

Massive formation of lawsonite in subducted sediments from the Schistes Lustrés (W. Alps): implications for mass transfer and decarbonation in cold subduction zones

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This study investigates the reactions allowing crystallization of large amounts of lawsonite ($\text{CaAl}_2\text{Si}_2\text{O}_7(\text{OH})_2 \cdot [\text{H}_2\text{O}]$) found in calcschists metamorphosed in a subduction zone setting. Previous studies of lawsonite-forming reactions in metasediments have highlighted its importance for the large-scale budget of CO_2 , as the calcium required to form lawsonite is thought to originate from decarbonation reactions. Yet, thermodynamic modelling as well as isotopic measurements have indicated that 80 to 90% of the carbon is retained in sediments, and there is no evidence of major decarbonation in the field. As lawsonite contains abundant H_2O and has a large stability field, understanding its crystallization is also important to assess fluid migration and mass transfer in a critical part of the subduction system where slow earthquakes are nucleating (such as LFEs or ETS). The upper units of the blueschist facies metasediments of the Schistes Lustrés complex (Western Alps), buried to depths of ~30-40 km, have been selected as an ideal case study as they host up to 40 vol.% of lawsonite. Lawsonite is found crystallized over several generations, in veins, in reactions fronts as well as in the rock matrix. Three types of lawsonite were identified. The most abundant type of lawsonite is associated with quartz and ankerite. This mineral assemblage formed from phyllosilicates and calcite in a continuous reaction: chlorite + calcite + kaolinite = lawsonite + ankerite + quartz + H_2O . According to thermodynamic modelling, this reaction is restricted to a narrow pressure-temperature domain and initiates around 180°C and 0.4 GPa. Lawsonite is also observed and predicted to grow from Fe-Mg-carpholite at higher metamorphic conditions. None of these reactions allow efficient net export of carbon, as one carbonate replaces another, and most observations are consistent with closed-system behaviour at outcrop-scale, in agreement with geochemical studies. At sample-scale and below, crystallization of lawsonite is linked to homogenization of carbonate and pelitic domains in geologically fast reactions. Dissolution of calcite produces reactive fluids prone to react with pelitic domains and crystallize lawsonite and another carbonate. Although metamorphic veins are ubiquitous to the upper units of the Schistes Lustrés Complex, most of them result from local reactions and do not indicate large-scale mass transfer.

Mots-Clés : lawsonite, metasediments, fluid/mass transfer, decarbonation, Schistes Lustrés, seismogenic depths