Planetary Geology (part of Chapter 9): General Processes Affecting the Terrestrial Planets (and the Moon)

Many geological features on planetary surfaces are shaped by processes within the planet's interior. The interior of a terrestrial world is divided into three layers of differing densities and chemical compositions: core of high-density metal, mantle of moderate-density rock, and crust of low-density rock. Although we see molten rock (lava) coming out of the Earth, only a thin layer near the top of the mantle is partially molten. However, the solid rock within planets can flow like a liquid over periods of millions of years at speeds of around 1 cm per year. The crust and very top part of the mantle do not deform or flow easily, they are called the lithosphere. The thickness of a planet's lithosphere affects how easily it can be fractured and rearranged into mountains and valleys, and how easily lava can be erupted onto the surface. Interior heat causes geological activity. Terrestrial worlds were heated during their formation due to accretion and differentiation, and are still heated today by radioactive decay. They are slowly cooling down, with heat moving up through the mantle by convection, up through the crust by conduction, and radiating out to space. Larger planets retain heat for longer than smaller planets, so larger planets are more geologically active. If a rapidly-rotating planet contains a layer of electrically conducting fluid, such as a liquid metal core, then it will have a magnetic field. This magnetic field can protect its atmosphere from the solar wind.

The four major geological processes are impact cratering, volcanism, tectonism, and erosion. When asteroids hit a surface at tens of km per second, lots of energy is released and a crater formed. The crater's properties are affected by the planet's surface. Small craters have a simple bowl shape, larger craters have a central peak inside the bowl. Many impact craters were formed at the end of solar system formation as the last planetesimals accreted onto planets. Volcanism is the eruption of molten lava onto the surface. Runny lava forms flat volcanic plains. These are seen on all terrestrial planets. Thicker lava forms shallow shield volcanoes, like Hawaii. These are seen on Earth, Venus, and Mars. Very thick lava forms steep stratovolcanoes, like Mt St Helens. These are only common on Earth. Volcanoes also move gases and liquids from planetary interiors to atmospheres/oceans. Tectonism is the stretching (extension, leading to rift valleys) or squishing (compression, leading to mountains) of the lithosphere, often by the effects of convection in the mantle. Erosion is a set of processes that fragment or transport rock through the actions of ice, liquids, or gases. Erosion can break apart existing geological features and create new ones, such as sedimentary rocks, sand dunes, or river deltas. Both volcanism and tectonism require interior heat. Erosion requires a dynamic atmosphere. These three process all erase impact craters. The age of a surface can be defined as the time since these three processes last affected that surface and measured by counting craters. Rapid planetary rotation leads to a dynamic atmosphere and strong erosion. Planets close to the Sun are too hot for ice, oceans, or rain, so little erosion occurs. Planets far from the Sun are too cold for rain or oceans, leaving only ice and snow to erode the surface. In between, oceans, rain, ice, and snow can all cause lots of erosion. Planetary size is most important. Large planets retain their interior heat longer, staying volcanically and tectonically active. Extensive outgassing also produces a thick atmosphere, required for strong erosion.