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Cenozoic drainage evolution of West Africa: Spatial and temporal constraints from the lateritic record

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In cratonic domains that are by definition mainly subjected to epeirogeny, climate is a first-order landscape-shaping agent. In the tropical belt, long-term topographic evolution of cratons involves punctuated development of lateritic covers of subcontinental extent that may be partially preserved by duricrusts. The present study combines drainage analysis and the spatial distribution of dated relict laterites to constrain the main reorganization stages of the large-scale drainage of the Man-Leo upwarp of West Africa.

Long-term climate oscillations over the Cenozoic (due to continental drift and dilatation/contraction of the inter-tropical zone) led to the formation of successive lateritic planation surfaces of regional extent on the rise and its surroundings. Warm humid periods were propitious to dominant rock weathering whereas pedimentation-dominated mechanical erosion prevailed during dryer periods. Five stepped paleosurfaces are recognized in West Africa. The Bauxite (Eocene, 59-45 Ma) and the Intermediate Surface (Oligocene-Early Miocene, 29-24 Ma) derived from intense in situ chemical weathering and are capped by alumino-ferriginous duricrusts (Reference 1). During these early periods, the drainage network was essentially dentritic with very gentle regional slopes and subdued relief. The High Glacis (Mid-Miocene, 18-11 Ma), the Middle Glacis (Late Miocene, 7-6 Ma) and the Low Glacis (Pliocene, 3 Ma) result from pedimentation periods characterized by cold /dry episodes interrupted by warmer humid episodes, which allowed moderate chemical weathering and subsequent ferricrusting of the pediment surfaces (ages that are given are those of the weathering of the surfaces, Reference 1). During pedimentation intervals, base level lowering led to the dissection of former lateritic covers. The High Glacis dissection stage had a profound imprint onto the landscape by the development of wide valleys that established the location of the main actual drains by at least 11 Ma and most probably by 18 Ma. The valleys became narrower and the drainage network denser as a result of down cutting of the High Glacis surface by the Middle and Low Glacis.

The West African drainage network consists in 4 major river systems: the Niger river, the Volta rivers, the Senegal river and the short coastal drains comprised between the Volta and the Senegal rivers. The systematic analysis of the drainage network reveals numerous river captures in each of these river systems. Combined with mapping of paleosurface relicts and the geological record of the Cenozoic intracratonic basins, these observations indicate that a major reorganization of the drainage occurred before the settlement of the Intermediate Surface by the latest Oligocene, by 29-24 Ma. This reorganization event corresponds to the capture of the northward-flowing drainage of the rise that fed intracratonic basins (Taoudeni, Iullumeden) by a modern Niger River flowing SE. The Atlantic drainage pattern from the Niger delta to Guinea has undergone a major wave of regressive erosion from the coast towards the interior of the rise that was accompanied by a northward retreat of the drainage divide. This retreat decreases from East (Volta system) to West (coastal drains). In the same way, the capture of upstream drains of the Niger River by the West flowing Senegal River attests to post Intermediate (i.e. 24 Ma) eastward regressive erosion from the Atlantic coast into the interior of the rise. Most of this denudation seems to have been achieved during the High Glacis stage i.e. between 24 and 18 Ma ago.

To summarize, the establishment of the main drains in West Africa is older than 24 Ma, instead of Plio-Quaternary as previously proposed by some authors. Later reorganization of the drainage consisted in northward / eastward migration of the main river watershed from the Atlantic coast towards the interior of the Guinea-Leo rise, essentially before 18 Ma.

Reference 1: Beauvais, A., G. Ruffet, O. Henocque, and F. Colin (2008), Chemical and physical erosion rhythms of the West African Cenozoic morphogenesis: The 39Ar-40Ar dating of supergene K-Mn oxides, J. Geophys. Res., 113, F04007, doi:10.1029/2008JF000996.