CONCRETE DETERIORATION - REACTION MECHANISMS REVEALED BY A MULTIPROXY APPROACH

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Deterioration due to aggressive aqueous environments acts as a major threat for the durability of concrete structures. One example is the thaumasite form of sulfate attack (TSA) which preferentially occurs in wet, highly sulfate-loaded and cold (<15 °C) environments such as in underground structures. Despite the fact that the destructive nature of TSA is well known, reaction paths and mechanisms that may even lead to a total destruction of concrete structures are still poorly understood. The aim of this study is to contribute to a deeper understanding by introducing a novel approach based on combined methodologies.
Our multi-proxy approach comprises a range of mineralogical methods such as X-ray diffraction with Rietveld refinement and electron microprobe, hydro-geochemical analyses, e.g. ion chromatography and inductively-coupled plasma-mass spectrometry, and PHREEQC hydrogeochemical modelling. The distribution of stable hydrogen and oxygen isotopes of water were analysed by wavelength scanned cavity ring-down spectroscopy.
The investigations were performed on damaged concrete samples taken from two tunnel sites in Austria, where the locally occurring ground water was classified as slightly aggressive in terms of SO_4 load (DIN EN 206-1. < 600 mg L^{-1}). Severely damaged mushy concrete consisted mainly of thaumasite, secondary calcite, gypsum and aggregate relicts. The expressed interstitial solutions from this altered material were extremely enriched in SO_4 and Cl (> 30000 and 12000 mg L^{-1}, respectively) (Mittermayr et al., 2013). Stable hydrogen and oxygen isotope ratios were feasible for verifying and quantifying the effect of evaporation and distinct degrees of relative humidity. An enormous and linear accumulation of incompatible dissolved ions (e.g. K, Rb and Li) clearly indicates that numerous wetting and drying cycles had occurred. Such a highly dynamic system is considered to have severe destructive effects on concrete structures. With this study we developed a new multi proxy approach to reveal the complexity of alteration processes involving chemical attack on concrete. Thus specific counter measures for structures affected by TSA, designing of advanced concrete admixtures and constructive measures for future projects can be facilitated.

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