Goldschmidt2017 Abstract

Great Artesian Basin authigenic carbonates as natural analogues for mineralisation trapping

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Central to any attempt to engineer accelerated mineralisation for sequestration of CO_2 is an understanding of the conditions under which relatively rapid carbonate mineralisation has formed in the geological past. Zones of significant carbonate cementation have been identified in shallow clastic aquifers where CO_2 migrating vertically from deeper source rocks or leaky hydrocarbon traps mixed with local formation water. These carbonates formed close to the naturally-occurring point of shallow subsurface leakage that indicates mineralisation has been rapid relative to the movement of groundwater. Significant scaling of oil wells by calcite precipitation also demonstrates that even relatively low concentration solutions can provide sufficient cations for rapid carbonate precipitation under conditions of high fluid flux. Oxygen isotope and fluid inclusion data for Great Artesian Basin cement and vein carbonates indicate that deeper hotter fluids mixed with shallower and fresher fluids during or just prior to carbonate precipitation in a number of cases. The migrating deeply-sourced fluids were mainly highly evolved meteoric water though evolved basinal brines and/or fluids associated with Palaeozoic marine evaporite deposits were also implicated in the formation of some carbonates. Carbon isotope evidence for mixed carbon sources may indicate that calcite precipitation occurs in the more basic and dilute region of the mixing zone where the migrating CO_2 is associated with hydrocarbons. This is supported by isotopic analysis of Eromanga fluid inclusion gases, which shows that the CO_2 is derived from a combination of Permian overmature coals and inorganic sources. Fault-assisted fluid migration apparently played a major role in the carbonate authigenesis, and a subset of samples was associated with hydrocarbon migration. Simulations of CO_2 co-injection with groundwater or coal seam gas brine diluted in groundwater were performed to evaluate the potential for accelerated mineralisation trapping in reservoirs. The CO_2-sandstone-groundwater simulations produced an increase in dissolved CO_2 due to dissolution of minor calcite, with some precipitation of ankerite. Both of the CO_2-sandstone-brine models resulted in calcite precipitation.