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Reply to Comment by W. Kurz on "Tectonic map and overall architecture of the Alpine orogen"

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We very much welcome the comment by Kurz (2005), which raises some important questions and allows us to further clarify some concepts behind our correlations between Western and Eastern Alps (Schmid et al. 2004). As a matter of fact, the principal question raised by Kurz (2005), namely the possible continuation of the Northpenninic (=Valais) ophiolites and Bündnerschiefer, originally defined in the Western Alps (Trümpy 1955, 1960), towards the east and into the area of the Tauern window (see Fig. 1 and plate 1 in Schmid et al. 2004) does not concern "details" (Kurz 2005), but represents a first order problem in any attempt to propose possible correlations of tectonic units and paleogeographical domains along the Alpine chain between Nice and Vienna.

As correctly stated by Kurz (2005), the Glockner nappe (referred to as "Upper Schieferhülle Unit" by Schmid et al. 2004), comprises remnants of an oceanic basement in the sense of a partly incomplete ophiolitic sequence, of course besides the volumetrically dominating calcschists referred to as "Bündnerschiefer" or "schistes lustrés" in the Western Alps. Indeed calcschists and ophiolitic remnants are not diagnostic for the Lower Penninic nappes derived from the Valaisan paleogeographical domain, and it is true that they also occur in Upper Penninic ophiolitic units of the Western Alps, derived from the Piedmont-Liguria ocean (such as in the Zermatt-Saas ophiolites of Western Switzerland and the Avers Bündnerschiefer of Eastern Switzerland). However, we do not understand why the fact that the Matrei zone at the southern rim of the Tauern window is occasionally missing, the Glockner nappe often being in direct contact with the Austroalpine lid, "would favour a Southpenninic (= Piedmont-Liguria) origin of the Glockner nappe" (Kurz 2005). The Matrei zone, which of course also contains calcschists (besides metapelites), is actually defined by the presence of tectonic slivers (or olistoliths according to the interpretation of Frisch et al. 1987) of Austroalpine derivation (Kurz et al. 1998). This clearly makes the Matrei zone an analogue of the Upper Penninic Arosa zone of Eastern Switzerland (Manatschal et al. 2003), also characterized by material derived from the Austroalpine domain (as parts of a tectonic mélange according to Lüdin 1987).

In Eastern Switzerland, as well as in the Tauern Window, these Upper Penninic units are considered as an integral part of the Cretaceous-age top-WNW nappe edifice by all workers. However, we differ from many Alpine geologists in that we follow Froitzheim et al. (1994, 1996) and consider top-WNW thrusting during Cretaceous orogeny as being very distinct from top-N thrusting during Tertiary orogeny, the two orogenies being separated by a Late Cretaceous (syn-Gosau) extensional event. It is Tertiary orogeny that led to the nappe stacking of the Lower Penninic (e.g. Glockner nappe), and the Subpenninic units (e.g. the "Zentralgneise" nappes, see Kurz et al. 1998), which constitute the deeper and major part of the Tauern window. Hence, contrary to the "classical interpretation" of most Austrian geologists (e.g. Frisch et al. 1987, Kurz et al. 1998), that envisage collision between the Zentralgneise and the Austroalpine margin to have occurred during Cretaceous orogeny, we interpret the contact between Glockner nappe and Matrei zone to mark a tectonic contact between two nappe edifices that formed during two distinct orogenies (Cretaceous vs. Tertiary). Thereby we are led by the strong analogies between the architecture of the Engadine window, which demonstrably was not closed before Tertiary times (Froitzheim et al. 1994), and the Tauern window. This strong analogy is additionally supported by the results of along-strike reflection seismic data (Pfiffner and Hitz 1997, their line E2) which demonstrate that the Lower Penninic Bündnerschiefer of the Engadine window are directly underlain by basement

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units attributed to the European margin (topped by the Subpenninic Adula nappe), i.e. units that perfectly correspond to the „Zentralgneise“ (topped by the Tertiary-age Tauern Eclogite Zone) in the area of the Tauern window. Moreover, the parallelisation between the Valais Bündnerschiefer of the Engadine window and the Glockner nappe of the Tauern window was recently confirmed on sedimentological grounds (Bertle 2004). Consequently, we cast doubts on the existence of a “Middle Penninic Zentralgneis block” (Frisch 1979, Kurz et al. 1998) in the area of the Tauern window, separated from proximal Europe by the Rhenodanubian flysch trough, regardless of the question as to whether this “block” represents the Briançonnais microcontinent (Tollmann 1965) or a part of the stable European continent (Kurz et al. 1998). Instead, we consider the Lower Penninic Rhenodanubian flysch to be rooted above and behind the „Zentralgneise“ of the Tauern window, in an even more internal position in respect to the Bündnerschiefer of the Glockner nappe (see Oberhauser 1995). It is clear that our alternative view demands by far more substantial N-S-shortening during Tertiary orogeny than commonly assumed by geologists working in the Eastern Alps, i.e. values that amount to some 500km (as calculated in Eastern Switzerland by Schmid et al. 1996) or even more.

We agree with Kurz (2005), and in fact we were rather explicit about this in our article (see Fig. 2c in Schmid et al. 2004), who states that “possibly the Briançonnais primarily ended between the Engadine and the Tauern Window, whereby the North- and Southpenninic basins merged eastward into a joint basin (Froitzheim et al. 1996)”. Of course the front of the Briançonnais could theoretically also be located south of the Tauern Window, as proposed by Kurz (2005), having completely disappeared by subduction (see also Froitzheim et al. 1996). Hence this postulate cannot be excluded, although it appears rather hypothetical since no evidence for high-pressure metamorphism is found in the very thin Briançonnais-derived sliver that outcrops in the Engadine window nearby (Tasna nappe, see Florineth and Froitzheim 1994).

Kurz (2005) reports that the paleogeography proposed by Trümpy (1988) shows that the Briançonnais ends east of the Engadine Window, as was proposed by us (Schmid et al. 2004). However, when Kurz (2005) writes that lateral displacement of the Briançonnais to the east, “re-occurring in the Pienidic Unit of the Western Carpathians” (he refers to parts of the Pieniny Klippen Belt, namely the so-called Czorstyn unit, see Birkenmajer 1986), he unfortunately misinterprets Trümpy (1988) who writes: „These platforms are not continuous; thus the Briançonnais belt disappears eastward in western Tyrol…” (Trümpy 1988, page 106).

Kurz (2005) correctly remarks that the paleogeographic separation into North- and Southpenninic becomes somewhat artificial in the Eastern Alps since the North- and Southpenninic basins, due to the disappearance of the Iberia-Briançonnais microcontinent, merged into one single Penninic basin east of the Engadine Window (e.g., Stampfli 1993, Froitzheim et al. 1996). We are fully aware of this problem and we do not wish to repeat the four criteria outlined in our article (Schmid et al. 2004, p. 99), except for re-mentioning the most important criterion, namely that of the age of accretion of these oceanic units (Late Cretaceous vs. Tertiary). By using this criterion we were again guided by the concept that two distinct orogenies affected the eastern Alps. Hence, we attributed the Rhenodanubian flysch, accreted to the Alpine nappe stack in Eocene times, to the Valais ocean, although it contains slices of Piemont-Liguria origin (Ybbsitz Zone of Decker 1990). These slivers occur at the base of the Kahlenberg nappe, which has also been interpreted as an element from the southern margin of the joint oceanic basin by Faupl & Wagreich (1992). On the other hand the Laab and Main Flysch nappes consist of material derived from the European margin in the north (e.g. Trautwein et al. 2001).

Rather than discussing a South Penninic (Piemont-Liguria) origin of the Rhenodanubian flysch, as suggested by Kurz (2005), we would like to propose that Wäggitaler, Schlieren and Gurnigel flysch units of the Swiss Alps, in which sedimentation does not stop before Eocene times, could also belong to the Valais oceanic domain (following a suggestion by R. Trümpy, written communication), contrary to common belief amongst Swiss geologists since the publication of Caron et al. (1989). We regret that we did not have the courage to propose this alternative view in our tectonic map, which we now consider by far more logical. However, at the same time we are glad to give credit to the grand old man of Alpine geology for first having made this “heretic” suggestion.

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