Geophysical Research Abstracts
Vol. 19, EGU2017-2996-1, 2017
EGU General Assembly 2017

New insights to the formation of modern dolomite in a terrestrial low-temperature environment

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Although dolomite [$CaMg(CO_3)_2$] is a rock-forming mineral in ancient carbonate platforms, its occurrence in modern-marine carbonate-depositing settings and in particular in terrestrial, low-temperature environments is scarce – an enigma that is referred to as the "dolomite problem". At present, it is generally accepted that microbial activity, bacterially-mediated sulfate reduction, high aqueous Mg/Ca ratios and anoxic conditions favour the nucleation and crystal growth of dolomite; albeit the precise reaction paths causing the formation of dolomite at low temperatures remain questionable. Here, we present a novel study about the environmental controls and reaction mechanisms leading to the formation of authigenic Mg-Ca carbonates in (active) fault zones of the Erzberg (Styria, Austria) – Europe's largest iron ore opencast mine. Our petrographic and mineralogical results revealed the presence of ~2-20 cm thick laminated successions of embedded needle-shaped, radiating aragonite and blocky low-Mg calcite (a repetitive sequence also-called "erzbergite") and subsequently deposited (Ca-rich) non-stoichiometric dolomite, which is clogging former voids and unconsolidated sediment in the heavily deteriorated fault zone. First U-Th age determinations of the respective aragonite layers indicate its formation at ~19,000-13,000 years BP, also suggesting a "young" age of the sedimentary dolomite. Based on the combination of X-ray diffraction and electron microprobe analyses we identified two types of matrix-replacing dolomite: type 1 dolomite is nearly stoichiometric (~51 mol% $CaCO_3$) and shows a high degree of cation ordering (0.4-0.6), whereas type 2 dolomite is characterized by Ca-excess (~55 mol% $CaCO_3$) and a low degree of ordering (<0.3). Both types of dolomite grow on the extent of matrix minerals, such as detrital low-Mg calcite, ankerite, siderite, quartz, goethite, chlorite and illitic clay minerals, implying a low-temperature origin of the Ca-excess dolomite and its formation through replacement of $CaCO_3$ precursor phases at high aqueous Mg/Ca ratios of the mineralizing (meteroric) fluids. Further analysis of the $\delta^{18}O$, $\delta^{13}C$, $\delta^{26}Mg$ and clumped isotopic (Δ^{47}) signatures of the authigenic Ca-Mg carbonates will give new insights to the physicochemical conditions and reaction paths causing dolomitization in such an exotic, terrestrial environment.