

Technical Description: Diversification of Magmas

Why is studying magma important?

The interaction between magma and country rock, magma differentiation, conditions for generation of magmas, behavior, and evolution are key processes that have been studied for decades due to a large range of basaltic magmas that can be produced. The understanding of the dynamics of magmatic diversification is important because it is a natural process capable of modifying the composition of magma, and leading to a spectrum of igneous rocks.

How do igneous rocks of different compositions form on Earth?

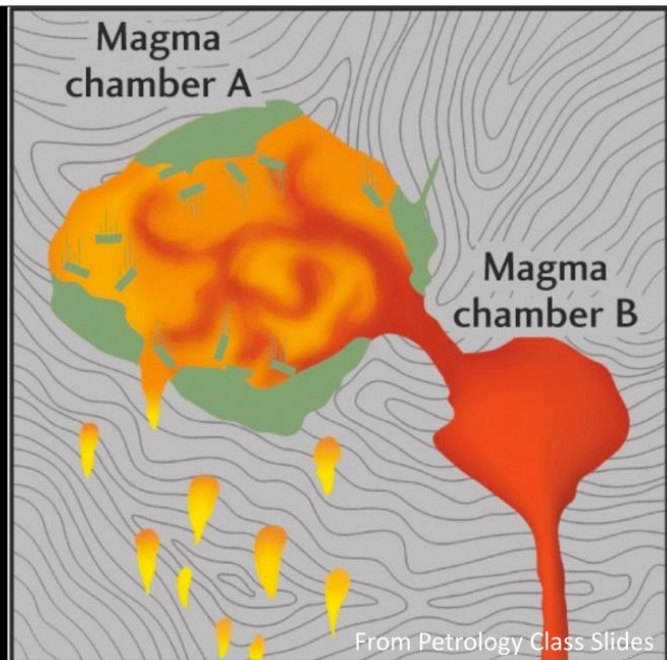
Diversification involves separating different phases of contrasting composition. This separation can happen during melting or during crystallization when phases in different states coexist. Many processes are involved in producing the diversity we see in intrusive igneous rocks today, but we will focus on fractional crystallization, partial melting, and magma mixing.

Partial Melting

Different minerals have different melting points. When the temperature starts to increase, felsic minerals are the first ones to melt. If the temperature does not get high enough, mafic minerals, which have higher melting points, will not acquire enough energy to change phases and become part of the melt. If the temperature keeps rising, the minerals that remain in solid phase will start melting until all of the components are incorporated into the magma. In other words, partial melting is a way of separating a liquid from the partially melted solid.

<https://opentextbc.ca/geology/chapter/3-2-magma-and-magma-formation/>

Partial melting & Mixing

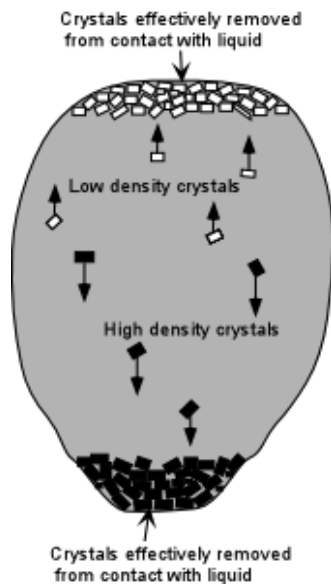


Magma Mixing

If two or more magmas, with different chemical compositions, come in contact with one another beneath the surface of the Earth, then they will mix with each other to produce intermediate composition rocks. Mixing two main primitive magmas in various proportions, one produced by partial melting of the mantle and the other derived similarly from the crust, creates intermediate magmas. The dynamics of magma mixing depend on the contrasting magma properties, such as the temperature, composition, density, volatile content, and viscosity.

Fractional Crystallization

As the temperature starts decreasing dense mafic crystals, like olivine, start to form. These minerals snow down to the bottom of the magma chamber resulting in more mafic material settling at the bottom. When removing iron, magnesium and calcium from the magma, the melt is depleted of those elements and enriched in sodium, potassium, aluminum and silica. Thus, the composition at the top of the chamber shifts towards the felsic end member, and the bottom towards the more mafic end member. The sandwiched magma results in intermediate composition rocks.



Fractional Crystallization

Figure 2. From Petrology lecture

Conclusion

Petrology is an exciting field where a lot of ongoing processes are still not well understood. If advances are made, we will be able to have better models for the genesis and role of magmas in the evolution of Earth and other planets.