Passive carbon mineralization of ultramafic mine waste by atmospheric CO_2

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Laboratory and field experiments on passive carbon mineralization ultramafic mine wastes by atmospheric CO_2 from various mining and milling waste chemical composition and mineralogy, over large time (10^1-10^8 s) and mass (1-10^6 g) scales [1], have been conducted to investigate spontaneous reaction of Mg-minerals with atmospheric CO_2 dissolved in water. The mineralogy of the waste materials is an important criterium as brucite, and then chrysotile, are the most reactive minerals studied to date. Pore water dissolves Mg from minerals and reacts with solute CO_2 to form hydrated magnesium carbonate species through exothermic carbon mineralization reactions. The neoformed minerals are metastable and recrystallize with time and temperature to hydromagnesite. Dissolution of Mg is enhanced by adjusting the chemistry of pore water, whereas precipitation of mineral species, such as iron hydroxides, or amorphous phases such as silica, on the reactive surface of the Mg minerals must be prevented to maintain reactivity. Mine waste water saturation and watering frequency are important to optimize transport of CO_2 and dissolution of Mg minerals to the reaction site.

Monitoring of interstitial air CO_2 and C isotope composition and temperature from experimental cells built of mining and milling waste under atmospheric weathering conditions in southern and northern Québec sites. The CO_2 concentration decreases from atmospheric (400 ppm) to less than 5 ppm inside the cell, because CO_2 diffusion in interstitial air and CO_2 dissolution in water are rate-limiting the carbon mineralization reactions. A 90-m deep well into the 110 MT Black Lake mine waste pile shows ingress of CO_2 is controlled by two regimes [2]. Iinterstitial air temperature indicate exothermic reactions generate 0.2-0.8 mW/m^3. In winter the warm (11-14 C) interstitial air becomes overpressured, and CO_2-depleted (10 ppm) air vents at the surface. In summer, ambient air is warmer that inside, and enters from the pile's steep flanks, reversing the airflow and CO2 advection. In this waste pile the carbon mineralization is limited by CO2 intake, which could be optimized to increase carbon capture.

[1] Beaudoin et a.l. (2017) Energy Procedia **114**, 6083-6086.
[2] Nowamooz et al. (2018) Environ. Sci. Technol. **52**, 8050-8057.