Micas as archives of metamorphic reworking: a case study from the migmatite gneiss of the Valpelline Series (Dent-Blanche Tectonic System, Western Alps)

Piloni C.B.*[1], Caso F.[1-2], Filippi M.[1], Cruz-Uribe A.M.[3], Villa I.M.[2], Farina F.[1], Roda M.[1] & Zucali M.[1]

[1] Dipartimento di Scienze della Terra "A. Desio", Università di Milano. [2] Dipartimento di Scienze dell'Ambiente e della Terra, Università di Milano-Bicocca. [3] School of Earth and Climate Sciences, University of Maine, Orono, US.

Corresponding author email: chiara.piloni@unimi.it

Keywords: $^{39}Ar/^{40}Ar$ stepwise heating method, in situ Rb-Sr geochronology, microstructures.

Micas crystallize over a wide range of magmatic and metamorphic conditions. In crystalline basement rocks, they are the main minerals responsible for defining and supporting foliation. $^{39}Ar/^{40}Ar$ and Rb/Sr geochronological methods allow the dating of mica crystallization. Therefore, a combined approach integrating microstructural, mineral-chemical, and geochronological data of micas enables the reconstruction of metamorphic conditions and their effective correlation with tectonic evolution, more so than is typically possible using accessory phases. However, ages obtained from micas are often younger than expected based on regional constraints, and several processes have been invoked to account for this mismatch. Among them, some suggest prolonged "cooling histories", with direct implications for tectonic process rates and the thermal state of the crust.

We conducted an extensive U/Pb geochronological dataset on various accessory phases such as zircon, titanite, and monazite in migmatites and granulites from the Valpelline Series with these rocks being a portion of the Dent-Blanche Tectonic System in the Western Italian Alps that represents a fragment of pre-Alpine deep continental crust. The results clearly indicate that the high-temperature metamorphic event was restricted to the Early Permian. In contrast, ages obtained from individual biotite crystals, using $^{39}Ar/^{40}Ar$ stepwise heating and *in situ* Rb/Sr methods, range between 220 and 160 Ma, well matching with the rutile U/Pb ages. These results appear to support the widely accepted hypothesis—based on similar geochronological interpretations—of a prolonged Permo-Triassic event that characterized the Mesozoic evolution of the Adriatic plate.

However, a detailed compositional analysis of the dated mica grains reveals textural and mineral-chemical variations using EPMA X-ray mapping at various scales. These analyses reveal that the polygenetic micas consist of multiple generations, each chemically distinct. Furthermore, a clear correlation exists between the degree of mineral replacement and the apparent age rejuvenation, suggesting that the younger isotopic signatures reflect metamorphic replacement processes rather than protracted cooling. A critical discussion of this correlation requires a reconsideration of the significance of the obtained ages and the Permo-Triassic event in the Alps. Given the prevalence of zoned and composite micas, the approach presented here offers a valuable framework for reconstructing complex, polyphase metamorphic histories in other orogenic systems worldwide.