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Climatic effects on chemical weathering rates of basalts in NE-Iceland

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The overall goal of this study is to determine the processes controlling the dissolution rate of basalt. The motivation for the study is the rapid weathering rate of basalt and basaltic glass, especially when large quatities of ground rock formed beneath glaciers become exposed to the surface environment. This study focuses on the chemistry and mass transport in eight river catchments in NE – Iceland. These rivers where chosen because they 1) drain almost exclusively basalt/basaltic glass, 2) experience limited but variable biological activity, 3) drain catchments of variable glacier cover 4) are unpolluted and 5) the Hydrological Survey in Iceland has monitored continuously the discharge of most of the catchments for the last 3 or 4 decades and the suspended load concentration of the glacial rivers for the same period.

During this study, many parameters were measured simultaneously; discharge of the rivers, water and air temperature, chemical composition of the dissolved and suspended matter as well as the concentration of the suspended matter. This information will be used to gain understanding of the individual effects the climate parameters, temperature and runoff, have on the saturation state of the minerals/glasses and the weathering rate of the basalt.

The relationship between the air temperature and discharge in the rivers under study depends on the type of river. Discharge of glacial rivers is very sensitive to air temperature as glacier melting increases with increasing air temperature, while the discharge of the direct runoff rivers is highest in the spring time, when the snow on the watersheds is melting but the air temperature is still relatively low.

The correlation between the concentrations of the dissolved major elements and discharge of the rivers at the time of the sampling was used with the average daily discharge of the rivers to calculate the flux of dissolved major elements of the rivers. All of the rivers show increased flux of dissolved elements with discharge but some of the rivers are more discharge dependent than others. For example there is a tenfold difference in the discharge dependency of the Na flux between the rivers and a three fold difference in the Ca flux.

Recent studies have shown that the dissolution rate of basaltic glass (Oelkers, 2001; Oelkers and Gislason, 2001; Gislason and Oelkers, 2003) depends on the ratio of hydrogen and aluminium activity, a^3_{H+}/a_{Al+3}, together with the saturation state (ΔG_r) of the basaltic glass. The ratio of hydrogen and aluminium has been termed ‘the driving force of the dissolution’. This study shows that the driving force increases exponentially with water temperature and above 10˚C it changes dramatically. The runoff dependence of the driving force is not as clear but linear regression indicates that the driving force increases with discharge. The Gibbs free energy of the dissolution of the basaltic glass becomes more negative, e.g. the basaltic glass becomes more soluble, with increasing temperature and discharge, both in glacial rivers, where discharge and air temperature are related and in the direct runoff rivers, where discharge and air temperature are not related. This indicates that the rate of chemical weathering in NE-Iceland is a strong function of the climate parameters.

Oelkers E.H. and Gislason S.R., 2001. The mechanism, rates and consequences of basaltic glass dissolution: I. An experimental study of the dissolution rates of basaltic glass as a function of aqueous Al, Si and oxalic acid concentration at 25˚C and pH = 3 and 11. *Geochimica et Cosmochimica Acta*, 65, 3671-3681