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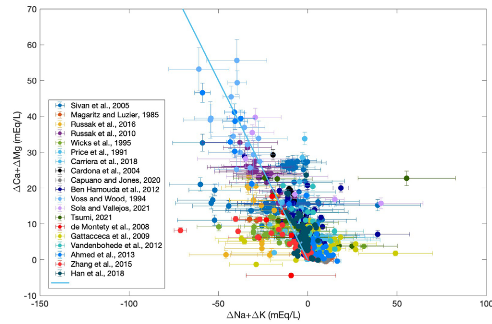
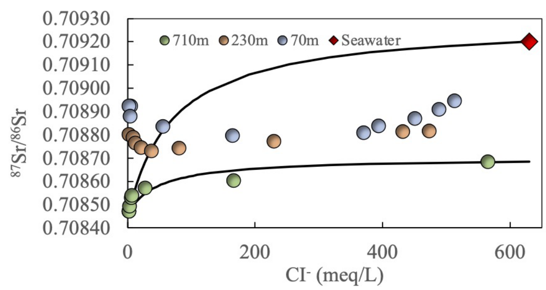


New advances in estimating the role of coastal aquifers in ocean chemistry

YAEL KIRO

Weizmann Institute of Science

Presenting Author: yael.kiro@weizmann.ac.il



Ocean chemistry is controlled by weathering, element transport from the land to the ocean, and the removal of elements by consumption, adsorption, and precipitation. While the role of rivers was established decades ago, other sources, such as mid-ocean ridge hydrothermal systems and submarine groundwater discharge (SGD), have been recognized more recently. Most SGD is comprised of circulating seawater in the coastal aquifer. The circulating seawater is driven by several mechanisms with different spatial and temporal scales, from short-term/small-scale circulation driven by tides and waves through seasonal exchange driven by the sea- or groundwater-level changes and 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, long-term processes have the potential to affect elements (e.g., Na, Ca, K, Mg, Sr) that are controlled by long-term geochemical processes. These are not affected by the short-term/small-scale processes, thus allowing differentiation and quantifying the long-term density-driven circulation only. Being able to differentiate the different circulating seawater components is a critical step toward quantifying major elements fluxes and other useful trace element and isotopes (e.g., Sr, U) from the coast into the ocean.

We show that Sr and U isotopes behavior is not conservative in coastal aquifers, and is strongly affected by the host rock and other sedimentary processes along the coastline. This are also affected by the water-rock interaction and groundwater flow time-scale (see figure).

Our study presents a new compilation of worldwide coastal aquifers' data, which allows for determining the major elements' end-member composition of coastal aquifer groundwaters (see figure). Based on these compositions and their uncertainties, we could quantify the SGD flux of the long-term component due to density-driven circulation. Based on the Ca^{2+}, K^{+}, Sr^{2+}, Mg^{2+}, Mg isotopes, and $^{87}Sr/^{86}Sr$ ocean budgets, the calculated long-term SGD flux is about 600 km^3/y. Although this flux is small compared to the global SGD water fluxes, it yields elemental fluxes of 8.0±3.5 Tmol Ca, -1.9±0.98 Tmol K, and 0.19±0.036 Tmol Sr per year, which are on the same order of magnitude as the fluxes through rivers.