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Origin and duration of late orogenic magmatism in the Pyrenean segment of the Variscan belt

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During late stages of the orogenic cycle, MP/MT to HP/LT metamorphism is often associated with intense magmatism. However, the nature and relative contribution of heat sources and the causal relationships between metamorphism and magmatism are still debated. A careful assessment of the chronology of i) the thermal evolution at crustal scale, ii) melt production and magma transfer, and iii) tectonic evolution in representative case studies is thus required.

The Pyrenean segment of the Variscan belt is affected by such a late high temperature event without evidence of prior significant crustal thickening due to its external position during the subduction and collision phases of the Variscan orogeny. The Pyrenees are thus a key area to discuss the origin of high geothermal gradients when radioactive decay related to crustal thickening is not a major process. The aim of this study is to discuss the relationship between metamorphism and magmatism based on a petrological and U-Pb geochronological study in the Chiroulet-Lesponne area in order to discuss the relative contribution of the mantle and crustal sources for the magmas as well as at heat sources responsible for high temperature metamorphism

The studied area is located in the western Axial Zone of the Pyrenees where the great diversity of metamorphic and magmatic rocks is well exposed within the Lesponne and Chiroulet metamorphic domes and the Neouvielle pluton. The Lesponne and Chiroulet magmatic rocks and the Neouvielle pluton were emplaced respectively in Cambrian to Devonian series and in Devonian to Carboniferous metasediments. The Chiroulet and Lesponne magmatic rocks are metaluminous to peraluminous granites intruded in metasedimentary rocks locally affected by partial melting and recording pressure and temperature in the range 3.5-6 kbar and 650-725 °C. The Neouvielle massif is a late-Carboniferous granodioritic pluton with a high-K calc-alkaline signature.

On the basis of geochemical and isotopic data, two magma sources have been recognized: i) a mantle source that produced metaluminous magmas best exemplified by the Lesponne diorite and a ii) metasedimentary source that produced peraluminous magmas like the Chiroulet and Lesponne granite and evidenced by the presence of migmatites.

Zircon U-Pb LA-ICPMS dating shows that magmatism took place over a period of about 10 My from ca. 303 to ca. 290 Ma. During the same period, below a depth of 8-10 km, the crust was mainly composed of partially molten metasediments intruded by mantle and crustal magmas. Thus, the late Variscan event lasted at least about 10-15 My until the beginning of the Permian time.

The abundance of high K calc-alkaline magmas associated with crustal partial melting and the presence of HT-LP metamorphism are in favor of a geodynamic context 1) without significant crustal thickening 2) during a late orogenic phase associated to a vertical thinning of the crust. Consequently, the late Variscan HT-LP must be explained by an enhanced heat flux from the mantle due either to a long lasting magma transfer from the mantle to the crust, and/or by hot asthenospheric mantle uplift.