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Exploring the formation and alteration of dolomites using a multi-isotope approach (Ca, Mg, C, and O)

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Dolomite is a rock-forming mineral that consists of calcium, magnesium, and carbonate ions and as a mineral or rock, commonly referred to as dolostone, occurs naturally in a wide variety of depositional and diagenetic settings. Owing to its predominance in the geological record, the chemical and isotopic composition of dolomites have been extensively studied. Work presented here deals with the combined Ca, Mg, C, and O isotopic signatures as well as the degree of order of dolomites belonging to three different depositional/early diagenetic settings: (i) marine evaporative dolomite (sabkha), (ii) marine altered dolomite and (iii) non-marine evaporative dolomite (lacustrine/palustrine). Significant relations between the four isotope systems and the degree of order for the different dolomite types exist. Primary sabkha dolomites have the lowest degree of order, the highest carbon isotope ratios and the lowest calcium isotope values. With increasing degree of order, dolomites are recrystallized and C and Ca isotope ratios tend towards higher values, closer to that of seawater. Thus, it can be reasonably assumed that recrystallized dolomites formed under near-equilibrium conditions. Marine altered dolomites clearly show meteoric overprint indicated by 18O depleted oxygen isotope values. The corresponding Mg and Ca isotope ratios display a trend towards higher and lower isotope values, respectively, with increasing alteration. Concluding, both Mg and Ca isotope values of marine altered dolomites approach meteoric isotopic composition. Non-marine evaporative dolomites display correlations between the degree of order, C, Ca, and Mg isotope values. This behavior might trace the influence of marine fluid, which leads to recrystallization of metastable precursor dolomite phases similar to what is observed for sabkha dolomites. In general, the combination of the above isotope proxies, and in particular the formerly less explored Ca isotopic composition of dolomites, is a promising (albeit complex) tool to gain further information on the formation conditions and alteration processes of dolomite and dolostone.