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A fundamentals mineralogical investigation of downhole cements within the context of underground hydrogen storage.

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Hydrogen is nowadays considered a promising way of storing energy from renewable energy sources. To store hydrogen in a feasible way, vast storage volumes are needed [1]. Underground Hydrogen Storage (UGHS) promises exactly that. However, to make UGHS a feasible process, fundamentals research investigating not just the integrity of reservoir and cap rocks, but also interaction of hydrogen with downhole materials (e.g., cement) used in boreholes is essential.

Boreholes provide access to geological reservoirs but are also the bottleneck of any production or storage operation. In general, boreholes are lined with downhole materials, consisting of a steel casing surrounded by cement. The cement acts as a bonding between the steel casing and the wallrock, providing mechanical stability and tightness for the hole. However, the effect that hydrogen might have on the mineralogical phase composition and subsequently on physical and mechanical parameters of downhole cement is still very scarcely known [1] [2]. This project, which is part of a PhD programme of Montanuniversität Leoben, Austria, on H_2 production and storage, aims to contribute to a better fundamental understanding of this issue.

The mineralogical phase composition of a cement class G, a standard type portland cement used in the petroleum industry, before and after hydrogen treatment was investigated and the influence was evaluated that potential reactions might have on the physical and mechanical properties.

The mineralogical methods applied were: XRD, FE-SEM, EPMA. Physical parameters such as porosity, pore size distribution and permeability were measured using Hg-porosimetry, N_2 sorption and nitrogen permeation, respectively. The mechanical properties were characterized by determining compressive and tensile strength.

Additionally, thermodynamic modelling using Gibbs Energy Minimization Software was carried out. The modelling indicates that ferric iron and sulphate bearing phases like brownmillerite, monosulfoaluminate and ettringite are altered, resulting in the formation of magnetite and iron sulphides.

[1] Reitenbach, Ganzer, Albrecht, & Hagemann (2015), Environmental Earth Sciences 73, 6927-6937.

[2] Zivar, Kumar & Foroozesh (2021), International Journal of Hydrogen Energy 46, 23436-23462.