

Mineral compositions indicate magma recharge processes in the Ilímaussaq Complex, Greenland

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The peralkaline Ilímaussaq intrusion, South Greenland, exhibits various types of syenites and nepheline syenites. The latest magma pulse represents the most evolved rocks (lujavrites), which mainly consist of eudialyte group minerals (EGM), feldspar, Na-pyroxene (aegirine) and sodic amphibole (arfvedsonite). Based on varying proportions of aegirine or arfvedsonite the lujavrites are subdivided into several units (Fig. 1). Our investigated samples cover the whole sequence of these rocks, including the upper part of the underlying cumulates (kakortokites). We analyzed early magmatic EGM to track the geochemical evolution of their parental melt. Textures (change from poikilitic to dispersed amphibole) and compositional variations (Fe/Mn and Ca/REE ratio systematics) imply that aegirine lujavrites I & IIA continuously evolved from the underlying kakortokites (Fig. 1). Data for arfvedsonite lujavrite A shift back to similar element ratios as aegirine lujavrite I and evolve further on a comparable trend. In contrast, aegirine lujavrite IIB and arfvedsonite lujavrite B data seem to evolve differently. We take these data as indication for the presence of three melts batches responsible for the formation of the lujavrite sequence, which is in contrast to earlier interpretations, who suggested that the kakortokite-lujavrite sequence formed from one single magma batch [1].

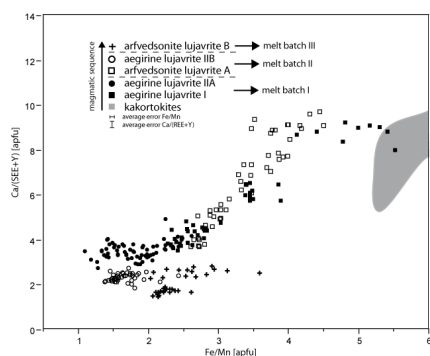


Figure 1: Element ratios in eudialyte; combined with data from [2].

[1] Sørensen *et al.* (2006) *Lithos* **91**, 286. [2] Pfaff *et al.* (2008) *Lithos* **106**, 280.

Electrochemical enhancement of carbonate and silicate weathering for CO₂ mitigation

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Given the urgent need to stabilize if not reduce atmospheric CO₂ levels, might it be possible to safely and cost-effectively accelerate the consumption and storage of CO₂ via mineral weathering? Exposure of silicate and especially carbonate minerals to elevated CO₂ (e.g. flue gas) can effectively increase the reaction rates leading to CO₂ capture and storage via bicarbonate and/or carbonate formation (1). However, the slow kinetics of the silicate/CO₂ reactions appear to require additional chemical and/or physical treatment, especially in consuming more dilute CO₂ such as found in air. Because of the sensitivity of carbonate and silicate mineral dissolution to acids, and given the ability of saline water electrolysis to generate strong acids, it has been previously shown that electrochemistry can be used to accelerate mineral weathering for purposes of air CO₂ mitigation (2, 3). To explore this further, powdered wollastonite or ultramafic rock standard (UM-4) was encased around the acidic anode of a saline water electrolysis cell composed of graphite electrodes and a 0.25M Na₂SO₄ electrolyte solution. After 0.5 to 1.5 hrs of electricity application (3.5V_{dc}, 5-10mA), the electrolyte pH rose to as much as 11.1 (initial and blank pH's <6.6). Subsequent bubbling of these basic solutions with air lowered pH by at least 2 units and increased dissolve carbon content (primarily bicarbonate) by as much as 50X that of the blanks. While Ca²⁺ and Mg²⁺ concentrations were elevated, these were insufficient to balance the majority of the bicarbonate anions in solution. We suggest that in these experiments the silicate minerals acted as acid absorbers, forming mostly insoluble CaSO₄ and MgSO₄ at the anode, thus allowing NaOH formation at the cathode to accumulate in solution, in turn reacting with air CO₂ to form NaHCO₃. Longer electrolysis times and/or alternative electrolyte solutions might allow formation and precipitation of Ca or Mg carbonates. Such electrochemistry might ultimately provide a safe, efficient way to harness the planet's: i) large, off-peak or off-grid renewable electricity potential, ii) abundant basic minerals, and iii) vast natural brine electrolytes for air CO₂ mitigation and carbon-negative H₂ production.

[1] Rau, G.H. (2011) *Environ Sci. Technol.* **45**, 1088–.

[2] House, K.Z. *et al.* (2007) *Environ Sci. Technol.* **41**, 8464–.

[3] Rau, G.H. (2008) *Environ Sci. Technol.* **42**, 8935–.