Chemical denudation rates of a basaltic catchment, SW Iceland

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The average chemical denudation rate of basalts in Iceland of 55 tonne/km^2/yr (Gíslason *et al.*, 1996) is almost double the world-wide average of 26 tonne/km^2/yr (Berner and Berner, 1996). This high weathering rate have been explained by high content of basaltic glass of Icelandic rocks, which dissolve about 10 times faster in dilute waters than crystalline basalt (Gíslason and Eugster, 1987).

The aim of this contribution is to study the processes influencing the chemistry of cold waters and chemical weathering rates of basalts in Iceland. For this purpose, river-, spring-, and surface peat waters were sampled from a small catchment area (195 km^2), and major elements analysed. The study area, Laxá in Kjós catchment area, is located at the western marigne of the rift zone, SW Iceland, and is characterized by glacial eroded valleys. The rocks are of Quaternary age, 1.5 to 3 million years old, with tick successions of basaltic lavas and large local hyaloclastite formations. With respect to vegetation, the eastern part of the area is covered by peat and mosses, the western part with dwarf scrubs and grasses, and some of the valleys of the southern parts are barren. The area, therefore, provides an ideal opportunity to study the influence of basaltic glass and vegetation on water chemistry and weathering rates under uniform climatic conditions and rock age.

Chemical denudation rates

The Si, Al, Fe and F concentrations are considered to be entirely due to weathering of rocks. However, dissolved Na, K, Mg, Ca and SO$_4$ are derived from precipitation and rock dissolution. The proportions of these elements derived from precipitation was calculated from the corresponding solute/Cl marine ratios and Cl concentrations from precipitation. B and Cl are incompatible elements in basaltic rocks and are therefore concentrated in the basaltic glass. They are therefore assumed to be released in near stoichiometric proportions during weathering. As B and Cl are also mobile elements in all types of waters, the Cl proportion derived from weathering and precipitation may be estimated from the B content of the waters and the B/Cl marine and rock ratios.
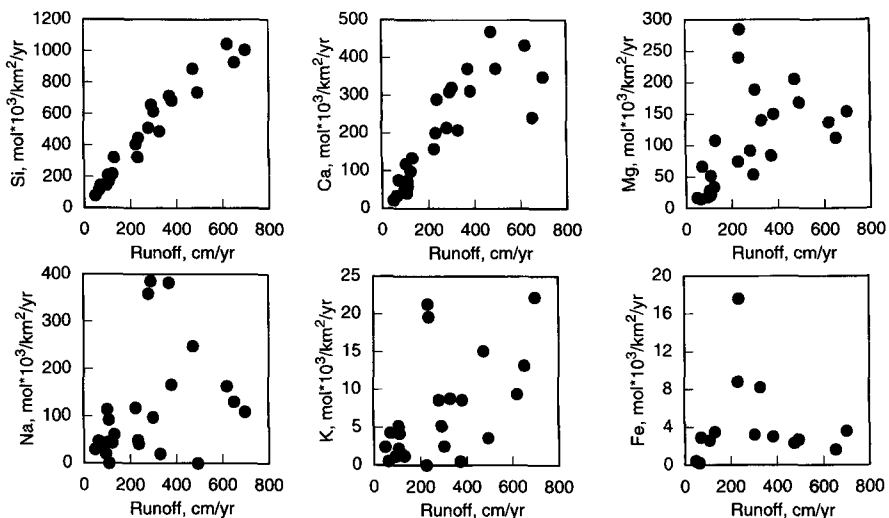

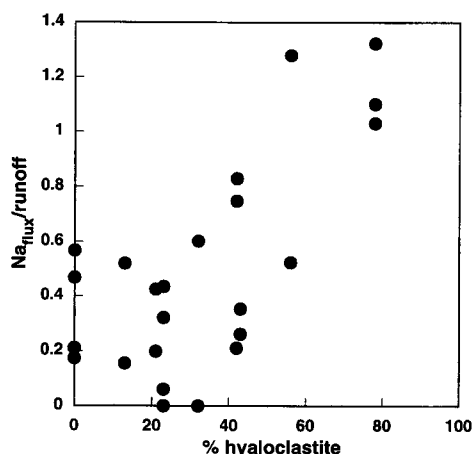FIG. 1. Solute fluxes derived from weathering versus runoff.

Fig. 2. Sodium fluxes derived from weathering nor-
malizes to runoff versus amount of hyaloclastite.

From the estimation of chemical constituents
derived from weathering and runoff we have
estimated the rock derived total chemical denudation
rates (TCDR) of $250-1830$ mol$*10^3$/km^2/yr and
atmospheric CO_2 consumption due to weathering of
basaltic rocks as $140-1760$ mol$*10^3$/km^2/yr.

Sodium is considered to be a mobile element under
weathering conditions. Si, Ca, Mg and K are
apparently less mobile compared to Na due to
consumption of these elements by secondary
phases, and Fe and Al are almost entirely left
behind relative to Na. Of particular interest is that
aqueous silica concentrations are uniform regardless
of sodium concentrations, suggesting that the
processes controlling silica are independent of
weathering intensity, rock composition and water
characteristics like pH. Similar trends is observed for
Ca as for Si, but the concentrations are more variable.
As a result of this linear trend of silica and calcium
with runoff is observed (Fig. 1). As these two
constituent make up to 75% of the elemental fluxes,
the TCDR also show positive linear correlation with
increasing runoff. However, poorer relationships of
solute fluxes and runoff are indicated for the other
base cations: Na, Mg, K, and Fe.

Sodium is considered to be a mobile element under

weathering conditions, as it is absent in the weath-
ering product (Crovisier et al., 1992). As shown on
Fig. 2, Na fluxes derived from weathering of rocks
normalized to runoff increases with increasing
amount of hyaloclastite of the catchment. This
suggest that hyaloclastite, which is primarily made
of basaltic glass, dissolve faster than fully crystalline
rocks under weathering conditions. However, as
many of the solutes are highly influenced or even
controlled by formation of secondary phases, this
increasing dissolution with increasing content of
basaltic glass is hidden, except for mobile elements
like Na

The less mobility of Ca and Mg compared to
sodium is assumed to be at least partially explained
by consumption of these elements by Ca- and Mg-
smectites. As the waters are close to equilibrium with
respect to ferri hydroxides, it is assumed that aqueous
iron is highly influenced by formation of this phase.
Vegetation cover influence these mineral solubility
by decreasing the pH leading to increased mobility
and higher fluxes of Mg, Ca and Fe at fixed runoff.
The weathering of Mg-Ca silicates and the subse-
quent transport of these chemical constituents to the
ocean are of primary importance in removing CO_2
from the atmosphere on geological time scale (e.g.
Berner, 1995). In addition to this, increasing Fe
fluxes to the oceans can trigger a massive
phytoplankton bloom which is an effective sink
from CO_2 on short time scale (Coale et al., 1996).

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