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Material trajectories in the frontal part of an ancient subduction channel

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The Northern Apennines of Italy have been recently interpreted as an unique example of ancient erosive subduction margin (Vannucchi et al. 2008). In fact, in the Early Neogene, the Northern Apennine wedge was characterized by the removal and underthrusting of its toe, formed by both the accreted oceanic sediments and the overlying wedge-top basin fill (i.e., the Subligurian Units), implying a process of frontal tectonic erosion. Therefore, from the early Miocene to the middle Miocene, this orogenic wedge was characterized by material transferred from the upper plate to the lower plate. This situation is well described by the subduction channel model of Cloos and Shreve (1988).

To explore the flow of material along the subduction channel, we focused on three tectonic windows located on the Adriatic side of the Northern Apennines. The three tectonic windows show outcrops of mélanges made up of rocks correlated to the Subligurian Units. These mélanges occupy the same structural position, i.e., below the upper plate, Ligurian nappe, but in each tectonic window they present compositional and structural characters that imply some local diversity.

There we collected samples for new fission track analysis. All the samples analyzed from these mélanges, irrespective of their stratigraphic age and outcrop area, show a common thermal history with a heating stage up to values in between the 80°C and the 120°C. Supposing that this heating event occurred due to burial, and assuming for the Northern Apennines a geothermal gradient of 20°C/km, all the sampled rocks were buried at depths ranging from 3 to 4 km. The heating stage has then been followed by rapid exhumation and cooling under 80°C starting at around 25-20 Ma. The cooling is also recorded in the samples with Chattian (26-23 Ma) and perhaps even Aquitanian (23-21 Ma) stratigraphic age. These data imply that the heating and the following cooling stage occurred soon after the deposition of the mélange rocks. Therefore, after its underthrusting along the plate boundary, the material was quickly underplated and left out the subduction channel. The exhumation of the underplated material occurred at the front of the upper plate. In this case the frontal part of the overriding plate entered in a stage of widespread deformation.

The reconstructed thermal evolution of the underthrust mélanges allows to reconstruct the material pathway inside the convergent margin. The mélanges formed at the frontal part of the upper plate and they kept on evolving following the plate interface. Their progression ended when they were added to the upper plate. The latter was then internally deformed allowing the exhumation of the material. This exhumation occurred while a large amount of material (the Subligurian Units) was still subducting along the plate interface being exhumed only after the complete deactivation of the subduction channel (10-8 Ma).

The reconstructed trajectories followed by the studied mélanges within the Apennine convergent margin show a case where the subduction channel coexisted with a deforming upper plate.