Cenozoic exhumation patterns across the Venezuelan Andes: insights from fission-track thermochronology

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ABSTRACT

This dissertation presents the results and observations of an investigation on the long-term (Miocene to present) exhumation history of the Venezuelan Andes, and the relationships between inherited structures and development of topography in response to tectonic and surface processes. The Venezuelan Andes are ideal for understanding the relationships between these processes, because they have involved through inversion and reactivation of pre-existing structures, they are associated with a major climatic gradient due to the orograpic effect of the belt and extensive data is available concerning their recent tectonic evolution. This mountain belt is the result of transpression caused by oblique convergence of the continental Maracaibo block and the South America Plate, controlled, on a larger scale, by the triple junction between the South American, Caribbean and Nazca plates. The complex kinematics of triple plate interaction and the continuous evolution of related structures coupled with surface processes have profoundly affected the evolution of the Venezuelan Andes.

An extensive low-temperature thermochronometer database composed of 47 new apatite fission-track (AFT) ages: 24 bedrock samples, 15 samples from synorogenic detrital sediments and 8 samples from modern rivers sediments is presented in this dissertation. The dataset is supplemented with 27 previously unpublished AFT bedrock ages and 10 revised AFT ages provided by B.P. Kohn. The AFT ages are converted into long-term exhumation rates using thermal modeling. Analyses of in-situ AFT data from seven tectonically delineated areas reveal variable exhumation patterns across the Venezuelan Andes. The Caparo and Valera blocks, which were separated by dextral movement along the Boconó strike-slip fault system, respectively have AFT ages ranging from 7 to 27 Ma, and 11 to 145 Ma, representing areas of relatively slow exhumation. In the central part of the Venezuelan Andes, AFT ages in the Sierra La Culata (5-8 Ma), El Carmen (2-3 Ma) and Sierra Nevada (5-8 Ma) blocks, record major recent exhumation in response to transpression and erosion along the Boconó fault system. To both sides of the chain, AFT ages in the Escalante block (5-6 Ma) on the far northern flank, and the Cerro Azul thrust block (5-8 Ma AFT age) on the southern flank provide evidence of significant compression, which produced the doubly vergent structure of the Venezuelan Andes during Late Miocene times. Fission-track analysis of detrital apatite from modern river samples permit a) verification and extrapolation of the bedrock cooling age patterns across the Venezuelan Andes, b) determination of sediment provenance, and c) analysis of relationships between exhumation rates and potential controlling factors. The results imply a strong correlation between relief and long-term exhumation rate but a lack of correlation between long-term exhumation rate and present-day precipitation or seismic energy release (measured during the last 20 years), indicating that the control of tectonic and/or climatic processes on exhumation cannot be discerned in a straightforward manner.

Fission-track data from synorogenic sediments in the Maracaibo and Barinas foreland basins permit tracing the present-day exhumation patterns back to the Late Miocene. Rock-Eval analyses of sediments sampled show that Mio-Pliocene sediments in these basins have not been buried deeper than the AFT partial annealing zone in the studied sections. Young AFT ages in samples from the Parángula Formation on the south flank imply that this formation is probably of Tortonian age, significantly younger than previously suggested. The AFT data, together with pollen analyses, imply that the Pliocene Betijoque Formation to the north corresponds in age to the upper part of the Río Yuca Formation to the south of the Venezuelan Andes.