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High-pressure migmatites as source of fluids during subduction and crustal thickening: the case of the Ulten Zone

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In subduction and continent collision zones, submersed continental crust will dehydrate and eventually melt at peak pressure-temperature (PT) conditions or during subsequent exhumation, thus forming migmatitic units like those exposed in denuded orogens. If we consider a sialic continental crust containing hydrous phases (micas ± amphibole ± epidote), the melt fraction generated at pressure generally below 4 GPa will be a hydrous granitic magma. Experimental petrology [1] and geochemistry [2] indicate that high-pressure and relatively cool granitic magmas could incorporate as much as 10 or more wt% H2O, depending on PT path, partial melting degree and initial hydrous fluid content (as intergranular free fluid and H2O stored in hydrous minerals) of the source rock. As a consequence, high-pressure migmatites produced during the submersion of continental crust in a subduction or continental collision zone may act as a sink of hydrous fluids as long as the crust is partially molten. Upon cooling and decompression towards subsolidus conditions, the fluid stored in the migmatitic leucosome will be released. These fluids have the potential to remove incompatible elements (e.g., large ion lithophile elements; light rare earth elements) from the crustal reservoir and, eventually in subduction zones, enhance the crystallization of hydrous and carbonated metasomatic phases such as amphibole, phlogopite and carbonates into the adjacent mantle [3]. However, what we direct observe and measure in high-pressure migmatites occurring in orogenic belts is the fluid linked to the actual hydrated phases, the amount and composition of which might have changed due to subsolidus evolution and late fluid influx, unrelated with the precedent geodynamic evolution.

In order to estimate the fluid contribution of a crustal unit involved in an orogenic collisional setting, we have modelled the fluid content of the Ulten Zone crust, which records high PT metamorphism accompanied by white mica decomposition melting during the Variscan continental collision. The modelling is based on the construction of PT path-H2O phase diagrams using a free-energy minimization computation method [4]. In these calculations, we consider a prograde metamorphic evolution from 500 °C and 0.9 GPa to 1000°C and 1.4 GPa [5]. Hydrous fluid was treated as pure water. The results show that the migmatitic Ulten crust could store between 2.5 and 4.5 wt% H2O at the derived peak conditions of 1.2-1.3 GPa and 750±30 °C. These water contents are in excess of the amount of water that can be stored in up to 27 vol% of white mica from the most fertile rock of the Ulten Zone, suggesting that grain boundaries and/or externally-derived water is needed to account for the crustal fluid budget. During cooling and tectonic uplift, the migmatite reservoir should have released the stored H2O in a narrow PT window. However, only an aliquot of the water of hydrous granitic magmas will be available as metasomatic fluids; the rest of water is assumed to be consumed by retrograde reactions producing hydrated phases.

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