

Weathering in Iceland

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Abstract — *Iceland is a good example of the volcanic and tectonically active islands of Earth that weather at a rapid rate due to the combined effect of high relief, high runoff, the presence of rapidly weathering volcanic rocks, and a lack of sedimentary traps. The annual river runoff in Iceland is 3.9 times the world average, the average chemical denudation rate of rock-derived elements in Iceland is 1.3 times the world average, and the average mechanical denudation rate including major floods is 5.9 times the world average. Excluding the major floods, the rate of mechanical denudation is 2.9 times the world average. Surface runoff dominates in the Quaternary and Tertiary formations of Iceland, whereas a large part of the precipitation falling on ice-free land in the younger volcanic zones, covered by post-glacial lavas, infiltrates and may discharge directly as groundwater into the ocean or emerge as springs to form spring-fed streams and rivers. Temperature, discharge and chemical composition of spring-fed rivers in Iceland are stable throughout most of the year, and the concentration of suspended particle matter is low. Glacier-fed rivers are loaded with suspended matter in the summer and early autumn when their discharge is highest. Discharge and concentrations of dissolved and particulate matter of direct runoff and glacier-fed rivers respond rapidly to precipitation. Most dissolved concentrations decrease but suspended concentrations increase with increased discharge in both direct runoff and glacier-fed rivers. The relative mobility of rock-derived major elements during chemical weathering of basalt in Iceland varies by four orders of magnitude. The most mobile major constituents, that is, those that dissolve in surface waters, are F, S, Na, K, Ca and Mg, whereas the least mobile major elements in the rocks are Fe, Ti, Al, and Mn. The least mobile constituents are consumed by oxyhydroxides and Al silicates that dominate weathering minerals in Icelandic soils. The main weathering products of basaltic glass with limited contact with soil or atmospheric CO₂ are Si-, Ca-, and Mg-rich particles with smectite structure and amorphous Fe-, Ti- and Al-rich material. The most unstable primary basaltic minerals in the surface waters of Iceland are Mg-rich olivine and Ca-rich plagioclase; in contrast the Fe-Ti-oxides are the most stable primary minerals. The rate of chemical denudation in Iceland increases with runoff but decreases with increased age of the catchment rocks. The difference in the chemical denudation rate between river catchments in Iceland can not be explained by variation in temperature alone. At the fixed age of the rocks, vegetation cover, etc., the effect of runoff and temperature dominate. High runoff lowers the pH of surface waters where the concentration of organic acids is low and it decreases the concentration of total dissolved Al and Mg, affecting the dissolution rate of plagioclase and basaltic glass, and olivine and pyroxene at all undersaturation levels. Furthermore, high runoff results in larger undersaturation of primary minerals, decreases oversaturation of secondary weathering minerals, and increases the reactive surface area between rock and water. The higher the temperature, the higher the dissolution rate of all minerals and glasses. Where the variation in runoff and age of rocks is small, the chemical denudation rate is enhanced by vegetation and increases for most mobile elements with the rise in glass content of catchment rocks. The mechanical denudation rates are at a maximum in the young, glassy, glaciated catchment rocks of south-eastern Iceland but at a minimum in the old, non-glaciated, crystalline Tertiary catchment rocks. Denudation increases with runoff, temperature, glacial cover and decreasing age of the catchment rocks.*