Oceanic nutrients from volcanic glasses

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Dissolved Fe is one of several factors governing biological production of the world
oceans. Coastal margin sediments, uppwelling, and aeolian transport have been con-
sidered the main source of soluble Fe in ocean surface waters (De Baar & Boyd, 2000).
Every year, about one km^3 of volcanic glass is produced in the surface environment
of the Earth, most of it along the oceanic ridges. Explosive aerial volcanic eruptions
can contribute enormous pulses of soluble Fe and other biologically important metals
to the ocean surface waters. Some of these eruptions produce pumice which can float
for years on the ocean surface providing a steady supply of Fe and other metals. Sig-
nificant amount of Fe and other metals is released to the deep ocean by hydrothermal
solutions and during submarine volcanic eruptions. Some of this iron is eventually
brought up to the surface ocean. We have studied by laboratory experiments the first
reactions taking place when pristine volcanic glass is exposed to seawater, defined
the steady-state dissolution rate and reaction mechanism of basaltic glass from 0 to
300˚ C, at pH 2 to 12, at various ligand concentrations, and the dissolution rates of
various glass compositions at pH 4 and 25˚ (Frogner et al. 2001; Oelkers & Gislason,
2001; Gislason & Oelkers, 2003; Wolff-Boenisch et al., 2004a,b;). Furthermore, we
have, indirectly, studied the flux of volatiles and metals, including Fe, during subma-
rine volcanic eruptions, by defining these fluxes during the 1996 eruption within the
Vatnajökull Glacier, Iceland (Gislason et al. 2002). The volcanic eruption occurred
beneath about 500 m of ice.

Pristine volcanic ash of basaltic-andesite composition and particle size 44-74 μm re-
leased 1.7 μmol/g/h P; 37 μmol/g/h Fe and 50 μmol/g/h Si during the first 45 minute
exposure to seawater. There is a continuous decrease in the steady-state dissolution
rate of natural glasses with increasing silica content of the glass. Basaltic glass dis-

solves about 10 times faster than silica-rich rhyolitic glass, its dissolution rate decreases dramatically with increasing pH under acid conditions, reaches a minimum at near neutral pH, and increases more slowly under basic conditions. The pH, at which basaltic glass dissolution is at minimum, decreases with increasing temperature. Organic ligands, F and SO4 greatly enhance the dissolution rate of glasses under acidic conditions. Volatile and dissolved element release to the meltwater within the Vatnajökull Glacier in less than 35 days exceeded one million tonnes, amounting to 0.1% of the mass of the erupted magma. The dissolved fluxes of C, Si, Fe, NH_4 and P were $1.4x10^{10}$, $3.6x10^9$, $1.5x10^7$, $8.2x10^6$ and $5.5x10^6$ mol, respectively. This study shows that subglacial and perhaps submarine eruptions affecting the surface layer of the ocean where either Mn, Fe, Si or fixed N are rate-determining for the growth of oceanic biomass have a potential for a transient net CO_2 removal from the ocean and the atmosphere.

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