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The effect of water structure and solute hydration on the kinetics of mineral growth and dissolution (Arne Richter Award for Outstanding Young Scientists)

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Classical crystal growth theory relates growth and dissolution rates to the degree of supersaturation. However, the solution composition may also affect the growth rate of carbonate minerals, via the Ca2+ to $CO_3$2- concentration ratio (e.g. Perdikouri et al., 2009; Stack and Grantham, 2010), ionic strength (e.g. Ruiz-Agudo et al. 2010) or the presence of organic matter (Hoch et al., 2000). For this reason, the influence of these parameters on the kinetics of mineral growth and dissolution has generated a considerable amount of research in the last decade. In particular, effects of both inorganic and organic impurities on mineral growth and dissolution have been frequently reported in the literature. Commonly, water in contact with rock forming minerals, contains significant and variable amounts of ions in solution. The effect of such ions on dissolution and growth rates has been traditionally ascribed to changes in solubility. However, experimental studies performed on different minerals have shown that the dependence of growth or dissolution rates on ionic strength is complex, and that the effect of ionic strength is not independent of the ionic species producing it. Here, we report investigations aimed at addressing the basic hypothesis that mineral growth and dissolution is governed by complex interactions between solvent structure, surface hydration and the ion solvation environment induced by the presence of electrolytes. It is proposed that any factor affecting ion solvation should alter growth and dissolution rates. These results have opened the possibility of a new understanding of very diverse phenomena in geochemistry and demonstrate the need for the inclusion of this “hydration effect” in the development of predictive models that describe crystal growth and dissolution in complex systems, such as those found in nature. Furthermore, we can hypothesise that ion-assisted dehydration of trace and minor element ions could occur in biological systems, thus affecting their incorporation and isotopic fractionation, providing interesting insights into the possible origin of anomalies found in systems used as environmental proxies and the so-called “vital effects”.

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