Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17783

Strontium and carbonate isotopes to reveal the effect of low-permeability barriers on the evolution of formation waters

STÉPHANE POLTEAU[1], INGAR JOHANSEN[1] AND CRAIG SMALLEY[2]

[1]Institute for Energy Technology

[2]Imperial College London

Presenting Author: stephane.polteau@ife.no

Sedimentary basins contain complex internal heterogeneities (i.e., permeability barriers) that control the dynamics of fluid flow at various length- and time-scales. Understanding such fluid flow dynamics is critical for processes key to present and future human society, such as oil and gas production, production of potable water from freshwater aquifers, use of saline aquifers for long term CO2 storage, short term storage of hydrogen, or pressured water/gas for subsurface energy storage. It may be demonstrated that the same features that control fluid flow also have an effect on the composition of the formation waters that occur within the pores of the rocks. Particularly useful compositional tracers are Sr isotopes (87Sr/86Sr) in waters and carbonate cements, and C-O stable isotopes in carbonate cements. These tracers are prone to modification through water-rock interaction, leading to fluid compositional heterogeneities; these variations will gradually homogenize and equilibrate through advection and diffusion, but differences will persist when bodies of water are segregated by permeability barriers. Sr isotopes in formation waters frequently have values much different from the water the host sediments were deposited in, demonstrating the effects of water-rock interactions during diagenesis. Sr isotope composition of formation waters forms trends with depth that reflect mixing by relatively rapid advection over larger distances (>100m), or slower diffusional mixing over smaller length scales (up to several 10's of m). Sr isotope depth trends enable identification of a dynamic residual signal that would otherwise not be noticeable by other data that equilibrate faster. Low permeability barriers can be caused by extensive carbonate-cemented layers, and here the Sr and C-O isotopes measured on cement provide information on its origin. Laterally extensive layers only develop where the process that forms the cement is laterally extensive. When combined together, the isotope composition of formation waters and of the cement can be used to characterize different bodies of water and the boundaries that separate them, along with the mixing processes and timescales involved. In conclusion, the interpretation of these geochemical patterns provides valuable information about the flow patterns in a sedimentary basin and help predict fluid connectivity and migration between different units.