

## Insights into the REE Characteristics and Formation Conditions of Southeastern Mediterranean Seep Carbonates

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Authigenic seep carbonates, which are found globally at continental margins, are unique archives to characterise the paleo-seepage activity of hydrocarbon-enriched fluids into the oceans. This study aims to identify past seepage activity and gas migration pathways on the south-eastern margin of the Mediterranean, based on the analysis of authigenic seep carbonates collected during the 2016 EUROFLEETS 2 SEMSEEP expedition aboard the RV AEGEO and the 2011 Nautilus expedition. Seep carbonates with three different morphologies (chimneys, crusts and pavements), are studied using standard sediment petrography (fluorescence, CL, standard optical microscopy), X-ray diffraction, LA-ICP-MS, Raman spectroscopy, and  $\delta^{13}\text{C}_{\text{VPDB}}$ . Recurrent cement and replacement phases identified contain aragonite, low-magnesium calcite (LMC), high-magnesium calcite (HMC) and dolomite. Carbonate chimneys consist of micrite ( $\delta^{13}\text{C}_{\text{VPDB}}$  of -10 to +5 ‰) with dispersed barite and dolomite crystals and fan-shaped aragonite ( $\delta^{13}\text{C}_{\text{VPDB}}$  of -52 to -30 ‰). Botryoidal LMC cements are present in small cavities. Carbonate crusts consist mainly of micrite, LMC breccias, HMC nodules ( $\delta^{13}\text{C}_{\text{VPDB}}$  of -35 to -20 ‰) and cements, and several stages of fan-shaped aragonite cement. Carbonate pavements consist mainly of micritic dolomite and HMC, but LMC microsparite can also be identified. Fan-shaped aragonite is locally present as pore-lining cement. Fe-oxides are coating the low- and high-Mg calcitic and dolomitic phases. Raman spectroscopic analysis indicate that organic compounds are associated with the aragonite and dolomite. LA-ICP-MS analyses confirm different REE+Y patterns in the different phases, at  $\mu\text{g/g}$  concentrations but varying by orders of magnitudes.

Sediment petrography, XRD and stable isotope analysis support several phases of methane seepage through time. Distinct mineralogies (dolomite and aragonite) within the seep carbonate morphologies, result from different formation mechanisms (anaerobic oxidation of methane during aragonite formation and predominately sulphate reduction during dolomite formation). LA-ICP-MS analysis, combined with Raman spectroscopy also support that the carbonates formed from different fluids and