

VOLCANIC PROCESSES SUMMARY

1. Magma forms by melting; nearly the entire mantle and crust are solid, but locally little bits of magma form when rock is caused to melt.
2. **Partial melting**: When rock partially melts, the resulting magma is more felsic than the original rock that melted. For example, when ultramafic mantle rock partially melts, a mafic magma is produced.
3. Mid-ocean ridges and hotspots
 - a. Melting at hot spots and divergent plate boundaries
 - i. Magma forms by **decompression melting**. In decompression melting, hot mantle rock rises towards surface. As it moves upwards it remains relatively hot but experiences greatly reduced pressure. Reduction in pressure causes it to partially melt – roughly 20% of the rising hot mantle rock melts.
 - ii. Mafic magma is formed because ultramafic mantle rock is partially melted.
 - b. Volcanism at hot spots and divergent plate boundaries
 - i. The mafic magma is relatively hot, low viscosity, and low in dissolved gases.
 - ii. Consequently, the volcanism tends to be non-explosive – although escaping gases can cause dramatic fountaining of lava.
 - iii. Large, shallowly sloped **shield volcanoes** can result – for example, Mauna Loa on Hawaii.
 - iv. The formation of **flood basalts** also results from decompression melting and basaltic volcanism.

Flood basalts occur when (and where) large amounts of decompression melting of hot mantle rock rapidly occurs in a localized area. The Columbia River basalts and the Siberian Traps are examples. [The eruption of the Siberian Traps, which cover an area nearly as large as Australia, may have caused the largest extinction event the Earth's history 250 million years ago]
4. Subduction zones
 - a. Melting at subduction zones
 - i. Melting is caused by **water fluxing**. In water fluxing, water is carried into the hot mantle in the subducting oceanic crust. The water is released into the hot mantle rock above the subducting lithosphere/crust, which causes it to partially melt. Adding water to hot rock is analogous to adding salt to ice.
 - ii. **Intermediate composition** magma is formed. Initially, mafic magma is probably formed, but the magma that solidifies into plutons (and whole batholiths) in the overriding crust, and reaches the surface to form volcanoes is, on average, intermediate in composition. The originally mafic magma is made more felsic by differentiation and assimilation.
 - i. Differentiation occurs when, as the magma first begins to become solid, mafic minerals (rich in Fe (iron), Mg (magnesium) and Ca (calcium)) such as olivine and pyroxene crystallize, sink, and are separated from the magma (recall from Bowen's Reaction Series that mafic minerals have higher melting temperatures than felsic minerals). The removal of mafic minerals from the magma leaves it depleted in those elements and enriched in Si (silicon).
 - ii. Assimilation occurs when felsic rock from the crust the magma is rising through is melted and incorporated into the magma. This makes the magma less mafic.
 - b. Volcanism at subduction zones
 - i. The intermediate magma is relatively cool, high viscosity, and rich in dissolved gases.
 - ii. Consequently, the volcanic eruptions often are explosive. Gases escape violently from thick lava and shoot columns of gas and pyroclastic rock miles into the air. Ash also can cascade down sides of volcanoes in destructive, deadly, 100 – 300 mph pyroclastic flows (nue ardente). Other times thick, viscous lava oozes out of the volcano during eruptions.
 - iii. **Strato – volcanoes** (also called **composite**) result. They consist of layers of lava that ooze out of the volcano and layers of ash that has been compacted and glued into pyroclastic rock
 - iv. Examples are Mts St Helens, Rainier, Baker, Hood, Shasta etc. in the U.S. northwest, as well as numerous volcanoes around the rim of the Pacific (Andes, Japan – Mt. Fuji, Alaska – Mt Augustine, Philippines – Mt Pinatubo, etc.).