Magma Series and their characterization

- **calc-alkaline magma series**
- **Tholeiitic magma series**

The calc-alkaline magma: series is one of two main subdivisions of the subalkaline magma series, the other subalkaline magma series being the tholeiitic. A magma series is a series of compositions that describes the evolution of a mafic magma, which is high in magnesium and iron and produces basalt or gabbro, as it fractionally crystallizes to become a felsic magma, which is low in magnesium and iron and produces rhyolite or granite. Calc-alkaline rocks are rich in alkaline earths (magnesia and calcium oxide) and alkali metals and make up a major part of the crust of the continents.The diverse rock types in the calc-alkaline series include volcanic types such as basalt, andesite, dacite, rhyolite, and also their coarser-grained intrusive equivalents (gabbro, diorite, granodiorite, and granite). They do not include silica-undersaturated, alkalic, or peralkaline rocks.

Geochemical characterization

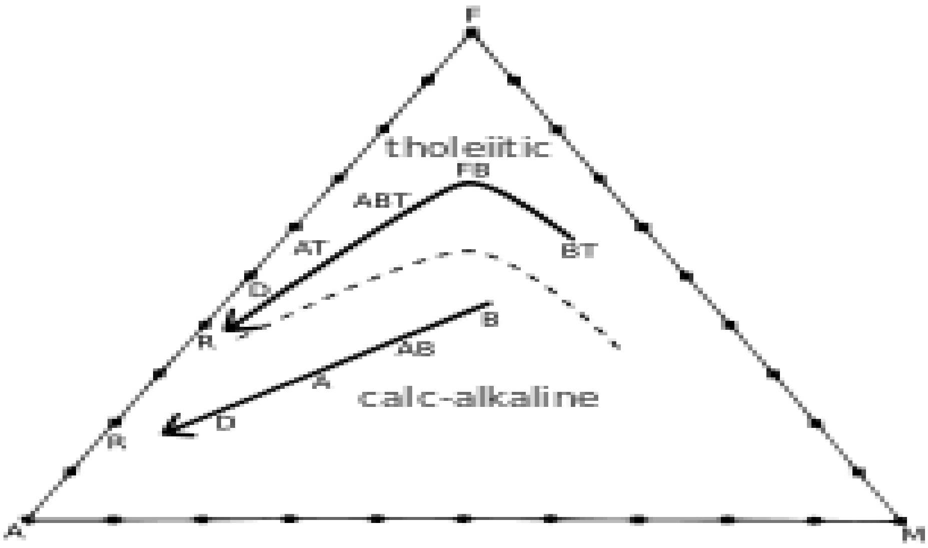
- Rocks from the calc-alkaline magma series are distinguished from rocks from the tholeiitic magma series by the redox state of the magma they crystallized from (tholeiitic magmas are reduced, and calc-alkaline magmas are oxidized).
- When mafic (basalt-producing) magmas crystallize, they preferentially crystallize the more magnesium-rich and iron-poor forms of the silicate minerals olivine and pyroxene, causing the iron content of tholeiitic magmas to increase as the melt is depleted of iron-poor crystals. (Magnesium-rich olivine solidifies at much higher temperatures than iron-rich olivine.)
- However, a calc-alkaline magma is oxidized enough to (simultaneously) precipitate significant amounts of the iron oxide magnetite, causing the iron content of the magma to remain more steady as it cools than with a tholeiitic magma.
- The difference between these two magma series can be seen on an AFM diagram, a ternary diagram showing the relative proportions of the oxides of $Na_2O + K_2O$ (A), $FeO + Fe_2O_3$ (F), and MgO (M). As magmas cool, they precipitate out significantly more iron and magnesium than alkali, causing the magmas to move towards the alkali corner as they cool. In the tholeiitic magma, as it cools and preferentially produces magnesium-rich crystals, the magnesium content of the magma plummets, causing the magma to move away from the magnesium corner until it runs low on magnesium and simply moves towards the alkali corner as it loses iron and (relic) magnesium. With the calc-alkaline series, however, the precipitation of magnetite causes the iron-magnesium ratio to remain relatively constant, so the magma moves in a straight line towards the alkali corner on the AFM diagram.Calc-alkaline magmas are typically hydrous, and also typically are more oxidized, with higher oxygen fugacities.

Tholeiitic magma series

- The tholeiitic magma series, named after the German municipality of Tholey, is one of two main magma series in igneous rocks, the other being the calc-alkaline series. A magma series is a chemically distinct range of magma compositions that describes the evolution of a mafic magma into a more evolved, silica rich end member. The International Union of Geological Sciences recommends that tholeiitic basalt be used in preference to the term "tholeiite" (Le Maitre and others, 2002).

Geochemical characterization

- Rocks in the tholeiitic magma series are classified as subalkaline (they contain less sodium than some other basalts) and are distinguished from rocks in the calc-alkaline magma series by the redox state of the magma they crystallized from (tholeiitic magmas are reduced; calc-alkaline magmas are oxidized [1]). When the parent magmas of basalts crystallize, they preferentially crystallize the more magnesium-rich and iron-poor forms of the silicate minerals olivine and pyroxene, causing the iron content of tholeiitic magmas to increase as the melt is depleted of iron-poor crystals. However, a calc-alkaline magma is oxidized enough to precipitate significant amounts of the iron oxide magnetite, causing the iron content of the magma to remain more steady as it cools than with a tholeiitic magma.
- The difference between these two magma series can be seen on an AFM diagram, a ternary diagram showing the relative proportions of the oxides Na2O + K2O (A), FeO + Fe2O3 (F), and MgO (M). As magmas cool, they precipitate out significantly more iron and magnesium than alkali, causing the magmas to move towards the alkali corner as they cool. In the tholeiitic magma, magnesium-rich crystals are produced preferentially, the magnesium content of the magma plummets, causing the magma to move away from the magnesium corner until it runs low on magnesium and simply moves towards the alkali corner as it loses iron and any remaining magnesium. With the calc-alkaline series, however, the precipitation of magnetite causes the iron-magnesium ratio to remain relatively constant, so the magma moves in a straight line towards the alkali corner on the AFM diagram.



- AFM diagram showing the difference between tholeiitic and calc-alkaline magma series
- This is an AFM diagram, a ternary diagram showing the relative proportions of the oxides of $Na_2O + K_2O$ (A), $FeO + Fe_2O_3$ (F), and MgO (M). The arrows show the path of the magmas in the tholeiitic and the calc-alkaline magma series.