Identifying and quantifying long-term seawater circulation in coastal aquifers

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Seawater circulation in aquifers is an important process affecting the chemical composition of coastal water. The circulation mechanisms vary by their spatial and temporal scales, from short-term/small-scale circulation driven by tides and waves, through seasonal exchange driven by sea- or groundwater-level changes, up to long-term/large-scale circulation driven by density differences. Although short-term circulation has been shown to affect groundwater chemistry and potentially modify the composition of seawater for some elements, the long-term processes have the potential to affect elements that are controlled by long-term geochemical processes. Previous studies show that the amount of seawater circulating through the long-term processes may be relatively large, especially in a heterogeneous medium. However, field-based estimation of the long-term circulation is challenging due to the difficulty in isolating the long-term process. Preliminary results from Indian River Bay, Delaware and the Eastern Mediterranean (EM), show potential for identifying long-term circulation in the aquifer, based on the geochemistry of the groundwater. Our results from seepage meters in Indian River Bay show that some of the groundwater compositions lie on a conservative mixing line, while others show a typical behaviour of enrichment in Ca and Sr and depletion in K. Based on the geochemistry, the long-term circulation discharge is ~10% of the total saline water discharge. In addition, 234U/238U and 87Sr/86Sr isotopic ratios in circulated seawater within the EM coastal aquifer show gradual change with distance from the shore. 87Sr/86Sr decreases and 234U/238U increases compared to seawater ratios. The 234U/238U change occurs faster than the 87Sr/86Sr change, and therefore these isotopes can be used for identifying the relative timescale of water–rock interaction. Based on existing data of Ca, K and 87Sr/86Sr and their oceanic budgets, the long-term seawater circulation may be estimated to be between 4% and 20% of river discharge and thus has a significant role in ocean chemistry.