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Inversion of the Tethyan passive margin in the external western Alps: Structural style, amount of shortening and microstructural constraints

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During Oligocene-Miocene times, the outer part of the European passive margin underwent collisional shortening. In its outermost part, collisional deformation gave birth to the Bornes, Bauges, Chartreuse and Vercors fold-thrust belts where shortening can be easily quantified through classical restoration techniques (i.e. considering constant length and area). The main thrusts root in a basal décollement within the sedimentary cover. This décollement is usually interpreted as being connected to a deeper (middle to lower crustal) décollement by the mean of large basement thrust ramps. At the rear, the innermore units, namely the External Crystalline Massifs (ECM), were underthrusted down to the brittle-ductile transition. In these units, both the structural style and the amount of shortening are still debated.
In this contribution, we show that shortening in the ECM has been localized within inherited Jurassic basins but without any significant décollement of the cover above the basement, similarly to what has been documented in the central Alps. The sedimentary cover is dysharmonic folded whereas the basement is locally sheared with no reactivation of the inherited normal faults bounding the pre-orogenic basins. These results have strong implications on the rheology of the crust, which was likely weak due to the combination of its Jurassic inherited structure and of Alpine P,T conditions (greenschist facies).
The amount of collisional shortening has been estimated with a new approach. We first reconstructed the pre-orogenic length of the margin according to the basement top length (as deduced from unfolded Triassic layers still attached to the basement). In contrast, the restoration of the Liassic layers was not performed considering a constant length, because this length likely strongly varied during shortening. Instead, the restoration was further made considering constant layer areas; this assumption is supported by geochemical studies on syn-shortening veins and cover host-rocks that indicate nearly constant volume deformation. The surface of sedimentary cover was divided into areas defined by both layer interfaces and fold axial planes. The validity of the restoration was checked using microstructural data and finite stain estimates. Both the length variations and the finite strain ellipsoids predicted by the restoration are consistent with those deduced from our microstructural analysis. Such an approach therefore provides to date the most reliable amounts of shortening for the whole external zone along the alpine arc, and is proposed as a valuable method to restore the ductilely deformed cover in the outer parts of orogens.