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The chemistry and element fluxes of the July 2011 Múlakvísl and Kaldakvísl glacial floods, Iceland

Iwona Galeczka (1), Eric H. Oelkers (1,2), and Sigurdur R. Gislason (1)

(1) Institute of Earth Sciences, University of Iceland, Sturlugata 7, 101 Reykjavik, Iceland, (2) GET–UMR 5563 CNRS Université Paul-Sabatier IRD, 14, avenue Edouard Belin, 31400 Toulouse, France

The glacial floods, called 'jökulhlaups', are common in Iceland and are of interest to geologists for several reasons. Firstly, the heat source origin – subglacial volcanic eruption or/and subglacial geothermal activity – determines the potential environmental impact of the floods. For example, if the heat was sourced by a volcanic eruption, acid gas input might lead to acidic flood waters and toxic metal release from the host rock. In contrast, geothermal heat melts the ice slowly allowing long-term fluid-rock interaction to neutralize the flood waters, limiting their toxicity. The chemical composition of the flood waters is often the only indicator of the flood triggering mechanism in volcanic and geothermal areas. As such river water chemistry monitoring might be an effective method to predict an upcoming volcanic eruption. Secondly, glacial floods may play an important role in global cycle of elements. Due to high discharge during the events, flood waters can transport large amounts of particulate material. This particulate material has large surface areas, making it especially reactive once it arrives in estuaries. Slow dissolution of particulate material releases micro- and macronutrients which could enhance primary productivity along the coast and in lakes.

In July 2011, two ~2000 m^3/s glacial floods from the Icelandic Mýrdalsjökull and Vatnajökull glaciers emerged into the Múlakvísl and Kaldakvísl rivers, respectively. Water samples collected during both floods had neutral to alkaline pH and conductivity from 100 to 900 μS/cm. The total dissolved inorganic carbon (DIC), present mostly as HCO_3^-, was ~9 mmol/kg during the flood peak in the Múlakvísl river but stabilized at around 1 mmol/kg; a similar trend was observed in the Kaldakvísl river. Concentrations of most dissolved elements in the flood waters were comparable to those commonly observed in these rivers. The concentration of suspended particulate material however, increased dramatically during the floods and dominated chemical transport during these events. The toxic metal concentrations were below WHO (World Health Organisation) drinking water limits. The most soluble elements were Na, Ca, K, Sr, Mn, and Mg, whereas the least soluble were Ti, Al, and REE. This is consistent with the compositions of typical surface waters in basaltic terrains and the compositions of global rivers in general. Increased concentrations of DOC, formate, and acetate in the flood waters suggests subglacial microbiological activity in the melt water prior to the floods. According to PHREEQC modelling, flood waters were supersaturated with respect to a number of clays, zeolites, carbonates, and Fe hydroxides. Reaction path modelling of the flood water chemical evolution suggests that it experienced subglacial water-rock interaction for at least a year in the presence of limited amounts of acid gases (e.g. SO_2, HCl and HF). This indicates that the heat source for glacier melting was geothermal rather than volcanic.