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The geodynamic evolution of the Alps: what can we learn further from the metasediments

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Based on mineralogical works, Ernst (1971) was able to use the plate tectonic concept for proposing a first modern model for the evolution of the Alps. In the meantime, Frey (1969), as well as Trommsdorff (1966), started to investigate metamorphism in isochemical systems provided by shales and siliceous carbonates, respectively. This allowed for quantitatively constraining the Cenozoic temperature evolution in the Central Alps. Frey et al. (1999) compiled all available information on the peak temperature distribution, and used the occurrence of eclogites to display the dynamics of the Alpine evolution. The regional distribution of late Cretaceous-Tertiary metamorphic conditions, documented in post-Hercynian metasediments across the entire Alpine belt from Corsica-Tuscany in the West to Vienna in the East, will be presented.

Based on metamorphic studies in metasediments, we evidence substantial differences in the metamorphic, and hence the geodynamical evolution along strike the Alpine orogen.

The Western Alps did not reach the mature stage of a head-on colliding belt as is indicated by a continuous metamorphic evolution, representing all the subduction related processes ranging from lower greenschist to UHP conditions. All the metamorphic rocks behind the Pennine frontal thrust were already exhumed to upper crustal level during ongoing oceanic and continental subduction and before collision with the Dauphinois domain from around 32 Ma onwards. Hence, the Western Alps represent a frozen-in subduction zone. Since then only exhumation by erosional processes affected the inner parts of the orogen.

The rest of the Alpine orogen later underwent a more important collision process due to the ongoing head-on geometry of subduction and collision. It therefore often but not always shows a bimodal metamorphic evolution with two distinct P and T peaks. The intensity of the thermal overprint relates to the amount of crustal material incorporated to the orogenic wedge. Thermal overprint is primarily related to the amount of crust involved in the subduction and collision processes rather than to processes of shear or viscous heating. The latter mechanism, which suppose high deformation rate will not allow for the preservation of HP-LT assemblages within high-grade rocks.

The relation between the volume of continental crust imbricated and intensity of high-temperature orogenic metamorphism can be generalized over the entire alpine edifice, except for Tuscany where the late (< 8 Ma) thermal overprint is clearly related to lithospheric thinning.