

Ti-mineral stability in metagabbros formed at different stages of the Wilson cycle

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Rutile, titanite and ilmenite are the most common Ti-bearing minerals found in metamorphic rocks at variable grades. Titanite is more stable at low-grade metamorphic conditions, rutile at HP (> 12 kbar), while ilmenite at HT-LP metamorphic conditions. Although, these Ti-phases have been the focus of growing interest, Ti-phase stability is poorly constrained at typical subduction conditions (HP-LT) as experimental and detailed petrological studies on natural samples are incomplete. Generally, rutile is considered as the only stable HP Ti-phase. However, recent work by Angiboust and Harlov (2017) on granitoids compositions suggested that whole rock composition (e.g. CaO content) could markedly increase the stability of titanite at higher pressure at the expense of rutile. Moreover, several studies on natural occurrences of pods of oceanic crust at eclogite facies conditions report the stability of titanite and the absence of rutile at pressure up to 20 Kbar for a temperature of 390°C (Ravna et al. 2010; Vitale Brovarone et al. 2011).

In this study, we have investigated the natural occurrence of Ti-bearing minerals in gabbroic rocks that record different stages of metamorphism during a Wilson cycle. These comprise metagabbros from the IODP, from an obducted ophiolite (Chenaillet) and alpine HP units that include blueschist (Schistes Lustrés) and eclogite (Monviso) rocks from the western Alps. We have performed detailed petrography, using SEM, and analysed major and trace elements mineral chemistry using EPMA and LA-HR-ICPMS.

In the IODP and Chenaillet metagabbros, a clear transition from brown to green amphibole is observed, replacing former clinopyroxene. Ilmenite is invariably unstable and systematically overgrown by titanite, found at the boundary between brown and green amphiboles, indicating it stabilised at lower temperatures. Rutile is also found in these ilmenite-titanite domains, either as coarser grains inside ilmenite, or as preferentially oriented, finer grains within titanite overgrowths. This rutile occurrence is interpreted as inherited from HT-LP metamorphism conditions occurring during the emplacement of gabbros in the ocean floor. Interestingly, these HT textures can be tracked to rocks that have undergone LT-HP metamorphism, such as in the Schistes Lustrés rocks. In these, titanite is clearly stable with the blueschist assemblage, but small remnants of rutile are often observable within titanite. Trace element compositions from these rutile grains are similar with those from the ocean-floor (Sc), and thus are remnants from ocean floor processes. As the slab is buried to increased depths, titanite breaks down to form new rutile at eclogite facies conditions, with distinct trace element compositions.

Finally, in this study, we reveal that trace element compositions of titanite and rutile at different P-T show some chemical systematics that are P-T sensitive.