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Dating the polyphase evolution of the Western Alps

Igor M. Villa (1,2)

(1) Centro Universitario Datazioni e Archeometria, Università di Milano Bicocca, Italy (igor.villa@unimib.it), (2) Institut für Geologie, Universität Bern, Switzerland

A traverse through the Western Alps from the Zone Houillère to the Monte Rosa eclogites includes an oceanic basin (filled with Hercynian detrital muscovite) which was subducted during Alpine convergence and eclogitized; the eclogites were sheared in greenschist facies and exhumed to the surface. In the W the Zone Houillère sediments are weakly metamorphosed; further ESE, in the Ruitor Unit, higher strain rates and high pressure parageneses are observed; the Piemont-Ligurian (PL) Oceanic Unit consists of eclogites.
Lu-Hf and Sm-Nd dating of prograde (55±4 Ma) and retrograde (41±7 Ma) garnet (Villa et al, JPetrol 55 (2014) 803) constrains eclogitization to the Eocene. 39Ar-40Ar ages of white mica show a spatial regularity: Zone Houillère (T ≈ 300 °C) muscovite ages are 270-100 Ma, Ar loss reaching 80 %; eclogitic phengite ages (P¬L Unit, T ≈ 500 °C, and Monte Rosa, T ≥ 600 °C) are constant at 47 Ma, independently of peak T, and agree with garnet Lu-Hf ages; Ruitor white mica ages depend on total strain and especially on the degree of phengitic substitution in detrital muscovite.
The observation that Ar can be lost at T < 300 °C while at the same time it can be retained at T > 500-600 °C appears counterintuitive if one assumes that ages are a unique function of T. The Zone Houillère pattern is explained by sedimentology: during diagenesis, sediments are dehydrated, and large amounts of circulating water very efficiently promote recrystallization and Ar loss. In the Ruitor Unit, an different eastward age decrease is observed: mica rejuvenation correlates with phengite content, whereby HP phengite replaced detrital muscovite. These samples record a progressive increase of retrogression reactions that produce a heterochemical replacement mineral with associated Ar loss. The Cl/K ratio in white mica is an essential discriminator, as retrogression can be associated with more or less saline fluids.
In the Monte Rosa and P-L Oceanic Units, the constant 47 Ma ages are best explained as complete Ar retention. The Ar record of an unrecrystallized Monte Rosa white mica was partly preserved during eclogitization at T > 600 °C, while the neighboring mylonitized phengite was reset completely at 47 Ma. In none of the studied areas do micas record "cooling ages". Cretaceous apparent mica ages, which were proposed to date eclogitization by earlier studies based on conventional "thermochronology", are due to Ar inheritance in incompletely recrystallized detrital mica grains.
In summary, the "closure temperature" approach is unable to predict the three features that charac-terize the Western Alps traverse: Ar loss at T < 300 °C, contrasting Ar retention at T > 500 °C, and the tight correlation between age and phengitic substitution. A process-oriented petrological analysis demonstrates the predominance of retrogression reactions. Ar is lost mainly when deformation and/or fluids promote recrystallization. In the absence of major recrystallization, Ar retentivity by white mica is known to be very high (Di Vincenzo et al, CMP 141 (2001) 14 and JPetrol 45 (2004) 1013; Beltrando et al, GCA 119 (2013) 359).