Influence of microbial activity on carbonate dominated mineral precipitates in tunnel drainage systems

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Carbonate scaling in motor- and railway tunnel drainages causes serious problems due to narrowed flow cross sections and clogging. Their removal generates high costs and traffic disturbances, arguing for an enhanced understanding of installation-specific chemical and mineralogical compositions, microstructures, and environmental controls on their formation and material characteristics. From a substantial set of case studies conducted in Austria, distinct types of scale materials can be distinguished ranging from unconsolidated soft and porous sediments to compact incrustations with distinct microstructure, mineralogy and variable porosity. In contrast to existing concepts, nearly all of the investigated scale types indicate a significant impact of microbial communities on scale deposition. Even in site-specific aqueous solutions, several types of bacteria could be detected. Documented chemoautotroph bacteria in these tunnel drainage solutions comprise of Gallionella sp., Leptothrix sp., Thiothrix, methylococcales, as well as rare photosynthetic algae. Metabolisms range from Fe (II) to Fe (III) oxidation, methanotrophy, sulfur oxidizing and sulphat reduzing to photosynthesis.

Thus, next to inorganically driven mineral precipitation of, e.g. calcite, aragonite, brucite, ferrihydrite and silica, distinct biomineralization products such as Fe/Mn–(hydr)oxides and (Mg-) calcite have to be considered. In the latter cases extracellular polymeric substances seem to play a vital role for the consolidation and stiffness of the resulting complex and spatiotemporally evolved scale deposits. An advanced process understanding of the individual evolution, composition, and character of scaling in drainage systems would allow for tailored monitoring procedures, countermeasures and cleaning strategies in order to tackle unwanted scaling in tunnels.