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Understanding the mechanisms of natural and anthropogenic glass weathering with XPS (X-ray photoelectron spectroscopy)

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The dramatic increase in CO_2 in air and water has resulted in an urgent need to develop techniques to capture and store carbon. Basalt, a common alkaline rock on land and under oceans, weathers during exposure to CO_2 and water, eventually producing limestone, dolomite, chalk and marble, where CO_2 is mineralised by divalent cations to carbonate phases. Industrialisation has also produced large amounts of waste, not least of which is waste from demolition of buildings and bridges and much of this material is also alkaline. For example, stone wool, used generally for insulation, has nearly the same composition as basalt and is amorphous, as basaltic glass. Stone wool also can weather, converting CO_2 into stable carbonate phases. An interesting question is *how* the amorphous materials react, because understanding the mechanisms would give clues for increasing reaction rates, thus one could use waste to mineralise CO_2.

Other studies in our group (Kanelis et al., Merino-Diez et al., Erlacher et al., Andersson et al.: abstracts in this volume) have demonstrated release of cations from various alkaline materials. The aim of this study was to observe the release using X-ray photoelectron spectroscopy (XPS), a technique that provides information about the chemical composition and bonding relationships in the top 10 nm of a surface. We investigated several types of glass, industrially manufactured (soda-lime-silica glass), synthesised to have specific calcium, aluminium and silica concentrations (CAS glass) as well as naturally occurring samples (basaltic glass and obsidian), to explore how their surface composition evolves in time and during exposure to water and humidity, in air and with various concentrations of CO_2. Results were compared with density functional theory (DFT) simulations.

Samples exposed to water lose cations from the surface and secondary phases form. An interesting point is that even in air, where humidity is low, the surface rearranges so secondary phases form in the capillary water layer that is adsorbed from air, even in low humidity.