The influence of groundwater inflow on neutralization rates in acidic mine lakes

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The controls on the internal neutralization of low productive, highly acidified waters by sulfide accumulation in sediments are yet poorly understood. It is demonstrated that the neutralization process can be controlled by the inflow of ferrous iron and sulphate rich groundwater from adjacent mine tailings, which keeps the pH in the sediments in a range allowing for simultaneous sulphate and iron reduction to occur. The investigated sediments adjacent to mine tailings and subject to the inflow of groundwater were richer in dissolved ferrous iron (up to 30 mmol L^{-1}) and sulfate (10-30 mmol L^{-1}) and showed higher pH values (4-6.5) than the sediments in parts of the lake not influenced by groundwater inflow. In the sediments influenced by the groundwater input from mine tailings contents of reduced inorganic sulfur and sulphate reduction rates were on average elevated as well.

These results have consequences for remediation measures in this type of lakes. In areas influenced by the inflow of ferrous iron rich groundwater from mine tailings increases in carbon availability, for example by the deposition of particulate organic matter, should enhance iron sulfide accumulation rates, whereas in other areas of the lake such increases would only result in enhanced rates of iron reduction without a lasting gain in alkalinity.

Generation, ascent and crystallisation of calc-alkaline silicic magmas

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Dacites erupted from Mount St. Helens volcano, 1980-86, are used to develop a generic model for the formation and evolution of silicic calc-alkaline arc magmas.

Experiments show that MSH dacites can be produced by partial melting or crystallisation of hydrous Cascades basalt at 1.1 GPa and 955-975°C, conditions appropriate to the base of the arc crust. A source H_2O content of 2.5 wt% is required, ruling out dehydration melting alone as a viable mechanism. Garnet, amphibole, plagioclase, cpx (or opx) and oxide are residual phases, the melt fraction is 15-25% and the melt contains 8-10 wt% dissolved H_2O. Despite its relatively high silica content (62-63 wt%), this melt will have unusually low viscosity (~10^4 Pa s) and density (~2300 kg m^{-3}). Once segregated from its source, it will be one of the most rapidly ascending liquids on Earth. If ascent is adiabatic, then the relative slopes of the adiabat and the constant-water liquidi mean that the melt is superheated after leaving the source. Any entrained source materials (“restite”) or accidental xenocrysts will tend to be partially or wholly resorbed during ascent.

A silicic melt with 10% dissolved H_2O attains saturation at ~400 MPa. Degassing at this pressure may account for deep long-period earthquakes, but will not be accompanied by crystallisation. Consequently there is little likelihood that liquids with 10% H_2O will be trapped as melt inclusions. Crystallisation does not begin until the water-saturated liquidus is reached at ~220 MPa, when the melt contains only 5-6 wt% H_2O, the maximum values recorded in MSH melt inclusions. Initially crystallisation is rapid: from 220 to 110 MPa the magma crystallises by 30-40%, increasing its viscosity by ~3 orders of magnitude. As a result, most silicic magmas ascend rapidly from their source, then stall in the shallow crust, unless further ascent and eruption are facilitated, e.g. by fractures or caldera collapse.

The early phase of crystallisation is driven almost entirely by decompression, with cooling of <50 °C relative to the source. Numerical simulations suggest that this process may occur on time-scales of years or decades at most. In contrast, subsequent crystallisation (>30-40%) of the stalled magma is driven by slow heat loss to the wall rocks over 10^3-10^4 years. These slow crystallising “proto-plutons” are vulnerable to thermal reactivation and eruption if heated by subsequent magma pulses. This may be a common mode of eruption, with clear implication for U-series disequilibria of silicic magmas.