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No erosional control on the lateral growth of the Alps

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On the base of literature data, we estimated the paleowidth of the Central Alps and the changing location of the inferred active fronts of the orogen from the Oligocene to the present. These compilations indicate that the absolute change of width, defined as the distance between the most external, but not necessarily active thrusts of the orogen was modest, amounting to less than 15 %, from 32 Ma to the present. This value lies within the error of estimate, and hence it is no sound evidence for lateral growth or retreat of the orogen. On the other hand the width of the active orogen, defined as the distance between the most external active thrusts, did increase in the early Miocene. This increase started already in the Oligocene as also concluded on the base of sedimentological findings, suggesting a continuous growth of thrusts through the Oligocene-Early Miocene interval (e.g. Schumacher et al., 1996). In the Late Miocene the active width of the Southern Alps decreased, as documented by a pre-Messinian out-of-sequence phase of thrusting (Lecco thrust; Schönborn, 1992) younger than the Milan Belt (Schönborn 1992).

Increasing erosion rates are expected to reduce the width of the orogen, whereas decreasing rates are expected to increase its width (Beaumont et al., 1992). Therefore, following the example of previous investigations (Schlunegger et al., 2001; Schlunegger and Simpson, 2002; Willett et al., 2006) we compare the reconstructed changes of width of the Alps with the depositional budgets of the Alpine foreland basins (Kuhlemann, 2000) inferred to be a proxy for the erosion rates of the Alpine belt. This comparison shows that the most significant increases in erosion efficiency do not lead to a decrease in the active width of the orogen. This is indicated by the pronounced foreland-directed growth of the Alps after the Messinian, i.e., during the phase of greatest increase in the erosion rates of the orogen. The best regional examples are the northward shift of the deformation front of the Jura Mountains (Nivière and Winter, 2000; Giamboni et al., 2004; Madritsch et al., 2008), the westward shift of the Chaines Subalpines (Lickorisch and Ford, 1998) on the western side of the orogen, and the southward migration of the active front in the eastern sector of the Southern Alps (Benedetti et al., 2000). The reduced erosional efficiency of the orogen, which started at 17 Ma and continued until the Messinian (Kuhlemann, 2000) also did not coincide to a phase of lateral growth of the orogen. Out-of sequence thrusting in the Southern Alps (Schönborn, 1992) reduced the width of the chain well before the Messinian crisis, i.e. during the phase of fading erosion efficiency. Therefore, erosion does not seem to have been the prime control on the changes of width of the orogen.

Alternatively, the effect of erosion on the lateral growth of the orogen can be tested by comparing the timing and the type of shifts of the active deformation front from different parts of the orogen. If climate changes are inferred to control changes in the erosional efficiency of the Alps (Willett et al., 2006), the tectonic response to a given change of climate is expected to be coeval and of similar type in all parts of the chain. This is especially true for an orogen as small as the Alps, whose different portions are all affected by the same climatic conditions. However, the mode of exhumation of the Eastern Alps is very different than that of the Western and Central Alps. The exhumation front progressively shifted towards the foreland in the latter case, whereas it remained focused in the axial zone of the orogen in the former case (Rosenberg and Berger, 2009). As a consequence, a broad metamorphic belt, with cooling ages younging from the axial zone towards the foreland formed in the western Alps, and a narrow metamorphic belt with cooling ages younging towards the axial zone of the orogen formed in the Eastern Alps. These first-order differences indicate that processes other than erosion and climate change controlled the migration of the deformation and exhumation fronts of the Alps.

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