Apparent dielectric constants of brines at high P-T conditions: A preliminary report

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Common geofluids may be mixed solvents of water and salt(s) with occasional gas species. A difference in chemical potentials of a jth solute ($D\mu^{o}_{j}$) in water and in the mixed solvent may be expressed as:
$D\mu^{o}_{j} = \omega_{j}\,(1/\varepsilon_{m} - 1/\varepsilon_{w})$,
where, ω_j is the Born coefficient of the solute and ε_m and ε_w are the dielectric constants of the solvent and water, respectively. Therefore, the constant is a key parameter characterizing chemical properties of the solvent. In other wards, we may obtain state quantities of solutes in any mixed solvent from those in water such as derived by SUPCRT92 when the constant of the solvent is known.
Numerous experiments of quartz solubility measurements at high P-T conditions have revealed that salting-in and -out effects occur in H_2O-NaCl solutions. The effects could be explained by the above difference in the chemical potentials of dissolved Si, mainly as $SiO_{2(aq)}$, in water and in the solution. In the most experiments at P = 50 - 200 MPa, T = 200 - 550°C with NaCl molalities as 0.5 - 1.6, quartz solubilities are higher than those in water, that is, the salting-in occurs in the conditions.
A simple formula to estimate apparent dielectric constants of 1 molal NaCl solutions at P = 50 - 200 MPa and T = 25 - 550°C has been obtained from the above quartz solubility data with an empirical equation for the dielectric constants of the solution at low temperatures (< 50°C). A ratio of the constants of the solution to water, $\varepsilon_b / \varepsilon_w$, at any P-T condition in the above range can be written simply by a Gaussian function as:
$\varepsilon_b / \varepsilon_w = a / (2\ \mathrm{pi}\ b)^{0.5} \exp(-(T - c)^2 / (2 b)) + d$,
where, pi and T are the ratio of the circumference of a circle to its diameter and a temperature in Kelvin, and a, b, c and d are constants as 300, 13000, 573 and 0.8, respectively. The equation implies that the salting-in effect is highest at around 300°C and vanishes at around 100 and 500°C.
Preliminary calculations of quartz precipitation from quartz saturated water and from the 1 molal NaCl solution with decreasing temperatures from 500 to 200°C at 100 MPa show that the amount of precipitation from water during a step of 25°C-decreasing temperature is largest at around 400°C (425 - 400°C), but is only 30% larger than that at 475°C, while it from the latter solution is largest at around 350 °C, and is 9 times larger than at 475°C. The results suggest that brine-rock interactions with decreasing temperatures may be enhanced extremely at around 350°C.

Keywords: dielectric constant, brine, water-rock interaction

