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Geodynamic significance of the Variscan eclogites in the External Crystalline Massifs (Western Alps): marker of a subduction or crustal thickening?

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The Paleozoic basement exposed in the External Crystalline Massifs of the Western Alps (ECM) contains numerous relics of Variscan eclogites and high pressure granulites preserved in high grade migmatitic gneisses. These relics are taken to indicate that the ECM underwent an early HP metamorphic stage during the Variscan Orogeny. However, due to the scarcity of recent thermobarometric and geochronological data, the geodynamic significance of this high pressure metamorphism remains unclear. Based on petrological similarities with other eclogite-bearing formations in the European Variscides (especially the “leptyno-amphibolic compex” in the French Variscides), it has been suggested that the high pressure rocks from the ECM mark a mid-Devonian subduction cycle, preceding the main Carboniferous Variscan collisional stage (Fréville et al., 2018; Guillot and Ménot, 2009). This interpretation mostly relies on one mid-Devonian U-Pb zircon age (395±2 Ma) obtained in eclogites from the massif of Belledonne (Paquette et al., 1989), which has been interpreted as the age of eclogitization. However, dating of high pressure granulites in the Argentera Massif (Rubatto et al., 2010) yielded a Carboniferous age (ca. 340 Ma) for the high pressure stage, questioning the previous geodynamical interpretation. We present here the results of a detailed petrological and geochronological investigation of the high grade formation of the Lacs de la Tempête in NE Belledonne, where some of the eclogites dated by Paquette et al. (1989) were sampled. This area exposes mostly high-grade migmatitic metasediments with intercalated lenses of orthogneiss and garnet-bearing amphibolites, preserving locally eclogitic assemblages. Thermobarometric estimations coupling forward pseudosection modelling, Zr in rutile thermometry and garnet growth modelling constrain the minimal P conditions during the high pressure stage at ca. 1.4-1.6 GPa and 700 °C. The early HP assemblage was then strongly overprinted by granulite facies metamorphism at ca. 1.0-1.2 GPa and 750 °C, also recorded in the surrounding metasediments. U-Pb dating of zircon reveals that the eclogites derived from Ordovician protoliths. Zircon overgrowth in the eclogites and the surrounding metasediments constrain the age of HP metamorphism between ca. 350-305 Ma, with no evidence for a Devonian event. Rutile dating in the eclogites supports the late

Carboniferous age of metamorphism. The middle-late Carboniferous corresponds to the main period of Variscan nappe stacking in the ECM, following a period of arc magmatism during late Devonian-Tournaisian (ca. 360-350 Ma, Fréville et al., 2018). We therefore suggest that the 350-305 Ma ages recorded in the HP units of the ECM do not correspond to a Devonian subduction, but rather represent the equilibration of orogenic lower crust at HP-MT conditions during the Variscan nappe stacking events, followed by re-equilibration at lower P during late Carboniferous. This evolution presents striking similarities with the high pressure units of the Moldanubian zone in the Bohemian massif (Schulmann et al., 2009). However, deciphering the exact meaning of U-Pb ages in retrogressed eclogites remains a challenge, and further field and petrological investigation is required to produce a consistent history of the Variscan collision in the ECM.