BRUCITE-SOLUTION INTERACTION: A SYSTEM TO REMOVE DIVALENT METALS FROM WATER

T. Rötting [1], C. Ayora [1], J. Cama [1], J.L. Cortina [2] y J. Joan de Pablo [2]

[1] Instituto de Ciencias de la Tierra Jaume Almera, CSIC, Lluis Solé Sabarís s/n, 08028 Barcelona, Spain.

C-E: troetting@ija.csic.es

[2] Departmeno de Ingeniería Química, Universitat Politècnica de Catalunya, Diagonal 647, 08028 Barcelona, Spain

Passive remediation consists of a permeable system which enables the water to pass through whilst retaining metals by means of biogeochemical reactions. Conventional passive treatments are based on calcite dissolution. This reaction increases the pH to values between 6 and 7, which are insufficiently high to precipitate divalent metals (Fig. 1). Alternative treatments are based on sulfate reduction with organic matter in order to precipitate metal sulfides. However, redox reactions are usually too slow to treat large groundwater flows as currently found in gravel aquifers (>50 m/a).

Caustic magnesia obtained from calcination of magnesium carbonate was tested in laboratory column experiments as an alternative material for passive remediation systems. Caustic magnesia (> 60% periclase, MgO) reacts with water to form brucite, $Mg(OH)_2$, which dissolves increasing the pH to values higher than 8.5. Then, zinc precipitates as β-$Zn(OH)_2$ (Fig. 2A), lead as hydrocerussite, $Pb_3(CO_3)_2(OH)_2$, copper as brochantite, $Cu_4SO_4(OH)_6$, and manganese (II) is oxidized and precipitated as manganese (III) oxides: manganite, γ-MnOOH, feitknechtite, β-MnOOH and hausmannite, Mn_3O_4. With respect to trace pollutants, at pH 8.5 cadmium is precipitated as otavite, $CdCO_3$, and cobalt and nickel form brucite-isostructural precipitates: theophrastite, $Ni(OH)_2$ (Fig. 2B) and β-$Co(OH)_2$. Thus, metal concentrations as high as 75 mg/L in the inflowing water are depleted to values below 10 mg/L.

Brucite dissolution is sufficiently fast to treat flows as high as 100 m/a. However, two main features threaten the durability of the remediation: passivation and clogging. For reactive grain size of 2-4 mm, the treatment system
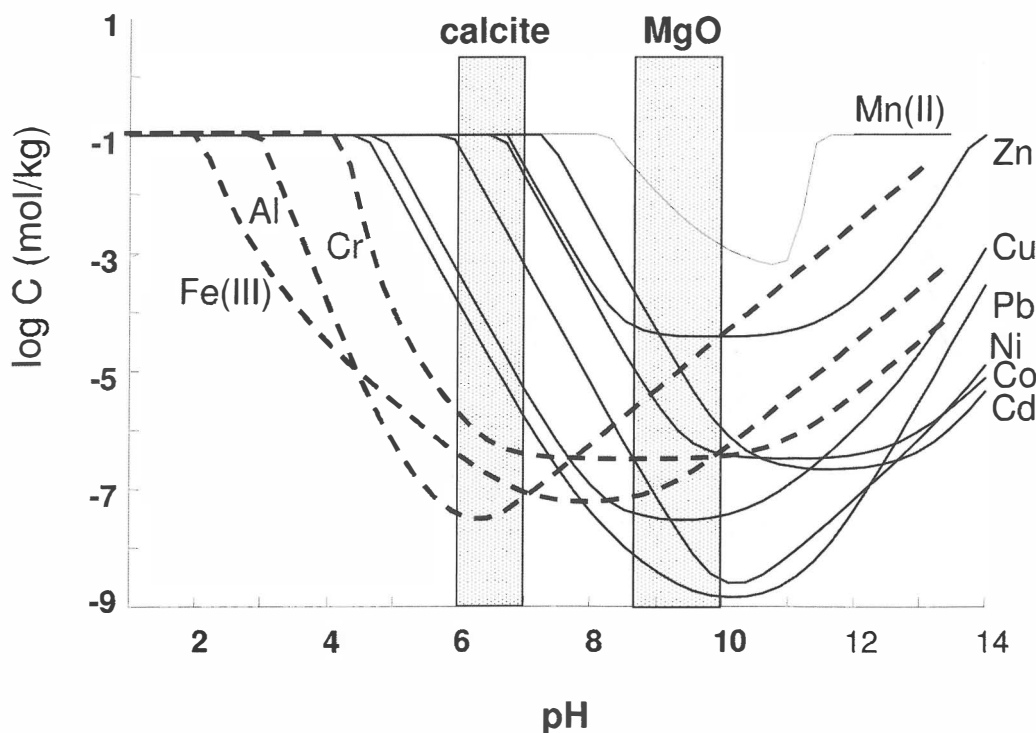

Figure 1: Variation of the metal concentration in equilibrium with the metal hydroxide. Thermodynamic data for $Co(OH)_2$ from Baes and Mesmer (1976), for $Ni(OH)_2$ from Hummel (2000), and for $Cd(OH)_2$ from Ball et al. (1987). In the absence of hydroxide, the maximum concentration assumed is 0.1 mol/L. The vertical rectangular fields indicate the pH values expected after passive treatment of acid water with organic matter and calcite, and with caustic magnesia.
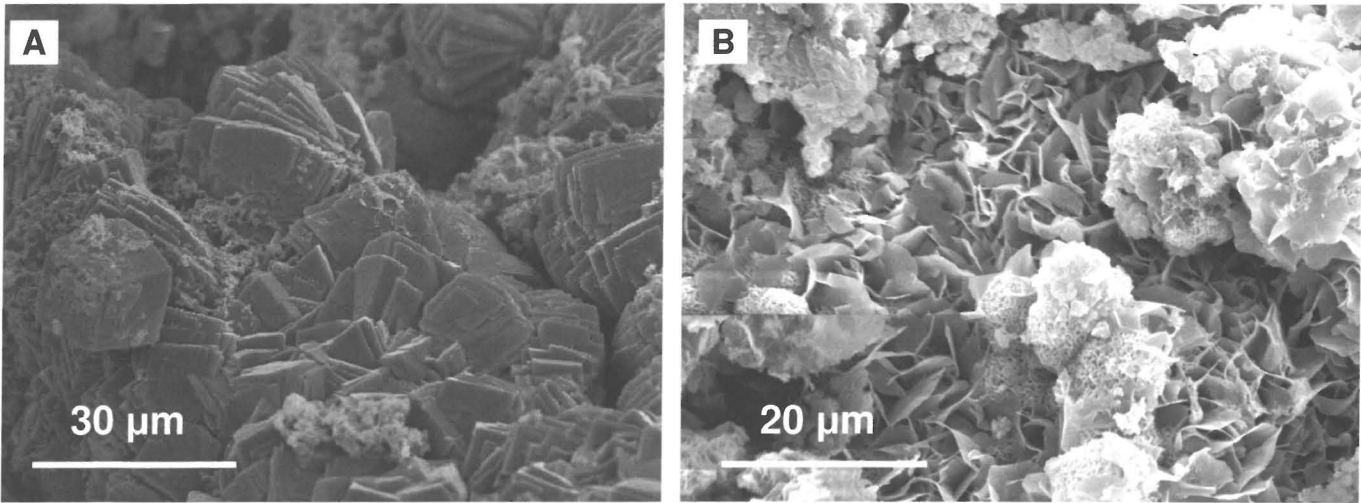
Figure 2: SEM images of (A) Rombohedral crystals of otavite (CdCO₃) precipitated on the surface of caustic magnesia, (B) Rose aggregates of plate crystals of a Co-rich phase (Co(OH)₂?) growing on a surface of brucite aggregates.

ends due to coating of the grains by precipitates especially when iron and aluminium are present in the solution. Thus, the surface becomes passive when only a small fraction of brucite has reacted. On the other hand, the new precipitates may lead to a permeability drop of the porous matrix. Mixtures of caustic magnesia and an inert material such as silica sand (approx 50% of each) have been shown to be as reactive as pure magnesia and permeable for a longer time (more than 10 months and 1000 pore volumes). We are now testing alternatives to solve passivation and clogging based on the dispersion of fine grained reactive material in an inert matrix.