Tackling challenges concerning the integrity of downhole cement/rock during underground gas storage: an interdisciplinary approach

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As we are getting closer to the mid 2020-decade current energy politics aim for an environmentally sustainable and secure energy supply resulting in the substitution of conventional fossil fuels by renewable energy sources. This is accelerated by the necessity of reducing greenhouse gas emissions to combat climate change and reaching the net zero goals by 2050 as implemented by the European Commission. To overcome weather and seasonal fluctuations in the energy production from e.g., wind or solar sources and thus address a significant challenge to the broad implementation of a sustainable energy transition, the promotion of large-scale and secure energy carrying gases is a necessity. One promising way of storing nowadays important gases (e.g., H_2, CH_4, CO_2) is underground gas storage (UGS). UGS is the concept of using natural geological bodies in the underground as potential storage sites. Potential applications of UGS are power to gas (PTG), large scale safe hydrogen storage (UHGS) or carbon capture and storage (CCS). Geological bodies suitable for UGS are aquifers, salt caverns and depleted oil and gas fields with the latter ones making up the majority. Other advantages of depleted fields are that already existing infrastructure, e.g., boreholes and surface handling facilities, can be widely used, therefore preventing high initial investment costs. Moreover, the reservoirs are already fairly well understood. However, to make UGS a feasible process, fundamental research investigating not just the integrity of reservoir and cap rocks, but also downhole cements applied in boreholes during the storage life of the well are essential. This is particularly important once the injection scale is industrial, as there is a severe knowledge gap regarding the interaction of these fluids with the downhole cement, which is a significant element for the well integrity and therefore safety. This study is an interdisciplinary approach among geoscientists and drilling engineers at Montanuniversität Leoben trying to link potential gas induced changes in the mineralogical phase composition of reservoir rocks and downhole cements to changes in their physical and mechanical parameters. In various projects a collection of siliciclastic sedimentary rocks as well as downhole cements were investigated. Important investigated parameters were permeability and porosity as well as compressive and tensile strength. The mineralogical methods applied were XRD, EPMA, SEM and optical microscopy. Using mathematical models to correlate the density, p-wave velocity and compressive strength, ultrasonic measurements were conducted to provide insight regarding the potential damage to the samples. The rationale of the investigations is to compare non-treated samples (baseline) with those exposed to well-defined gas compositions for longer time spans. The experiments were done using hydrothermal autoclaves (100 bar, ambient temperature) and individual experimental runs lasted 3 to 4 weeks.