TECTONIC AND CLIMATIC IMPLICATIONS OF FLUVIAL ARCHIVES IN THE SOUTHEASTERN BRAZILIAN ATLANTIC PLATEAU

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The Quadrilátero Ferrífero (QF–'Iron Quadrangle') is a remarkable mountainous region in southeastern Brazil inserted in the Atlantic Plateau. Its morphology has carved itself into Archaean and Proterozoic rocks and can be defined as the result of the evolution of a highly deformed geological substrate, resulting from the Precambrian orogeneses. Cenozoic tectonic inputs led to intense dissection through drainage and the strong structural control induced the inversion of the relief (relatively topographically elevated synclines and lowered anticlines) during Neogene and Quaternary. Therefore, there has been a predominant role of fluvial work in shaping the landscape in the QF region.

In view of the importance of fluvial work and aiming to deepen understanding of regional geomorphology during the Late Cenozoic, several surveys on fluvial terraces and depositional successions have been undertaken in the QF, but they have been of a local nature and few of these works presented ages of the analysed fluvial deposits. The present paper intends to fill the gaps left by the many localized studies about the evolution of fluvial systems in the QF and synthesize them in a super-regional overview.

An extensive literature review was carried out in regard to fluvial archives in the QF. Then, study sites were identified and revisited to review and reinterpret the data in the field and in the context of their regional setting. In total, 13 river valleys were investigated, covering the main valleys in terms of preserved fluvial sedimentary records. In each valley, the predominant means of identifying different fluvial levels were the heights and characteristics of the sediments of which they were composed. Finally, the depositional levels (floodplains and terraces) of all valleys were divided into regional phases of fluvial evolution. This organisation was based on the relationship among data from the characterisation of the depositional successions (such as the presence of duricrusts), geomorphological context of each level in its respective valley (i.e. its relationship with older and younger levels), and sediment ages when available. The studies with absolute dating techniques in the region are still in a process of building up data resolution and data density. So, we present a first attempt to synthesise these data which can be re-evaluated in the future.

The regional fluvial archives indicate a dynamic and young fluvial landscape, sensitive to tectonic forces and climatic oscillations of the Late Quaternary. The framework of fluvial levels in each valley (Fig. 1) allow to propose seven regional phases of formation of fluvial depositional levels (terraces and floodplains) between ~83 ka and the present (Fig. 2).

A number of evidences can be highlighted regarding tectonic influence on the evolution of the river valleys, such as trapped tectonic sediments and deformation and failure of sedimentary deposits. The widespread presence of terrace staircases in the valleys of the QF can be considered a response to phases of greater fluvial incision. The consecutive formation of river bedrock terraces is commonly attributed to regional uplifts [1], [2]. However, each fluvial dissection phase is unlikely to correspond to a neotectonic pulse, as there is no evidence in the literature of such a large number of different pulses during the last ~100 ka. For this reason, the Late Cenozoic neotectonic activity is considered to have led to an intense process of fluvial incision in the QF; however, it would have occurred in phases, accelerated to a greater or lesser extent according to the variable conditions of sediment production and outflow in the river valleys.

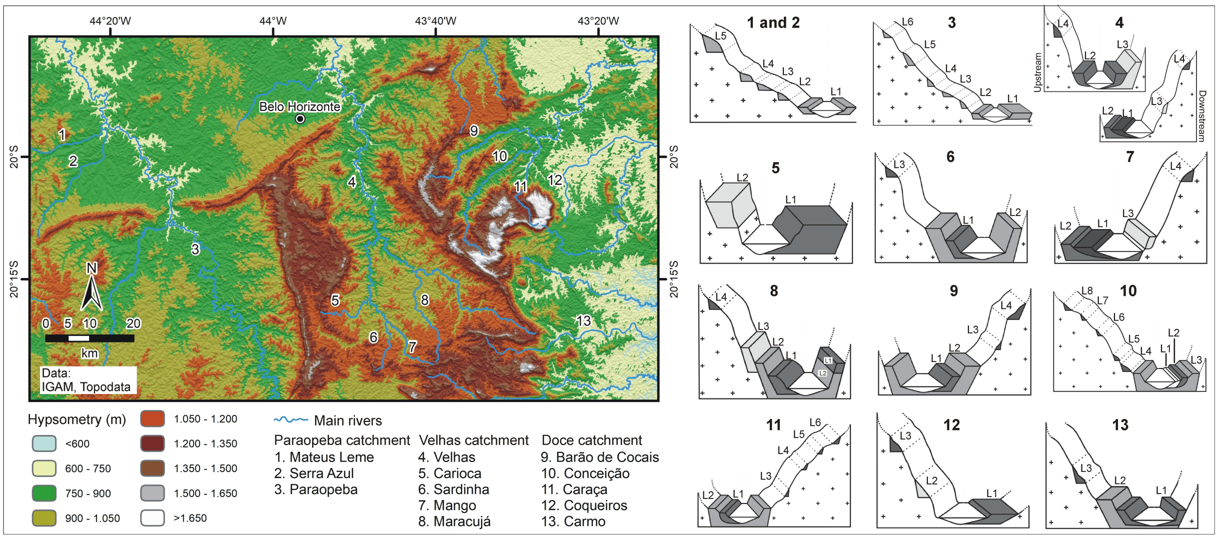

Figure 1. Topographic map of the QF and surroundings with the studied watercourses and the respective profiles of the depositional levels (without scale).

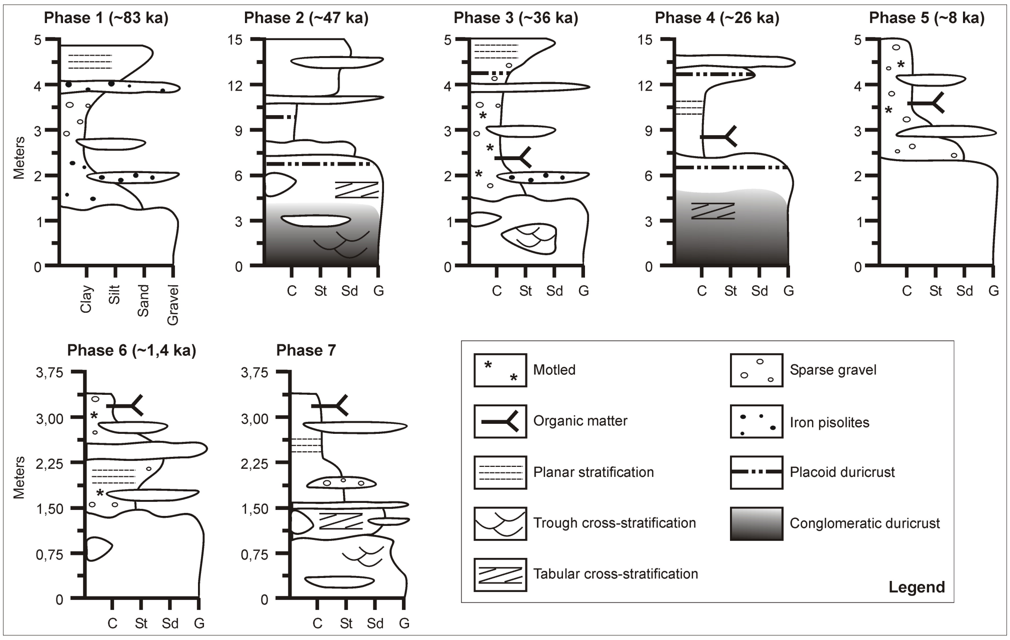

Figure 2. Stratigraphic profiles of synthesis relative to the evolutionary phases of the QF fluvial systems.

The data suggest that the Paraopeba catchment is draining a tectonic block that had greater uplifting during the Late Quaternary; hypothesis reinforced by the fact that in the Phase 2 and in similar deposits (Juatuba Formation), an E/SE tilting was registered with a dip of about 5º [3]. Still, in Phase 2 deposits, [4] described neotectonic faults, indicated by breaks in the gravel line. Likewise, the altimetric differences (about 20 m) between this deposit and those of the same terrace located downstream are indicative of a post-depositional tectonic uplift [4]. It is also noteworthy that excavations for a dam construction in the Serra Azul River revealed low angle planes, leading to the thrusting of Neoarchean schists over Quaternary alluvium [5]. Formation of the thick silt and clay packets in the upper-middle Paraopeba catchment (Phase 2) itself would probably have been conditioned by the movement of old faults or shear zones.

It is also noteworthy the high fluvial incision values found in the Holocene, with values close to those of orogenic environments [6]. However, it is crucial to point out that in no case was the outcrop of hard rocks observed to be below the river archives, and they were always on saprolite. Thus, it appears that the incision in the saprolite would explain the high river incision values, highlighting the importance of valley bottom weathering processes.

The occurrence of conglomeratic duricrusts in the riverbed can also influence incision rates. Phase 2 (~47 ka) records are at a height of 60–80 m (a.r.b.) in the Paraopeba valley, while in the Conceição valley, deposits are at 15–20 m (a.r.b.). In the former valley, there are basically no conglomeratic duricrusts, whereas in the later valley, they were formed recurrently. Duricrusts (Phase 4, ~26 ka) are also present in several other valley bottoms (Conceição, Caraça, Barão de Cocais, Mango and Maracujá) and may have prevented the waterways from experiencing a later fluvial incision phase.

Another important question to note is a clear alternation between fluvial phases developed under a moister and/or warmer climate and phases in drier and/or cooler periods according with literature data. The average interval between the moister/warmer phases is approximately 41 ka, while that between the drier/cooler phases varies between 21 and 18 ka. Thus, the interval between the moister/warmer phases approaches that of the earth's obliquity variation cycles, whereas those between the drier/cooler phases approach the earth's cycles of precession of the equinoxes. However, it would be reckless to invoke the mechanism of crustal 'loading' and 'unloading' [1] to explain the pattern of terraces observed, because the existence of several fluvial levels within the same 100 ka cycle is considered rare [1].

It seems that there may have been filling of valley bottoms in the dry phases (thicker successions) and formed duricrusts, i.e. the valleys would have filled and there would have been no river downcutting into bedrock. In the wet phases, there may have been a relatively quick fluvial incision, which would have occurred in the previously accumulated sediments, and, in the following context, in the saprolite, leaving staggered dry phase records. If fluvial incisions occurred in a certain balance with sedimentation, then fluvial successions during the wet phase would be accumulated. However, due to the permanence of the incision, there would be a migration of knickpoints and consequent abandonment of the wet phase records. Reinforcing a Pleistocene-Holocene neotectonic pulse [7], epirogenetic movements induced by the crustal mass balance in response to intense regional denudation may also have been responsible for that abandonment. The return of a dry phase would start a new cycle.

In the QF, only climatic oscillations—inducing hydrosedimentological changes in the river systems—could have caused abandonment and formation of fluvial levels in response to the new climatic conditions of the Holocene. Phase 4 fluvial archives are still present in the Mango, Maracujá, Conceição, Caraça and Barão de Cocais valleys, so that subsequent records are inset (Phases 6 and 7). Consequently, there is no fluvial downcutting. There are also no traces or evidence of large Holocene rearrangements in the river systems that would justify a change in the hydro-sedimentological regime through the loss of drainage areas.

REFERENCES

1. Bridgland, D.; Westaway, R. 2008. Climatically controlled river terrace staircases: a worldwide Quaternary phenomenon. Geomorphology, 98, 285–315.

2. Schanz, S.A.; Montgomery, D.R.; Collins, B.D.; Duvall, A.R. 2018. Multiple paths to straths: A review and reassessment of terrace genesis. Geomorphology, 312, 12–23.

3. Romano, A.W. 1984. Geologia da folha de Esmeraldas. Belo Horizonte, Instituto de Geociências Aplicadas.

4. Marques, M.R. 1997. Morfodinâmica fluvial cenozóica no vale do Rio Paraopeba entre o Fecho do Funil e Juatuba, Minas Gerais. MSc Thesis. Belo Horizonte, Federal University of Minas Gerais – Brazil.

5. Saadi, A. 1991. Ensaio sobre a morfotectônica de Minas Gerais: tensões intraplaca, descontinuidades crustais e morfogênese. Full Professor Thesis. Belo Horizonte, Federal University of Minas Gerais – Brazil.

6. Safran, E.B.; Bierman, P.R.; Aalto, R.; Dunne, T.; Whipple, K.X.; Caffee, M. 2005. Erosion rates driven by channel network incision in the Bolivian Andes. Earth Surface Processes and Landforms 30, 1007–1024.

7. Saadi, A. 1993. Neotectônica da Plataforma Brasileira: esboço e interpretação preliminares. Geonomos 1 (1), 1–15.