with sinking cold material it will generate compressional stresses at the surface - it bunches up the surface if you will. A great examples the Appalachian Mountains. Two convection cells with down drafting material squeezes the surface material together - making mountains.

If you have two adjacent cells with hot upwelling material, you can stretch the surface, pull it apart. This can create valleys. You can see this kind of activity on Mars where uprising material pulls the surface apart to make the lithosphere thinner. Sort of like anti-mountains!

Internal stresses on the surface of a planet can also come from the planet cooling down. The surface scrunches up as the interior shrinks because of being cooled. You see examples of such planet-wide compression forces on Mercury - which is cooling off. The image below shows one geological feature you get - long steep cliffs known as scarps. The core is loosing temperature, thus shrinking. The surface , which is sort of like this shell on the outside, wants shrink too. But it can't completely and uniformly because - well, there is material in the way. And so you get these very sharp, very long scarps on Mercury.



Tectonic activity on Earth is always accompanied by earthquakes. In the Ring of Fire, as its called, active earthquake regions are also accompanied by volcanism. Planetary scientists are quite keen on putting miniature seismometers on other worlds to see if the too have quakes.



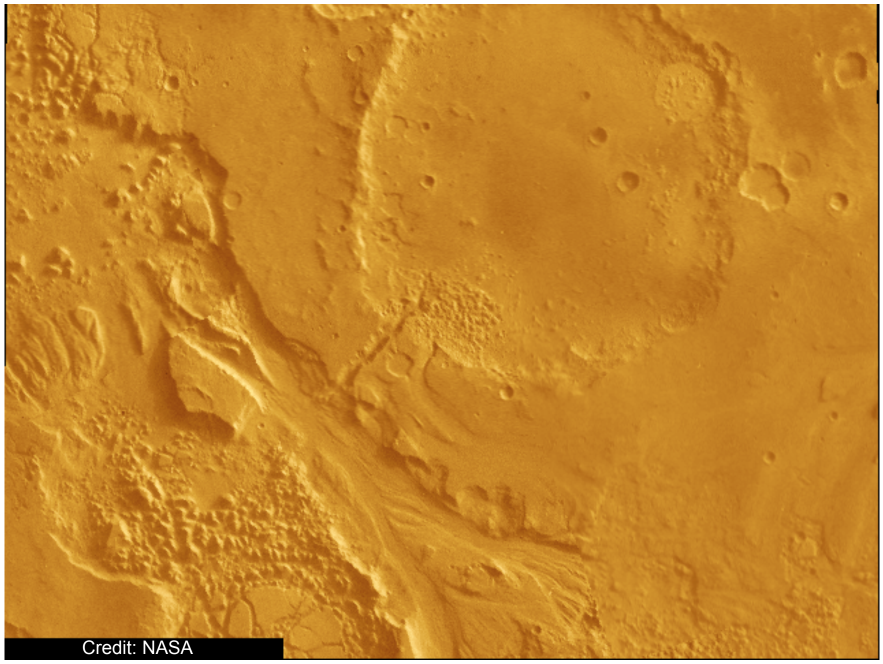
Erosion -- that's our fourth surface carpentry process -- is the breakdown and transport of rocks by volatiles such as water, carbon dioxide or methane if its cold enough. It’s the moving around of material, the breakdown and building of geological features, due to weathering.

Erosion breaks stuff down and erosion can also build new stuff up.The image above shows both. Breaking something down -- the Grand Canyon, as the Colorado river rips through -- but also the building something up -- sand dunes and river deltas as the Colorado river changes its path or gets more water.

The image below is a great shot from the Mars Global Surveyor, showing what looks very much like the river deltas you see on Earth. Such erosion-driven features, giving visual and geological evidence that water once flowed quite freely on the surface of Mars.

We're explore erosion more when we come to the atmospheres of the terrestrial planets , as erosion is an interaction between the atmosphere of a planet and the surface processes on the planet.

Thanks! Bye Bye.


Credit: NASA