# THERMOTECTONIC HISTORY OF THE ANDES, SOUTH ECUADOR: EVIDENCE FROM FISSION-TRACK DATING

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## INTRODUCTION

A study of the thermo-tectonic history and assessment of the amount of uplift and exhumation in the Ecuadorian Andes yields information that helps one to reconstruct the paleogeography. The uplift event of Late Miocene and Early Pliocene age was described by Kennerley (1980) as "the Andean Event", which caused differential vertical movement in the Sierra and folding and thrusting of the Subandean zone in the Oriente. Uplift and deformation events are also recorded in the fill series of Neogene basins in the Interandean zone of southern Ecuador (Hungerbühler et al., 1996). In the Cordillera Real, an earlier uplift event during Late Cretaceous, was shown through radiometric age determinations on metamorphic rocks (Aspden et al., 1992). In the current, ongoing study, samples from the "basement" rocks of southwest Ecuador, in an east west profile from 3000 m to sea level, have been collected for fission-track analysis to determine exhumation rates.

## METHODOLOGY

The fission-track technique is now a widely used dating method with particular application to thermo-tectonic histories of mountain belts. Since the blocking temperature of apatite is quite low (approximately 105° C, Parrish, 1983), relative to other dating methods, it has become particularly applicable for evaluating low temperature thermal histories. Thermal history information can be obtained not only from the ages but also from length measurements of the etched tracks. From the age and track length distribution, time temperature paths experienced by the apatite can be estimated. Modelling using genetic algorithmus can sometimes refine the interpretation. This application of apatite fission-track technique is a very useful tool in the analysis of tectonic evolution of mountains, including exhumation, unroofing and/or cooling histories, locating and determining amount of vertical movement of major faults, and provenance studies of sedimentary sequences that have not seen the required temperatures to erase the initial detrital grain ages. In addition, dating of zircon, with a higher blocking temperature, allows cooling histories to be extended back in time. Current temperatures for zircon are approximately 240° C, (Yamada et al., 1995).

The concept of a single unique blocking temperature for fission tracks has had to be extended to a range of temperatures since, as a rock sequence passes upwards and / or cools down, there is a range of temperature over which the tracks begin to both form and disappear (anneal); this is called the partial annealing zone. This temperature range is generally accepted as between 120°C and 60°C for apatite. Below 60° C one can assume for all essential purposes that the tracks that are formed are retained.

By measuring track lengths in apatites insight into the rate of exhumation and the thermal history of the rock can be estimated. Only tracks in grains in which the c-axis is parallel to the polished surface of the grain are measured. Further the tracks must be beneath the surface having been etched through cracks or through other tracks (Bhandari et al., 1971). In order to measure full lengths, only those horizontal to the plane of the surface are measured. Such tracks are termed confined horizontal tracks. The form of the tracks-length histogram and associated statistics allow more detailed information regarding the history of a rock.

England and Molnar (1990) pointed out the confusion between exhumation or uplift of rocks with tectonic uplift. They define the relationship as:

$$\text{tectonic (surface) uplift} = \text{uplift of rock} - \text{exhumation}$$

It is well to keep this in mind when interpreting fission-track data.

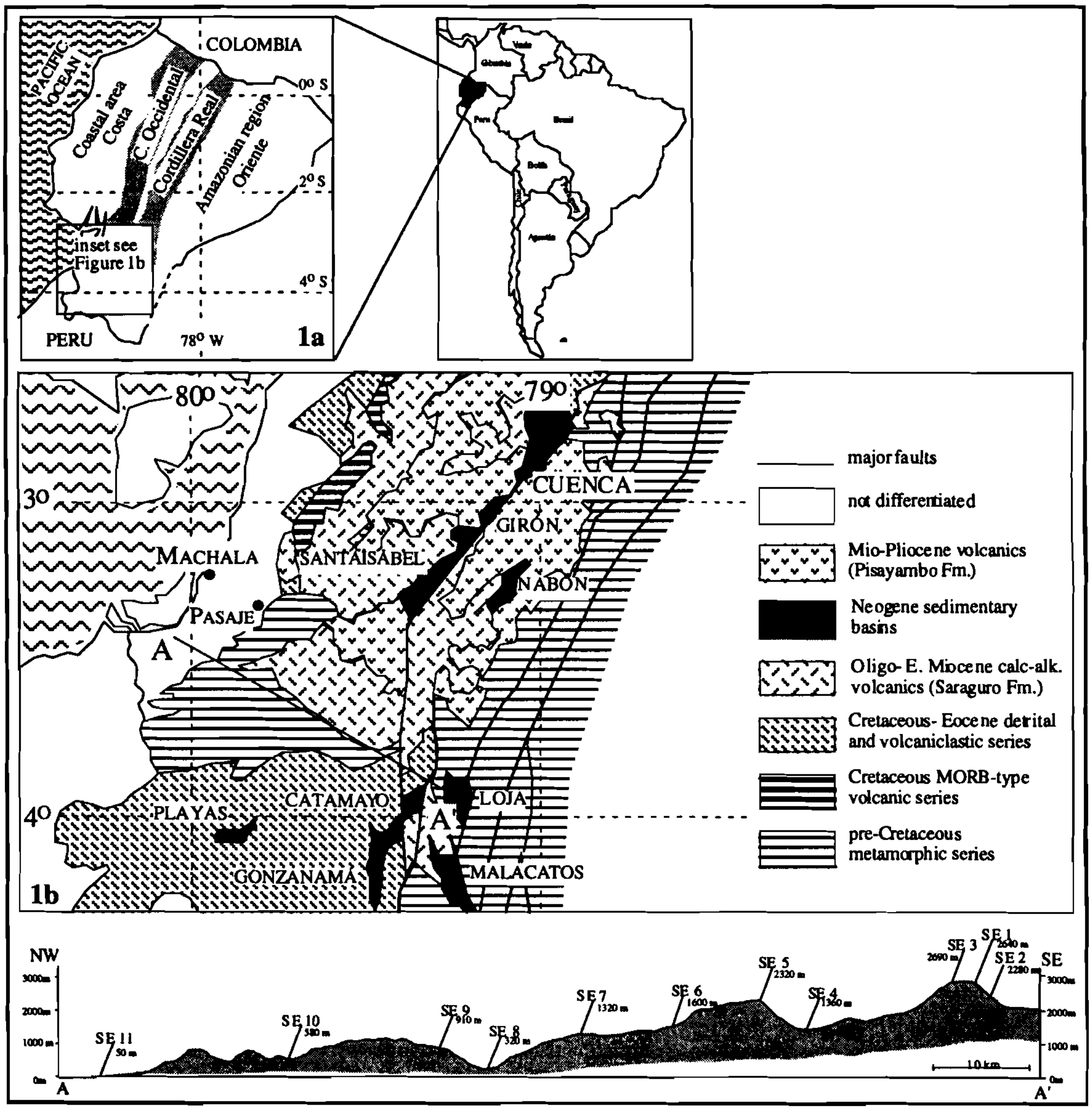


Fig. 1 Simplified geological map of southwestern Ecuador (after Litherland et al., 1993). The NW-SE cross-section (A-A') shows the sample location and the altitude above see level (v.e. = 3x) .

## GEOLOGICAL SETTING AND INITIAL RESULTS

Southern Ecuador is composed of three major geological zones (Fig. 1): 1) Paleozoic to Mesozoic metamorphic series in the Cordillera Real and in the El Oro Province; this El Oro metamorphic belt separates 2) Cretaceous to Eocene detrital volcaniclastic series in the southwest from 3) Cretaceous to Eocene MORB typ and island arc volcanic series in the north (Cordillera Occidental).

Fourteen samples from these "basement" rocks and from granitic intrusions were collected in roadcuts from Loja to Machala and from Pasaje to Girón. 12 zircons and 11 apatites samples were separated, 1 from the San Lucas intrusion (Eocene), two from the metamorphic Chiguinda Unit (Paleozoic?), two from the Alamor Group (Cretaceous), six from Jurassic to Miocene intrusions and one from the Yunguilla Fm. (Cretaceous). The Loja - Machala section crosses several terranes which were accreted during Mesozoic collisional events (Aspden and Litherland, 1992). The fission-track analysis of this section will demonstrate if the terrane boundaries were reactivated during the Cenozoic.

Initial zircon ages range from Cretaceous to Miocene; apatites range from Palaeocene to Miocene. Mean confined track lengths in the apatites lie between 13 and 14 µm with unimodal distributions, implying a simple exhumation/cooling history, from a depth of 3-4 km, over this period.

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