Tracing exhumation and orogenic wedge dynamics in the European Alps with detrital thermochronology: REPLY

REPLY: doi: 10.1130/G31644Y.1

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Bernet (2010) and Bernet et al. (2001, 2009) interpreted the European Alps as being in steady-state for the past ~30 m.y. In order for this to be true, rates of tectonics and erosion need to be kept constant or in balance with each other for over 30 m.y. Given the plethora of complex geological processes, as well as major changes in global climate that have occurred since the Oligocene, this seems unrealistic.

I, (Carrapa, 2009) observed that critical taper models (e.g., Davis et al., 1983) provide testable predictions about the kinematic and exhumation history of the Alps. In particular, I observed that the foreland record indicates a complex evolution of the orogen in time and space that generally follows such predictions.

Unfortunately, Bernet (2010) and previous papers only present zircon fission-track data from selected localities and do not discuss such data in a broader context, including other thermochronological data. I presented a more complete thermochronological data set from multiple isotopic systems on detrital material from the Alpine pro- and retro-foreland basins. It is true that different thermochronometers have different closure temperatures and may behave differently, especially during slow and complex thermal histories; however, if exhumation is fast, like during periods of intense tectonic activity, closure temperatures for different thermochronometers are closer together and thus differences between ages recorded by different thermochronometers can be small and irresolvable. Despite using the same approach as the one used by me, Bernet suggests using mean ages of the entire age spectrum from a sample, rather than the youngest ages or populations, to interpret different taper states. However, a mean age from a detrital sample would be meaningless because it would mix young cooling ages with older inherited ages.

Bernet points out that I omitted some data from Bernet et al. (2009). This was indeed an oversight; however, in Figure 1 of this Reply, the missing data have been added along with more data gathered from the Eastern Alps (Zattin et al., 2003). This revised figure, even more, shows the level of complexity apparent from my figure 3 (Carrapa, 2009) and highlights the overall nonlinear trends of the data.

The only data sets that seem to show a quasilinear trend are those from Bernet et al. (2001, 2009). However, Bernet et al. (2001) did not consider the possibility of a strong volcanic input from the Periodic magmatic complex in the Central Alps (Dunkl et al., 2001) in their samples from the Apennines. Bernet also claims that similar trends observed in my figures 3B and 3D are interpreted as representing conflicting taper states. However, a closer look at the data shows that neither of the trends highlighted by Bernet is a steady trend. The trend from 18 to 8 Ma (my figure 3A), albeit poorly defined, shows an up-section increase in lag time, whereas the trend from 12 to 0 Ma (Fig. 1) exhibits a clear up-section decrease in lag time.

Bernet finds the fact that different parts of the same orogen can behave differently at the same time. This is likely the result of different responses to changing gravitational body stresses within the orogenetic wedge, and plate stresses along strike (Central-Eastern Alps) and in the pro- versus retro-wedge.

My overall aim was to compile as broad a spectrum of data as possible to promote new thinking about ways to explain a complex data set, rather than continuing to rely on an over-simplistic and unrealistic mode of interpretation. The amount of thermochronological data available from the Alps provides a unique opportunity to move forward in understanding feedbacks between tectonics and erosion at a level of detail previously not possible.

REFERENCES CITED