Segregation veins in tholeiitic lavas: implications for the formation of silicic magmas in Iceland and for the genesis of primitive continental crust on Earth.

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How the continental crust began to form early in Earth's history is unconstrained. However, it is reasonable to presume that higher heat flow in the past, resulted in more frequent interaction of mantle plumes and mid-oceanic ridges. If true, then Iceland could be a good analogue for processes occurring at Earth at its youth stage. This is supported by the relatively high abundance of silicic rocks in Iceland but their rarity on other oceanic hot spots. The origin of Icelandic silicic rocks has been a subject of a lively debate but has been shown to be principally formed by partial melting of hydrothermally altered basaltic crust. However, in rare cases, their origin by fractional crystallization from mantle derived basalts cannot be eliminated.

Segregation veins in lava flows frequently contain interstitial glasses of silicic compositions. Moreover, they allow more rigorous test of the effectiveness of the fractional crystallization mechanism than before. These veins form as gas-liquid mixtures during cooling and degassing of solidifying lava flows, after approximately 50% fractional crystallization of anhydrous minerals. Pairs of samples, host lava and associated segregation veins, from Reykjanes Peninsula (Iceland), Lanzarote (Canary Island) and Masaya's volcano (Nicaragua), allow the assessment of a near-complete fractional crystallization of olivine tholeiitic basalt at pressure close to one atmosphere. Interstitial glass patches in segregation veins represent the final product of this process (80-97% of fractional crystallization). These ultimate liquids are of granitic composition in the case of Lanzarote and Masaya but overwhelmingly trondhjemitic at Reykjanes. It appears that the initial K_2O/Na_2O of the basaltic liquid controls the evolution path of the residual liquid composition produced at pressure close to 0.1 MPa (1 bar). Granitic liquids are generated from basalts of high initial K_2O/Na_2O whereas low initial K_2O/Na_2O leads to trondhjemitic compositions.

The trondhjemitic composition of glass patches from the segregation vein at Reykjanes Peninsula is close to those of the Archaean TTG (trondhjemite-tonalite-granodiorite) formations. Taken at face value, this may imply that fractional crystallisation of olivine tholeiites (low K_2O/Na_2O) could have played a significant role during the formation of the early continental crust. At higher pressure, where garnet is on liquidus, fractional crystallisation can generate the observed trace element patterns observed in TTG. The progressive cooling, crystallization and degassing of basaltic magma ocean, thought to have been prevailing during the Hadean, could have led to high degree of fractional crystallization producing significant volume of trondhjemitic melts that because of its buoyancy contributed to the formation of the earliest continental crust.