Flow in porous materials: a of tale X-rays, minimal surfaces and wettability

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I will provide an overview of the current revolution in our understanding of flow, transport and reaction processes in porous media, enabled by 3D imaging from the nanometer scale upwards, micro-fluidics, and improved numerical methods. This will be illustrated by examples from work at Imperial College London on multiphase flow in rocks with application to carbon dioxide storage and oil recovery. X-rays are used to image flow processes in rocks at a spatial resolution of down to 1 micron and a time resolution between 1 and 1,000 s. These experiments can be used to measure traditional multiphase flow properties – relative permeability and capillary pressure – while providing pore-scale insight into displacement processes. We show how an accurate characterization of wettability, or the local distribution of contact angle, enables us to understand flow and trapping, and explain the circumstances which are optimal for storage or recovery applications. The experiments also provide a wealth of data to calibrate and validate pore-to-core scale flow and transport models.

The chemical history of seawater: insights from marine carbonates

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The chemical composition and redox state of seawater is intimately linked to Earth's crustal evolution, climate history and changing biosphere, all of which have evolved considerably through Earth's history. Lawrence Hardie in his 1996 paper (Geology, 24, p. 279-283) observed that “the major ion chemistry of seawater has changed significantly back through geologic time. This point of agreement transcends the existing disagreements on the details of the changes and should provide us with an important stimulus to expand our efforts to unravel the apparently eventful chemical history of seawater”. Over the last several decades, there have been considerable advances in our understanding of this eventful chemical history of seawater, particularly in relation to major element composition, redox conditions and nutrient availability; all the way from the early Archean to today. Many of these advances have been insights from the sedimentology and geochemistry of carbonates. In this overview I will present a broad chemical history of seawater, with an emphasis on new and published data from marine carbonates. In particular, I will focus on the links between carbonate mineralogy and the major ion composition of seawater; ocean redox conditions and the Precambrian "dolomite problem" ; and how a low-oxygen Precambrian ocean-atmosphere may have significantly influenced the style and chemistry of Earth's early carbonate systems. In many aspects of this ocean history, it appears that the present may not always be the key to the past.