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Characterization of Fluid Connectivity in Sedimentary Sequences using Strontium Isotopes

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Sedimentary basins typically contain complex internal heterogeneities that can segregate fluids into a series of isolated compartments. The permeability of these heterogeneities is often dynamic and time dependent: they can form impermeable barriers that prevent porous flow in timescales of a few years, while allow mixing of fluids by advection and/or diffusion on geological timescales. In general, the isotope composition of formation waters forms trends reflecting mixing by advection or slow equilibration controlled by diffusion during isotope exchange. In nature, when two systems (rocks, minerals, water/rock mixtures) are in chemical equilibrium but have different isotope compositions, both systems exchange their atoms to tend towards isotopic homogeneity while being chemically heterogeneous. Hence, the trends in isotope data enable the identification of a dynamic residual signal that would otherwise not be noticeable by other data that equilibrate faster. For example, pressure differences between sedimentary units equilibrate rapidly within a few thousand years, while millions of years are necessary to homogenize the isotopic composition of formation waters across low-permeability boundaries. Interpretation of these geochemical patterns provides information about the flow properties of the system and help to predict fluid connectivity and migration between different units. As such, Strontium Residual Salt Analysis (SrRSA) can help pinpoint important flow barriers and identify fluid connectivity in sedimentary basins.