

In-situ test for CO₂ fixation in serpentinite rock mass

Ikuo Okamoto[1]; Tatsuya Yajima[2]; Yukihiro Mizuochi[3]; Takayuki Katoh[4]; Atusi Ninomiya[5]; Takashi Ohsumi[1]

[1] RITE; [2] Research Institute of Innovative Technology for the Earth; [3] Sumitomo Metal Mining Co.,Ltd.; [4] Earth Sci. Co.; [5] SUMICON

<http://www.rite.or.jp>

1. Introduction

Serpentinite rock mass with highly alkaline groundwater has a potential of CO₂ mineral fixation as carbonates. The groundwater acidified by injected CO₂ dissolves brucite (Mg(OH)₂) and serpentine (Mg₃Si₂O₅(OH)₄) in the host serpentinite to increase its Mg content. The Mg-rich groundwater diffuses in the serpentinite-groundwater system with further dissolution of brucite and serpentine to recover its alkalinity. It is possible that Mg carbonates precipitate from the highly alkaline groundwater by a reaction between CO₂ and excess Mg component.

The purpose of this study is to develop the efficient CO₂ fixation system in the ultramafic regime with an in-situ CO₂ injection test and laboratory experiments.

2. In-situ Test

The in-situ CO₂ injection test was carried out at the Iwanaidake ultramafic mass in the Kamuikotan metamorphic belt, Hokkaido, northern Japan. The Iwanaidake ultramafic mass mainly consists of harzburgite and serpentinite of harzburgite-origin. On the other hand, most of the bored core is dunite-originated serpentinite, which composed of 3 vol. % of primary minerals, 76 vol. % of serpentine and 16 vol. % of brucite. The minor harzburgite-originated serpentinite consists of 47 vol. % of primary minerals (olivine, orthopyroxene), 47 vol. % of serpentine and 5 vol. % of brucite.

The depth of the bored hole is 101 m. pH value of the groundwater is about 10.5. The groundwater level is 39 m. A relatively large crack with high permeability exists near the bottom. The CO₂ gas was injected at the pressure of 0.7 MPa.

Electric conductivity and Mg concentration of the groundwater have increased from 21 to 220 mS/m and from 16 to 200 mg/l, respectively, for one day after CO₂ injection. Mineral precipitation by the CO₂ injection in the bored hole was observed by the video camera. In the pumped up groundwater the precipitates are amorphous iron hydroxide, Fe, Mg-amorphous silicate and hydromagnesite (Mg₅(CO₃)₄(OH)₂·4H₂O). In contrast that the ratio of Mg/Si in the ideal chemical formula for the serpentine is 1.5, that ratio is about 1 in the amorphous silicate. It is suggested that dissolution of serpentine with high Mg/Si ratio and precipitation of the amorphous silicate with low Mg/Si ratio makes Mg content in the groundwater high, and that the hydromagnesite precipitates by the reaction between CO₂ and surplus Mg. This process would be useful for the CO₂ fixation.

3. Laboratory Experiments

Laboratory experiments on the reaction among CO₂, the groundwater and the powder samples of dunite- and harzburgite-originated serpentinites of the Iwanaidake core were carried out. These materials have reacted for 28 days under the conditions 25C, 0.7 MPa the same as the in-situ test and 50C, 10MPa equivalent to the 1000m depth.

Analyzing the reaction products clarified that the small amount of serpentine and the whole amount of brucite dissolve to precipitate the Fe, Mg-amorphous silicate. The carbonates of pyroaurite (Mg₁₀Fe₂(CO₃)(OH)₂₄·2H₂O) or coalingite (Mg₆Fe₂(CO₃)(OH)₁₆·4H₂O) reddish brown in color were also formed. In addition to them, hydromagnesite precipitated in the case of the experiment of the dunite-origin serpentinite.

4. Conclusion

It is possible that the combination process of dissolution of the serpentine and following formation of the amorphous silicate after CO₂ injection into the serpentinite-groundwater system increases the Mg component in the groundwater. Mg carbonates possibly precipitate by the reaction between injected CO₂ and excess Mg.

Next year, the in-situ test and laboratory experiments will be improved to understand the details for the fixation of CO₂ related to the ultramafic mass with the insight for the spatial distribution of reaction field.