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Thaumasite Formation in Concrete - An Isotope Study

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Enormous cost may arise when concrete constructions are subjected to chemical attack. Various degradation processes such as the Thaumasite Form of Sulphate Attack (TSA) and Alkali-Aggregate Reactions (AAR) have repeatedly been discussed in the literature (Bellmann and Stark, 2007, Schmidt et al, 2009). Deteriorated concrete samples were taken from Austrian railroad and highway tunnels. To gain new insight in the complex degradation reactions and to decipher the origin of compounds of newly formed damaging minerals as thaumasite, investigations including a chemical characterisation of groundwater, concrete and natural in situ rock samples were carried out. Petrological, hydrochemical and stable isotope ($^{34}S/^{32}S$, $^{13}C/^{12}C$ and $^{18}O/^{16}O$) analysis were performed. Analysis revealed intensively degraded concrete material that consists mainly of thaumasite and to a lower extent of quartz sand aggregates and secondary calcite. The former cement matrix and dolomite aggregates have been completely altered or dissolved. In cases where sulphate-resisting Portland cements (SRPC) were used, no effect on lowering the degree of damage was indentified. Analyzed interacting ground water is characterized by high (14-120 mM) SO_4^{2-} and Ca^{2+} contents. The solutions are mostly saturated with respect to gypsum and exhibit high HCO_3^- content and slightly alkaline pH values. The application of stable isotopes strongly suggests dissolved ions from the ground water to be the origin of the TSA. The DIC in the local SO_4^{2-} bearing ground water and thaumasite yield $\delta^{13}C_{VPDB}$ values in the same range. E.g. in case of the Tauern highway tunnel characteristic $\delta^{13}C_{VPDB}$ values range from -6 to -9 ‰İn contrast calcite sinters in the tunnel drainage system exhibit $\delta^{13}C_{VPDB}$ values down to -40 ‰ which indicates the absorption of atmospheric CO_2 with an additional impact of combustion from construction vehicles. At the Bosruck railroad tunnel the initially suspected sulphur source for the concrete damage was soot. Shotcrete was conveyed as a renovation measurement after a 50 year period of fossil fuel powered trains on the sooty tunnel wall. Nevertheless the damaged shotcrete at the boarder of the old tunnel wall is a result of ground water interaction. The sulphate minerals of the damaged horizons of the concrete, local ground waters and local evaporites comprise $\delta^{34}S_{VCDT}$ of 20 $\pm$ 5 ‰Ṡoot relicts as a potential source of sulphur can be ruled out as the respective analysed $\delta^{34}S_{VCDT}$ values are in the range of 4 ‰

References:

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