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Melting of silicates with water (SUBDUCTION ZONES)

Handout: Melting of silicate solids in the presence of H_2O

In subduction zones, the thermal gradient is inverted due to the introduction of the cold slab. This makes possible flux melting: in the lower part of the mantle wedge, vapor saturated melting occurs. The melt ascends, encounters hotter mantle, and melting continues. Mantle crystals dissolve into the melt, lowering the water content and freeing the water for more vapor saturated melting.

30,000 km of ocean ridges→80% of the volcanic activity on earth, generating 25 cubic km of basalt magma per year
40,000 cubic km of subduction around earth, 3-8 cubic km volcanism in arcs.

Bowen (1928) – studied the rock series found at subduction zone settings, the calc-alkaline trend, work focused on the amount of CaO
Fenner (1921) – studied the tholeiitic trend, typical of oceanic basalts (though at this point, the technology to dive to the ocean floor and knowledge of the mid-ocean ridge volcanism did not exist)

The calc-alkaline trend shows depletion in FeO with increase of SiO_2. The tholeiitic trend shows constant SiO_2 and sharply rising FeO. The difference is H_2O! The tholeiitic system does not involve melting with H_2O, but the calc-alkaline system requires it.
Important effects of H_2O:

1) suppress early crystallization of plagioclase, so olivine and pyroxene crystallize and drive down the FeO content
2) spinel (Fe_3O_4) becomes a liquidus phase

H_2O increases the anorthite content of plagioclase by destabilizing albite. As a result, anorthite concentration is a good indicator of the amount H_2O present in melting (see handout)

Early thermal models of subduction zones were very uncertain about predicting temperature in the cold subducted slab and the hot mantle wedge. Calc-alkaline igneous rocks have heavy element signatures matching subducted slab. But based on the major elements present in the melt that forms calc-alkaline igneous rocks, at least 90% of the melt is from the mantle. Either some materials are melting out of the slab or fluids carry the heavy elements from the slab into the melt.