Radium co-precipitation in evaporitic systems

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High concentrations of naturally occuring radium pose environmental and health concerns in natural and industrial systems. Compared to fresh water, adsorption of Ra^{2+} is limited in saline conditions while co-precipitation may become an effective process in decreasing Ra concentration. Despite its importance, co-precipitation was hardly studied in high ionic strength environments such as evaporitic systems.

The fate of Ra in the concentrate of a desalinization plant was studied by evaporation batch experiments at ionic strength ranges (I) of 0.7-7.8 m. Precipitation sequences revealed that Ra co-precipitates in barite with an apparent partition coefficient of $K'_D=(Ra/Ba)_{solid}/([Ra]/[Ba])_{solution}= 0.8\pm0.2$. Although co-precipitation of Ra in barite is a well documented phenomenon, this value of K'_D is significantly lower than the accepted value for relatively diluted solutions (1.8±0.1 [1]). We examined the effects of both kinetic and ionic strength on Ra co-precipitation and K'_D value.

Ra activity coefficients were calculated with the Pitzer formalism using PHREEQC geochemical software. Pitzer parameters for Ra^{2+}-Cl^- interaction where evaluated primarily through linear regression of published parameters for Ca, Mg, Sr and Ba to their 8-fold hydrated ionic radii.The $RaSO_{4,aq}$ ion pair was explicity recognized as suggested by Paige *et al.* [2]. Using these parameters we were able to describe the results with a numerical model. Distribution of Ra and Ba between the solid and aqueous phases was determined by their activity ratio in the solution. The partition coefficient that best fit the results, $K''_D=(Ra/Ba)_{surface}/(a_{Ra+2}/a_{Ba+2})_{solution}= 1.7$, is in good agreement with the accepted value (1.8), suggesting that the reaction is near equilibrium and kinetic effects are insignificant.

It is often assumed that activity coefficient ratios of similar alkaline earth elements is close to unity and therefore may be neglected when deriving K''_D. Our calculations show that above I=1m the ratio $\gamma_{Ra+2}/\gamma_{Ba+2}$ decreases significantly, therefore reducing Ra removal. Understanding such effects is crucial for risk assessment in systems where both high Ra concentrations and high ionic strength conditions are met.

[1] Doerner & Hoskins (1925) *J. Am. Chem. Soc.* **47,** 662-675.
[2] Paige *et al.* (1998) *Geochim. Cosmo. Acta.* **62,** 15-23.

Can aerosol-induced slowing of rain formation weaken hurricanes?

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It has been recently recognized that aerosols, by slowing the conversion of cloud water into precipitation, can invigorate deep tropical convective clouds. Simulations of the impact of the same aerosol-induced microphysical changes to tropical cyclones suggest the weakening of the storm intensities. We hypothesize that the fundamental cause for these opposite effects is their organization. In unorganized or linear storms such as squall lines, the low level exhauset cool air is left behind. In contrast, the surface convergence in closed circulating tropical storms forces this cool air to be eventually lifted on expense of the kinetic energy of the storm.

More specifically, the small CCN make a larger number of smaller cloud drops, which then are slower to coalesce into rain drops. The unprecipitated cloud water can either evaporate or ascend to the heights above the freezing level. The cloud water that evaporates cools the low level air. The cloud water that is carried to the cold regions freeze onto ice precipitation, and release there the latent heat of freezing. This invigoration at the periphery decreases the convergence of mass and moisture to the center, because some fraction ascends at larger radii, and so weakens the winds around the center. In addition, the ice precipitation melts at the low levels and cools the air there further.

The added evaporation and melting cool the low level air, which converge towards the center of the storm. Some of the kinetic energy of the storm has to be invested in lifting the cooler and heavier air when it reaches towards the eye wall. This takes away from the wind speed of the storm, and reduces its intensity.

A major challenge in this hypothesis is the extent to which ultrafine aerosols can slow the conversion of cloud drops into precipitation in the presence of sea spray giant CCN. This question is addressed initially by observations of polluted convective clouds over ocean. The recent eruptions of Kilauea volcano in Hawaii emitted plumes of SO_2 and fine aerosols that were ingested in convective clouds downwind. Analyses of the clouds with combined satellite and radar observations of cloud microstructure and precipitation are exploited to look into this question. Initial results show that precipitation is suppressed, but to a lesser extent than previously reported due to air pollution and smoke over land areas.