km. This and the absence of elements showing associated major surface uplift, such as palinological changes associated with increasing paleoelevation or an intense influx of coarse gravels towards the foreland basins, implies that an initial stage with shortening experienced minor surface and rock uplift. E-W dominant contraction is expressed by folding and penetrative deformation, as well as calcite and SiO_2 filled tension veins oriented parallel to maximum compressional stresses. Extensional structural highs and extensional folds were amplified, but as the resulting rock uplift associated with folding was minor, reactivation of extensional faults was likely not substantial during this initial deformation phase. Quantifying the amount of shortening by internal strain supports this notion of folding by buttressing and minor reactivation. Shortening by folding is close to 20% and penetrative deformation resulted locally in an additional 20%, localized in the inclined limbs of anticlines and the hinge zones of some synclines.

Syntectonic facies changes in the foreland basin to the east since the late Eocene (Parra et al. this volume) and the presence of what we interpret to be synfolding mineralizations dated as old as Maastrichtian-Paleocene in the eastern flank of the Cordillera (Cheilletz & Giuliani, 1996; Romero-Ordoñez et al., 2000) constrains the timing of early deformation. This initial contractional phase predates the main Pliocene and Quaternary episode of exhumation and shortening episode.

The main results of our apatite fission-track (AFT) analysis show a significant cooling event younger than 4 my, documented from 3 vertical profiles from the eastern flank of the Eastern Cordillera. Palynological data obtained from the present highlands of the Sabana de Bogotá within the Eastern Cordillera suggest that important surface uplift occurred at the end of the Miocene (van der Hammen et al., 1973). Our data show that this uplift was accomplished by reactivation of normal faults and continues to the present day only on the eastern side of the Cordillera, as documented by uplifted Quaternary terrace systems in addition to our AFT analysis. In contrast, in the Sabana de Bogotá palynology suggests that it has remained at a similar elevation and has not experienced significant exhumation since the Pleistocene (Hooghiemstra & Cleef, 1995). A comparison of our cross sections and AFT data with that from Gomez et al. (2003) shows that, since the Pleistocene, exhumation and shortening on the eastern flank have been much higher than on western flank and almost absent in the axial Sabana de Bogotá. Therefore, the most important uplift and shortening of the central segment of the Eastern Cordillera ocurred after the initial low amplitude folding and was not an ubiquitous phenomenon beginning in the Late Miocene, as previously interpreted (van der Hammen et al 1973; Dengo & Covey, 1993; Cooper et al., 1995). This uplift has resulted in a 4000-m-high orographic barrier that must have been fully established in (early?) Pliocene time (Hooghiemstra & Cleef, 1995). Since then, this barrier has effectively focused orographic precipitation and accounts for important climatic and erosional gradients in eastern Colombia. The big contrast between a continued and intense uplift on the eastern side of the orogen, which is also the region undergoing the highest erosion, and the stability of the internal Sabana de Bogotá since the Pliocene, demonstrates that inherited structure and erosion interact in a diachronous pattern during the Neogene and Quaternary to produce the present-day structural configuration.

The compilation of available data on palinology and AFT together with our own data also suggests that for the past 2 Ma, rock uplift and denudation appear to have been in equilibrium in the central segment of the Eastern Cordillera. This implies that the orogen is close to a steady-state condition. We propose that this balance is mainly conditioned by the presence since the Pliocene of an orographic barrier on the eastern side of the orogen.

Therefore, the long-term structural asymmetry (eastward vergence) appears to be conditioned by a feed-back loop between tectonics and climate that had not been previously identified in the Northern Andes.

CONCLUSIONS

Tectonic inheritance and exhumation patterns are both important in the configuration of the Eastern Cordillera at the latitude of Bogotá. Pre-existing extensional structures exert the primary control on the location and style of contractional structures. After the establishment of an orographic barrier, efficient denudation triggers more intense and continued shortening in the eastern flank. The precise location of this shortening is conditioned by inherited structures.

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