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Leaching of Natural Gravel and Concrete by CO_2 – Experimental Design, Leaching Behaviour and Dissolution Rates

Rita Fuchs (1), Albrecht Leis (2), Florian Mittermayr (3), Gerhard Harer (4), Hanns Wagner (5), Peter Reichl (6), and Martin Dietzel (7)

(1) Institute for Applied Geosciences, TU Graz, Graz, Austria (rita.fuchs@student.tugraz.at), (2) Institute for Water, Energy and Sustainability, Joanneum, Graz, Austria (albrecht.leis@joanneum.at), (3) Institut für Materialprüfung und Baustofftechnologie mit angeschlossener TVFA für Festigkeits- und Materialprüfung, TU Graz, Graz Austria (f.mittermayr@tugraz.at), (4) Geschäftsbereich Projekte Neu-/Ausbau, ÖBB-Infrastruktur AG, Graz, Austria (Gerhard.harer@oebb.at), (5) Streckenmanagement und Anlagenentwicklung, ÖBB-Infrastruktur AG, Graz, Austria (Hanns.wagner@oebb.at), (6) Institute for Water, Energy and Sustainability, Joanneum, Graz, Austria (peter.reichl@joanneum.at), (7) Institute for Applied Geosciences, TU Graz, Graz, Austria (martin.dietzel@tugraz.at)

The durability of building material in aggressive aqueous environments is a key factor for evaluating the product quality and application as well as of high economic interest. Therefore, aspects of durability have been frequently investigated with different approaches such as monitoring, modelling and experimental work.
In the present study an experimental approach based on leaching behaviour of natural calcite-containing siliceous gravel used as backfill material in tunnelling and sprayed concrete by CO_2 was developed. CO_2 was introduced to form carbonic acid, which is known as an important agent to induce chemical attack. The goals of this study were (i) to develop a proper experimental design to survey the leaching of building materials on-line, (ii) to decipher individual reaction mechanisms and kinetics and (iii) to estimate time-resolved chemical resistance of the used material throughout leaching.
A combined flow through reactor unit was successfully installed, where both open and closed system conditions can be easily simulated by changing flow directions and rates. The chemical compositions of the experimental solutions were adjusted by CO_2 addition at pHstat conditions and monitored in-situ by pH/SpC electrodes and by analysing the chemical composition of samples throughout an experimental run. From the obtained data e.g. dissolution rates with respect to calcite were obtained for the gravel material, which were dependent on the individual calcite content of the leached material. The rates were found to reflect the flow rate conditions, and the kinetic data lay within the range expected from dissolution experiments in the $CaCO_3$-CO_2-H_2O system. In case of concrete the reactions throughout the leaching experiment were complex. Coupled dissolution and precipitation phenomena (e.g. portlandite dissolution, calcite formation) occurred. The coupled reactions can be followed by the evolution of the solution chemistry. The overall rates of elemental removal from the gravel and concrete samples were used to assess their durability at various boundary environmental conditions.