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# Mineral carbonation of alkaline industrial by-products: advancing our understanding of reaction pathways

**PASCALE BÉNÉZETH**[1], GIUSEPPE SALDI[2], HUGO BARRÉ[3], SIMON BLOTEVOGEL[4], LÉNA ROSSI[1], FLORIAN VATINEL[5], CEDIC PATAPY[6] AND ALAIN CASTILLO[7]

[1]Géosciences Environnement Toulouse
[2]University of Perugia
[3]Toulouse University-UPSSITECH
[4]Ecocem - LMDC
[5]LMDC-INSA Toulouse
[6]LMDC
[7]Géosciences Environnement Toulouse - CNRS

To reach net zero emissions by 2050, storing $CO_2$ safely and permanently is one of the major options for which a number of CCUS technologies and process concepts are proposed, each with its own distinct advantages and applications, as well as limitations. Among them, mineral carbonation (MC), a process that occurs naturally over hundreds to thousands of years, is a promising CCUS technology in particular in helping decarbonize hard-to-abate $CO_2$ emissions of industries such as cement and concrete, which represent ~8% of global $CO_2$ emissions. Some of these intrinsic emissions in Portland cement production can be reduced by substituting the clinker with supplementary cementitious materials (SCMs) that are naturally occurring or by-products of human activity such as alkaline industrial by-products. Indeed, every year, millions of tons of alkaline residues/wastes such as electric arc furnace (EAF) slags, obtained during steel production or ultramafic waste rock and mine tailings, are produced globally and could have the potential to effectively be converted into reactive phases in cementitious environments via MC. However, the carbonation efficiency and reactivity depend strongly on the physico-chemical conditions and the mineral composition of the alkaline industrial by-products.

In this study, we focused on the carbonation of EAF and ferronickel slags, as well as synthetic Ca/Mg silicates, which represent the mineralogical compositions of the EAF slags. The experiments were conducted under varying physico-chemical conditions and combined liquid (e.g., ICP-OES, ICP-MS) and solid phase analyses (e.g., XRD, TGA, NMR, SEM) before and after the carbonation runs, as well as numerical simulations. The first results of the EAF carbonation experiments show that aragonite, dolomite, calcite, and ankerite were the principal carbonate phases formed with a total amount varying from 0.54% to 47.85%, depending on the starting material and the carbonation temperature. For some synthetic raw minerals, the formation of an amorphous Si-Al gel or an Al-rich surface layer suppressed the carbonation reaction, as also observed previously for the carbonation of epidote[1]. Data from the experiments performed with the ferronickel slag, for which the mineralogical composition primarily consists of a ferroan-forsterite and amorphous phases, will also be presented.

[1]Bénézeth *et al.* (2022), doi.org/10.2139/ssrn.4274163