New perspectives on carbonate mineral behaviour for carbon accounting and carbon utilization

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Understanding carbonate mineral behaviour is important for ensuring long-term carbon storage, accurate carbon accounting, and safe utilization of mineral products. Here, we provide some new perspectives on the behaviour of carbonate-bearing minerals within the context of Carbon Capture, Utilization and Storage (CCUS).

Our experiments and field studies show that atmospheric water vapour plays an essential role in mediating the amorphous-to-crystalline transition and hydrated carbonate phase transitions in water-undersaturated conditions. The decomposition of amorphous and crystalline carbonate phases occurs via humidity-mediated dissolution–precipitation in thin films of adsorbed water at grain surfaces. Low humidity conditions stabilize some crystalline phases to unexpectedly high temperatures (e.g., lansfordite remains stable at room temperature and RH <20% for at least 7 years) whereas high humidity causes rapid decomposition or crystallization. Storage of amorphous carbonate phases under low humidity decreases their rate of crystallization. Our observations indicate that fractional crystallization of amorphous Mg-carbonate (AMC) and Ca-Mg-carbonate (ACMC) can take months to years at RH < 30%. Notably, we show that much of the CO_2 stored in at least one mine tailings storage facility is in the form of AMC. Our results suggest that amorphous carbonate phases may play a greater role in CCUS, during enhanced weathering of alkaline rocks and mineral wastes, than previously anticipated.