The uplift of the Andean cordilleras in Ecuador as recorded by heavy minerals and detrital zircon ages in the Andean Amazon Basin sediment series

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The Andean Amazon Basin developed to the east of the evolving Andean chain from the Late Cretaceous to the Recent. The basin represents a shallow marine to continental facies retro-arc foreland basin. Consequently, the clastic sedimentary record is highly useful for monitoring the long lasting history of the supplying Andean chain. Detrital grain analyses (heavy minerals), and fission track thermochronology of detrital zircons (lagtime), reveal a punctuated tectonic control on the uplift and erosion of the Andean cordilleras in general.

In the Late Cretaceous sediments, zircon-tourmaline-rutile dominated heavy mineral spectra and highly variable (400-0 Ma) lagtimes measured in detrital zircon grains (Ruiz, 2002; Ruiz et al., 2004) suggest that the Amazon Basin first was supplied by both the Guyana Shield to the east and a primordial Andean Cordillera Real to the west. Sediment input from the Guyana Shield died out during the Maastrichtian and an increasing amount of detrital metamorphic mineral grains (epidote, chloritoide, garnet) in Cenozoic sedimentary rocks documents the continuous exhumation of deeper levels of the nascent Andean chain. The exposure of high-grade metamorphic source rocks first occurred during the Eocene and Oligocene, resulting in erosion and reworking of kyanite and sillimanite grains into the Andean Basin. In particular, the combination of heavy mineral data and detrital zircon fission track ages (lagtimes) from the same sandstone layers record the reactivation and quiescence of particular faulted blocks of continental crust of different metamorphic grades within the Andean source region.

The input of mafic mineral grains (chromian spinel, olivine, clinopyroxenes) into the Amazon Basin since the Miocene, suggests that the Cordillera Occidental (which hosts an extensive mafic crystalline basement sequence) became a provenance region for the Amazon Basin. It can be inferred that since the latest Miocene - Pliocene, an orographic situation similar to today has existed (e.g. Steinmann et al 1999, and present work).

A high correlation is observed between the measured temporal changes in sediment composition and the periods of cooling in the source terranes and large-scale tectonic rearrangements within the Ecuadorian Andes and forearc. Thermochronological data derived by the $^{40}Ar/^{39}Ar$ and fission track methods from the metamorphic basement and cover sedimentary rocks of the Andean belt (Steinmann et al., 1999; Spikings et al., 2000, 2001, in press) indicate that the contemporaneous continental margin was being rapidly cooled (e.g. $\geq$20°C/km) during 75-60 Ma, 43-30 Ma, 15$\pm$1 Ma and 9$\pm$1 Ma. Apatite fission track ages from the igneous basement rocks within the Subandean Zone suggest they were rapidly cooled during the Late Miocene (Ruiz, 2002). Furthermore, apatite (U-Th)/He data, when combined with apatite fission track data from the same samples, record rapid cooling in the northern Cordillera Real and faulted rocks of the Cordillera Occidental at 5.5 – 3.3 Ma (Spikings and Crowhurst, 2004; Winkler et al., in press). These sharply defined periods of cooling have been attributed to exhumation processes, which can be temporally related to, i) periods of terrane accretion with the allochthonous forearc (Late Cretaceous until Eocene), ii) the impact and subduction of the Carnegie Ridge since ca. Late Miocene, and iii) transcurrent reactivation of the ocean-continent suture during the latest Miocene – Pliocene.

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