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Experimental investigation of Mg-silicate mineral formation at ambient temperatures

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The formation of Mg-silicates and modulated Mg-phyllosilicates at Earth‘s surface conditions has aroused great attention in the geoscientific community during the last five decades. Minerals in the sepiolite-palygorskite series, (Mg8-y-zR3+y□z)[Si12-xR3+x$O_3$0](OH)4(OH2)4•R2+(x-y+2z)/2(H_2O)8-(Mg5-y-zR3+y□z)[Si8-xR3+x$O_2$0](OH)2(OH2)4•R2+(x-y+2x)/2(H_2O)4, are commonly precipitating from oversaturated surface waters and thus these silicate minerals have been widely used for the reconstruction of sedimentary facies in modern and ancient lacustrine and peri-marine settings, and more rarely in diagenetic environments. Although the environmental conditions leading to sepiolite formation are generally understood, significant gaps in knowledge still persists regarding (i) the underlying mineral forming processes (i.e. dissolution/re-precipitation), which are linked to the co-precipitation of Mg2+ and silica, and (ii) the subsequent growth rates of the hydrous Mg-silicate crystals. In order to gain a better understanding of the above processes, sepiolite was experimentally precipitated in 1 L incubation reactors at 25±5°C, using initial experimental solutions (silica-doped seawater and synthetic MgCl2-brines), which are undersaturated in respect to amorphous silica and brucite/Mg(OH)2, at molar Si/Mg ratios of 1:27.5, 1:55, and 1:110. Changes in solution chemistry and solid-phase composition were monitored over a three months period using UV-vis spectroscopy, ICP-OES analysis, XRD, FT-IR, and TEM techniques.

Our experimental results indicate that modulated Mg-rich phyllosilicates are the only precipitate in our experiments: the crystals are fibrous (10-50 up to 100 nm in length), poorly crystalline, and show well-resolved IR bands that are diagnostic for sepiolite. The apparent growth rate of sepiolite precipitated from seawater and the synthetic solution were calculated to be 6.0±5.2•10-9 and 2.3±1.9•10-8 up to 1.1±4.0•10-4 mmol sepiolite per days of reaction time, respectively, mainly depending on the degree of supersaturation in respect to sepiolite. Sepiolite precipitation from silica-doped seawater is kinetically inhibited, most probably because of the formation of MgSO40 aquo-complexes in seawater, as indicated by hydrogeochemical modelling. This might explain why sepiolite-palygorskite group minerals are relatively rare in many marine sediments. In order to shed a light on the reaction paths and environmental controls of sepiolite formation in modern and ancient (diagenetic) environments, we plan to investigate Mg and Si stable isotope fractionation during precipitation of sepiolite-type minerals.