TERRANE ACCRETION AND OROGENIC GROWTH IN ECUADOR

R.A. SPIKINGS[1], W. WINKLER[2], D. SEWARD[2], G. RUIZ[2] and R. HANDLER[3]

1. Section des Sciences de la Terre, Université de Genève, Rue des Maraîchers 13, CH-1211 Genève 4, Switzerland. spikings@terre.unige.ch
2. Geologisches Institut, ETH-Zentrum, Zürich CH-8092, Switzerland. winkler@erdw.ethz.ch, seward@erdw.ethz.ch, ruiz@erdw.ethz.ch
3. Institute for Geology and Paleontology, University of Salzburg, Hellbrunner Str. 34, 5020 Salzburg, Austria

KEYWORDS: Northern Andes, Thermochronology, Terranes, Caribbean Plate, Carnegie Ridge,

INTRODUCTION

Oceanic hotspot activity, generating large oceanic igneous plateau provinces, plate rearrangements and the generation of new spreading centers since at least 90 Ma has resulted in large structural, thickness and density heterogeneities in the approaching and subducting oceanic slab offshore NW South America (SOAM; Figure 1). At the present day, various oceanic allochthonous terranes comprise western Ecuador and the relatively thick and buoyant Carnegie Ridge is subducting beneath the upper plate with a flat configuration (Gutscher et al., 2000). We present the results of $^{40}Ar/^{39}Ar$ (white mica and biotite) and fission track (FT; zircon and apatite) data from traverses (labelled a – f in Figure 1) across the Eastern Cordillera and the Amotape Complex, which collectively define the palaeo-continental margin, that is presently sutured against oceanic basement in the vicinity of the Inter-Andean Valley (Figure 1). A quantitative framework for the thermal and exhumation history of the palaeo-continental margin since ~70 Ma has been established, which reveals systematic and distinctive along-strike trends, which can be correlated with contemporaraneous heterogeneities in the approaching and subducting oceanic crust. These results will be compared with preliminary thermochronological data from the Western Cordillera (Pallatanga and Macuchi terranes), which is built upon a part of allochthonous Ecuador, above oceanic crust.

RESULTS, THERMAL MODELLING AND INTERPRETATION

The distribution of $^{40}Ar/^{39}Ar$ ages and FT ages from the palaeo-continental margin can be split into three groups; 1, Traverse A, where the ZFT and AFT ages are ≤15 Ma, with long AFT lengths (>14 μm) occuring at ~9 Ma; 2, Traverses B and C where a larger range in FT ages is observed with AFT ages ranging between 44 – 9 Ma and ZFT ages ranging between 67 – 28 Ma, with long AFT lengths occurring at ~41 Ma. Plateau $^{40}Ar/^{39}Ar$ ages range between 66 – 56 Ma; 3, Traverses D, E and F, where AFT ages are distinctly older and range between 64 – 11, ZFT ages range between 68 – 33 Ma and the longest AFT lengths occur at ~59 Ma.

Forward modelling of the AFT data from individual samples has been combined with overlapping ZFT and $^{40}Ar/^{39}Ar$ ages (obtained from the same respective sample) to generate potential thermal history paths for several samples from temperatures ≤380°C (Figure 2). Various regions of all of the traverses experienced rapid cooling rates (~ 30 - 20˚C/My) during 70 – 55 Ma and 43 – 30 Ma. However, the region to the north of S1°30' (Traverses A, B and C) experienced rapid cooling (up to 50°C/My) at 15 and 9 Ma, whereas the region to the south (traverses D, E and F) remained thermally stable.

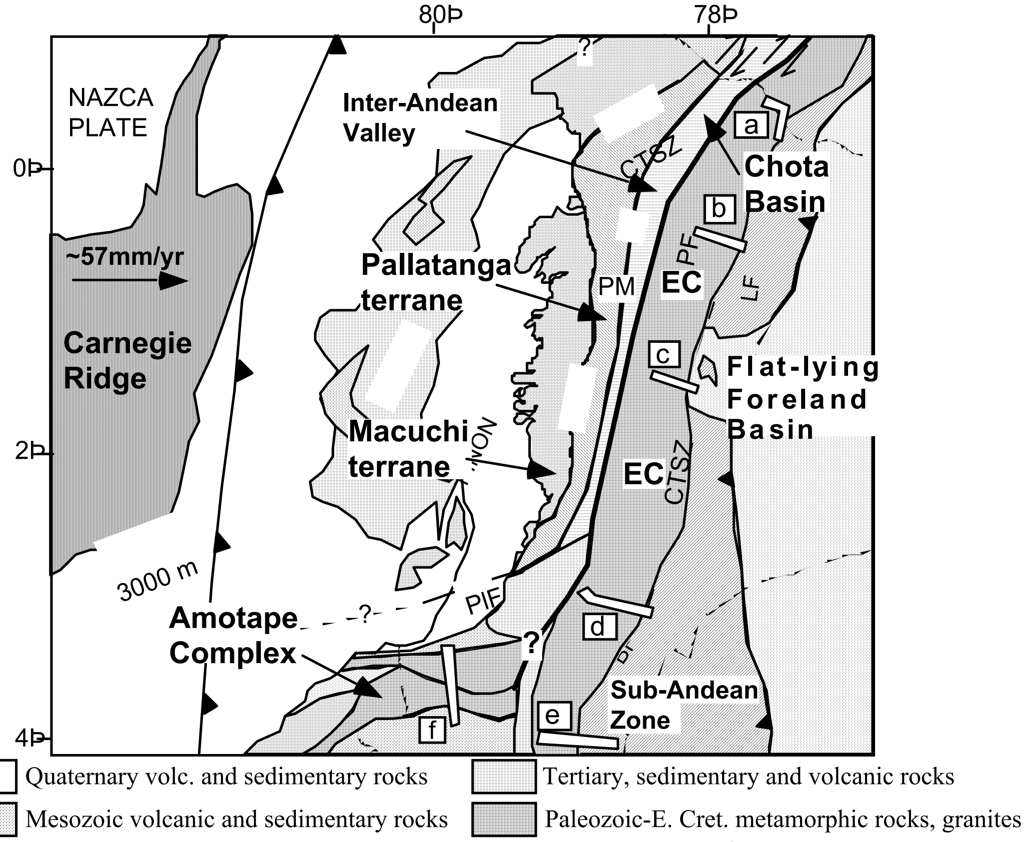

Figure 1. CTSZ: Chimbo-Toachi Shear Zone, EC: Eastern Cordillera, PF: Pujilí Fault, PlF: Pallatanga Fault, PM: Pujilí Melange. Thick black line is the ocean continent suture.

Field mapping (Hughes and Pilatasig, 2002) and geochemical and geochronological similarities between the basement peridotites and basalts of the allochthonous oceanic Pallatanga and Macuchi terranes and the Caribbean Plateau, combined with kinematic reconstructions of the Caribbean Plateau (citations listed in Spikings et al., 2001), provide convincing evidence that the oceanic allochthonous terranes originally formed as island arcs at the leading and trailing edges of the buoyant Caribbean Plateau. The Plateau and southern branches of the island arc systems collided with the NW SOAM continental margin, resulting in the accretion of the Pallatanga and Macuchi terranes during the late Cretaceous and Eocene, subsequently causing the entire contemporaneous continental margin to uplift and exhume.

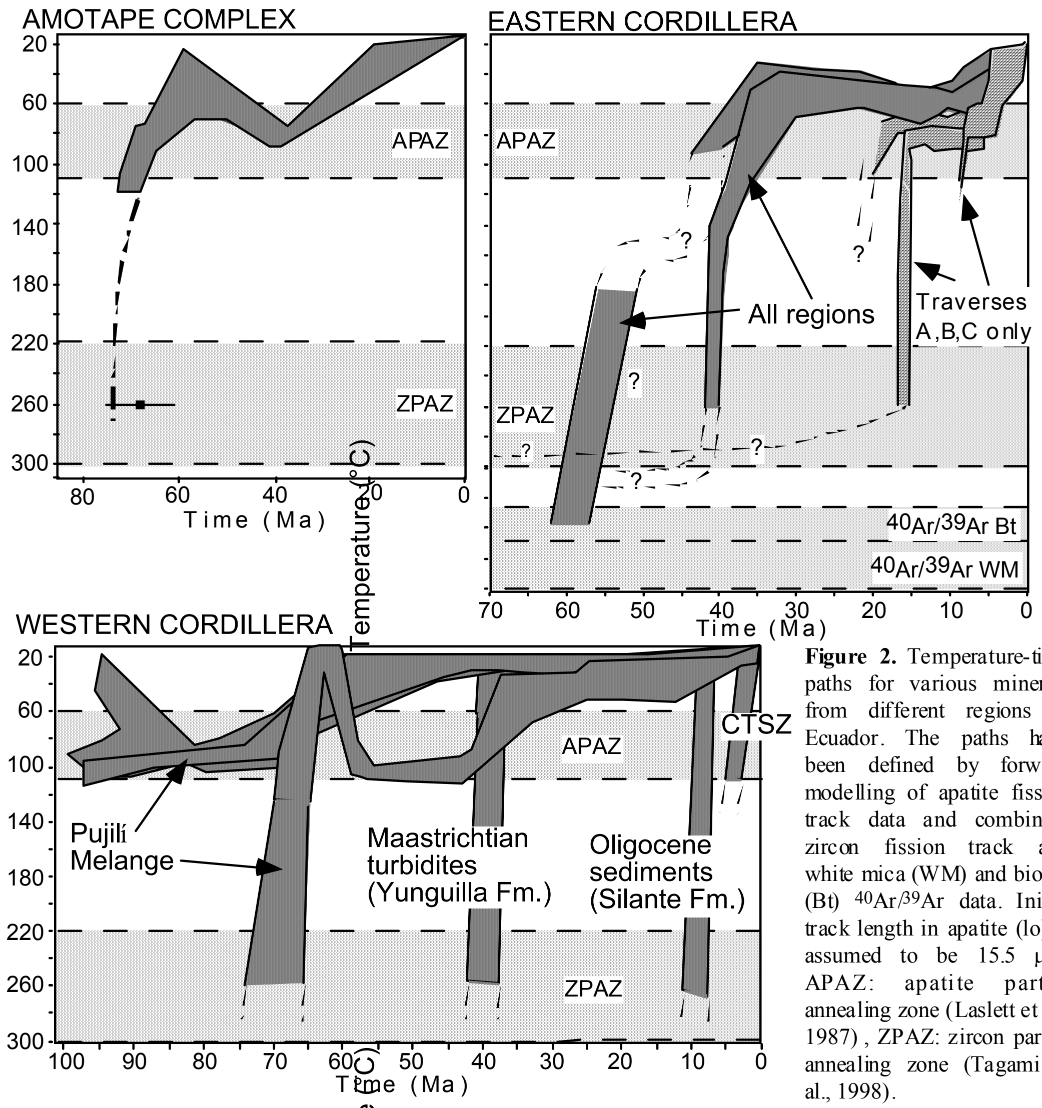

Figure 2. Temperature-time paths for various minerals from different regions of Ecuador. The paths have been defined by forward modelling of apatite fission track data and combining zircon fission track and white mica (WM) and biotite (Bt) $^{40}Ar/^{39}Ar$ data. Initial track length in apatite (lo) is assumed to be 15.5 μm. APAZ: apatite partial annealing zone (Laslett et al., 1987), ZPAZ: zircon partial annealing zone (Tagami et al., 1998).

ZFT and AFT data from a tectonic melange exposed in the Western Cordillera (Pujilí Fm.; Figure 1), which formed in the suture zone between oceanic crust of the Pallatanga Terrane and the continental margin (Hughes and Pilatasig, 2001), experienced increased cooling rates during 80–60 Ma (Figure 2). The cooling was probably a result of both regional exhumation that accompanied the collision and thermal relaxation following frictional heating within the melange. Therefore, assuming that the melange formed during the early stages of the collision, the suture can be dated at ~80 Ma and the progressive formation of the melange via reactivation of the suture probably continued until 60 Ma, as recorded in the Amotape Complex and the Eastern Cordillera. Rapid cooling of Maastrichtian sandstones (Figure 2) in the far northern Cordillera Occidental at ~40 Ma was probably a result of increased rates of exhumation, driven by the accretion of the Macuchi Terrane.

The timing of collision of the Carnegie Ridge with the North Andean margin (Figure 1) has been a matter of conjecture for over 20 yr and previous estimates for the timing of the onsett of collision range between 25 – 1 Ma (e.g. Lonsdale and Klitgord, 1978). However, we propose that the distinct and dramatic increase in cooling rates observed in parts of traverses A,B and C (Figure 2), which lie directly above or close to the flat subducted slab segment that is supported by the buoyant Carnegie Ridge (Figure 1), was caused by the collision of the Carnegie Ridge with the trench at ~15 Ma. This estimate corroborates with limits imposed by the relative convergence rates of the SOAM plate and the Nazca Plate (Spikings et al., 2001). The collision produced increased compressive stress, uplift, exhumation and cooling in northern Ecuador. Coupling of the Carnegie Ridge and upper plate may have caused isostatic disequillibrium and a further period of increased stress, resulting in increased exhumation rates at 9Ma, which is also recorded in parts of the Western Cordillera (Fig. 2).

Late Miocene and younger FT ages (< 6 Ma) from the cordilleras are restricted to highly strained rocks, which form part of the CTSZ in the Western Cordillera (Figure 1). Furthermore, rapid late Miocene exhumation rates of ~0.7km/My during 5 - 0 Ma are recorded in the northernmost Eastern Cordillera (Spikings et al., 2000). Finally, ZFT chronostratigraphy of the intermontane Chota Basin, located in the far northern Inter-andean Valley, suggests the oldest sedimentary rocks are 5.4±0.4 Ma, which are the oldest inter-montane sediments in the Inter-Andean Valley. Collectively, this evidence suggests that late Miocene and younger fission track ages from the CTSZ may record cooling that followed a period of shearing and exhumation at ~6 - 5 Ma. Dextral strike-slip displacement of the allochthonous oceanic terranes towards the north-northeast since ~6 Ma produced a complex transcurrent system that included the CTFZ, and uplifted fault blocks comprising the northern Eastern Cordillera. The same system generated the pull-apart Chota Basin and younger basins to the south which collectively form parts of the Inter-Andean Valley.

REFERENCES

Gutscher M-A., Malavieille J., Lallemand S., Collot J-Y. 1999. Tectonic segmentation of the North Andean margin :impact of the Carnegie Ridge collision. Earth and Planetary Science Letters, 168, 255–270.

Hughes R.A., Pilatasig L.F. 2002. Cretaceous and Tertiary terrane accretion in the Cordillera Occidental of the Ecuadorian Andes. Tectonophysics, 345, 29-48.

Laslett G.M., Green P.F., Duddy I.R., Gleadow A.J.W. 1987. Thermal annealing of fission tracks in apatite 2: A quantitative analysis. Chemical Geology, 65, 1–15.

Lonsdale P., Klitgord P.D. 1978. Structure and tectonic history of the eastern Panama Basin. Geological Society of America Bulletin. 89, 98 –999.

Spikings R.A., Seward D., Winkler W., Ruiz G. 2000. Low-temperature thermochronology of the northern Cordillera Real, Ecuador: Tectonic insights from zircon and apatite fission track analysis. Tectonics, 19,649-668.

Spikings R.A., Winkler W., Seward D., Handler R. 2001. Along strike variations in the thermal and tectonic response of the continental Ecuadorian Andes to the collision with Heterogeneous oceanic crust. Earth and Planetary Science Letters, 186, 57–73.

Tagami T, Galbraith R.F., Yamada R., Laslett G.M. 1998. Revised annealing kinetics of fission tracks in zircon and geological implications, in: P Van den Haute, F. de Corte (Eds.), Advances in Fission-Track Geochronology, Solid Earth Sciences Library 10, Kluwer Academic, Norwell, 1998, pp. 99–112.