Synthesis of silica, iron oxide, magnesium carbonate from serpentine minerals

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Serpentine minerals [$Mg_3Si_2O_5(OH)_4$] consists of various and useful cations. Consequently, this minerals have a potential for the production of Mg, Si, and carbonate minerals. The objectives of this study were to synthesize nano- and carbonate-minerals using serpentine via acid dissolution and pH swing processes.

Serpentine collected from LAB Chrysotile mine in Canada was pulverized (≤ 75 μm) and then dissolved using various acids such as HCl, H_2SO_4, HNO_3. Acid treated serpentine was recovered from the solution (step 1). And then the residual solution containing dissolved serpentine was titrated using NH_4OH. And pH of the solution increased up to pH=8.6 to obtain precipitates (step 2). After recovery of the precipitates, the residual solution reacted with CO_2 and then pH increased up to pH=9.5 to precipitate carbonate minerals (step 3). The mineralogical characteristics of the original sample and harvested precipitates were examined by XRD, XRF and TEM-EDS analyses. ICP-AES analysis was also used to investigate solution chemistry.

The serpentine mineralogy was an ortho-chrysotile consisting of SiO_2 (44.9 wt. %), MgO (42.5 wt. %), Fe_2O_3 (9.9 wt. %). The concentration of Mg in the acidic solution dissolved serpentine was about 1,280 mg/L and concentrations of Si and Fe were about 10% compared to Mg. The chrysotile was changed to noncrystalline silica after acid treatment (step 1). The precipitate at pH=8.6 was mainly amorphous iron oxide, which ranged from 5 to 20 nm and consisting of Fe, O and Si (step 2). At pH=9.5, nesquehonite [$Mg(HCO_3)(OH)\cdot 2(H_2O)$] was formed after reaction with CO_2 (step 3). The crystal size of carbonate minerals was ranged from 0.5 to 5 μm.

These results indicate that the acid treatment of serpentine and pH swing processes can synthesize silica, iron oxides and magnesium carbonate. Therefore, these methods may be applicable for recovery of useful materials from minerals and carbon sequestration.