Reviewed research article

Low-temperature alteration of basalts – the effects of temperature, acids and extent of reaction on mineralization and water chemistry

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Abstract — *The weathering and low-temperature alteration of basaltic glass was studied by geochemical modelling in order to gain an insight into the effects of temperature, acid supply and extent of reaction on the secondary mineralogy and water chemistry. Basaltic glass was dissolved in dilute water at 10–150°C in a closed system and secondary minerals commonly observed in nature allowed to precipitate when saturated. The weathering of basalts in the presence of CO_2 was observed to go through three stages; initially simple insoluble Al and Fe hydroxides were formed. Upon progressive basaltic glass dissolution imogolite, allophane and/or kaolinite and Ca-Mg-Fe smectites predominated, decreasing the mobility of Al, Fe, Si, Ca and Mg whereas extensive weathering and alkaline pH values resulted in the formation of smectites, zeolites, calcite and SiO_2 minerals. Under low-temperature geothermal conditions and in strong H_2SO_4 acid solutions (pH<4) amorphous silica, kaolinite, Al-Fe oxyhydroxides and sulphur-containing minerals were most important and most cations like Na, K, Ca and Mg were observed to be mobile. Under mildly acid conditions in CO_2 enriched waters (pH 5-7) kaolinite, chalcedony, Ca-Mg-Fe smectites and Mg-Fe-Ca carbonates predominated and Fe, Al and Si were found to be immobile, whereas Mg and Ca mobility depended on the mass of carbonate formed and water pH. Under alkaline conditions (pH >8) that resulted from a low acid supply and/or extensive basaltic glass dissolution chalcedony, celadonite, Ca-Mg-Fe smectites, zeolites and calcite were found to form, greatly reducing the mobility of most dissolved elements. The dominant factor determining the weathering and low-temperature alteration of basaltic glass and the associated elemental mobility is the pH of the water. In turn, the pH value is determined by the input and type of acid and their ionization constant and quantity of basaltic glass dissolution and secondary minerals formed that increases with the extent of the reaction and the temperature. The weathering mineralogy observed associated with basaltic glass in Iceland is typical of low to moderate degree of alteration under low (atmospheric) CO_2 conditions. The low-temperature regional geothermal alteration commonly observed in Iceland is also typical for low CO_2 alteration and the reaction order of celadonite and chalcedony, followed by mixed clays and chlorite and eventually zeolites and calcite, indicate increased water-rock interaction at pH >8 with temperature being less important on the overall reaction path.*