Experimental study of CO_2 dissolution by reaction with carbonate and water for sequestration into seawater

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CO_2 can be dissolved into water by reaction with carbonates ($CaCO_3$+CO_2+H_2O=Ca^{2+}+2HCO_3^-). Caldeira and Rau (2000) demonstrated the possibility of CO_2 seqestration into seawater after neutlization by this reaction because direct dissolution of CO_2 into seawater causes acidification. In this study, beaker and two types of gas-flow experiments and theoretical approaches were performed to apply the above reaction to remove CO_2 from cement plants (>20 vol% CO_2).

Experimental procedures

In beaker tests, powdered carbonates collected from the Yokose mines, Saitama, Japan, were reacted with CO_2 (20 vol%) -N_2 gas mixture in tap water or sea water. The pH and HCO_3^- concentration of waters were continuesouly measured.

Flow tests have been performed in a column type (10 cm in diameter, 20 L in volume with packing particuls) or a pipe type (10 cm in diameter, 2 m in length) with flow rates of CO_2-N_2 gas mixture (1 to 20 L/min) and tap water (1 to 10 L/min) for 1 hour.

Results and discussion

In the beaker tests, the pH and HCO_3^- concentration in tap water changed from 7.5 to 6.7 and from 1.3 to 10.8mmol/L, respectively, within 12 minutes. For sea water, HCO_3^- concentration increased up to 15.4 mmol/L. After reaction, >20 % of dissolved CO_2 in the treated water is released to atmosphere within 2 days, whereas no degassing can be observed for the diluted water even in a week.

In the column- and pipe-type (13°; angle of dip) tests, 75% and 50% of concentrations of saturated solution, respectively, can be removed at gas/water volume ratios of 2.
The rate constant of dissolution of CO_2 into water depends on the flow rates of water and the gas/water ratios.

The reactions of neutrization between the CO_2 treated water and carbonate particles are modelled considering gas-water interface and gas/water ratio. The reaction rates in each experiment are obtained by comparing experimental results with calculated ones based on the model. The calculated best gas/water ratios and flow rates of water are 2 and 8L/min, respectively, in this study. The reaction rate in the column type is 10 times higher than that in the pipe-type.

Reference

Caldeira, K. and Rau, G.H. (2000) Geophys Res Lett 27, 225-228.

Geology of the Acasta Gneiss Complex: New evidence of the oldest rocks in the world

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Ancient crustal rocks provide the only direct evidence for surface tectonics, and the processes and products of differentiation in early Earth. However, the oldest recognized terrestrial rocks (≥3600 Ma) are rare, and only nine terrains are preserved. The Acasta Gneiss Complex contains the 4.03 Ga orthogneisses (Bowring & Williams, 1999), which are the oldest rocks in the world so far.

We reinvestigated geology and geochronology of the Acasta Gneiss Complex in Slave Province, Northwest Territories of Canada. We recognized six distinct lithofacies, and at least eight tectonothermal events, based on detailed 1:5000 scale geological mapping and petrographic investigation of about 1000 specimen. It mainly comprises early Archean Gray (GG) and White Gneisses (WG) and mid-Archean Foliated Granite (FG), with young aplitic and basaltic dikes, which underwent the amphibolite facies metamorpshim. Gray Gneiss occur as enclaves within WG and FG, in the range from 3x1 km^2 to 10x10 cm^2 in scale. They form block, boudin and layer. Some blocks have asymmetrical structure, showing direction of deformation at the tonalitic and granitic intrusion (WG). Some have clear compositional banding, but most are massive. White Gneiss have three types; massive, banded and layered. The massive and banded WG are petrographically classified into three types, pale-grey tonalitic, white granitic and white pegmatitic gneisses. Layered White Gneiss have both compositional banding and foliation, and occurs only in the western area, together with FG. White Gneiss are widely distributed all over the Acasta Gneiss Complex, and also occur as intrusions within GG. The gneissic structure of WG is concordant with the shape of the included Gray Gneiss, but completely discordant to the gneissosity within GG.

The lines of geological evidence show at least eight tectonothermal events; (1) quartz-dioritic and gabbroic magma (Gray Gneiss), (2) metamorphism and deformation 1 (gneissosity of Gray Gneiss), (3) tonalite and granite magma (White Gneiss), (4) metamorphism and deformation 2 (gneissosity of White Gneiss), (5) granite sheets (Foliated Granite), (6) fault between eastern and western parts, (7) basaltic dikes, (8) amphibolite facies metamorphism during *ca*. 1.9 Ga Wopmay orogeny. In addition, the cross-cutting relationship indicates that the Gray Gneiss and the included hornblendite pods are older than the well-dated (*ca.* 4.03-Ga) White Gneiss. Evidence of partial melting of some Gray Gneiss enclaves suggests that the early-formed Gray Gneiss was assimilated into the tonalitic magmas during the emplacement.