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A proposed drainage evolution model for Central Africa—Did the Congo flow east?

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Abstract

Understanding the origin of Sub-Saharan biodiversity requires knowing the history of the region's paleo-ecosystems. As water is essential for sustaining of life, the evolving geometry of river basins often have influence on local speciation. With this in mind, we analyse drainage patterns in Central and East Africa. Evidence from marine fossils suggests the Congo Basin was submerged for much of the Cretaceous, and after being uplifted drained eastwards through a paleo-Congo river towards the Indian Ocean. Two remnant peneplains in the Congo Basin are interpreted as evidence that this basin was tectonically stable on at least two occasions in the past. The lower peneplain is interpreted as the base level of the drainage pattern that had its outlet in Tanzania, at the present Rufiji Delta that was once over 500 km wide. The Luangwa, today a tributary of the Zambezi river, was a part of this drainage network. This pattern was subsequently disrupted by uplift associated with the East African Rifting in the Oligocene–Eocene (30–40 Ma). The resulting landlocked system was captured in the Miocene (5–15 Ma) by short rivers draining into the Atlantic Ocean, producing the drainage pattern of Central Africa seen today.

Keywords: River basins of Central Africa; Paleo-drainage; Biodiversity; Geomorphology; Tectonics

1. Introduction

Africa has a unique bimodal topography inherited from its birth during the break-up of Gondwana 120–180 million years ago (Doucouré and de Wit, 2003; Stankiewicz and de Wit, 2005a,b). At that time only the southern parts of Sub-Saharan Africa stood above sea level, supporting a Gondwana-related biodiversity that included early Afrotheria mammals and a complex Gondwana-rooted flora (e.g. Murphy et al., 2001; Eizirik et al., 2001; Anderson and Anderson, 2003; Masters and de Wit, submitted for publication). Most of Africa to the north remained below sea level until the end-Cretaceous (65 million years ago). Thereafter a complex series of uplifts and stream captures created the river basins of Sub-Saharan Africa as we know them today, and during which ex-Gondwana stocks evolved into Africa's modern biodiversity. New river-basins and related ecosystems developed across this dynamic landmass, closely entwined with the simultaneous changes in global and local climate changes during the Cenozoic. Biodiversity of Sub-Saharan Africa changed in response, including the development of grasslands and the acceleration in silicate weathering (Retallack, 2001). This is but one example of the complex way in which Earth systems interact with each other. Tracking such paleo-ecodynamics remains a formidable and urgent challenge to African Earth and life scientists, as today this biodiversity across much of Africa is being severely decimated in various ways through human over-consumption of nature's net primary production (de Wit and Anderson, 2003; Imhoff et al., 2004). Little is known about the rate of this decline, or about any biodiversity thresholds that might exist. Evolution of paleo-landscapes, and in particular of river basin and drainage patterns of Sub-Saharan Africa,

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provide a first order constraint within which to chart changes in past biodiversity, and to help predict them in future (e.g. Cotterill, 2003).

In our study we trace river basin evolution of parts of Sub-Saharan Africa from the Cretaceous, when Central Africa emerged above sea level. We show that it is possible that the proto-Congo river at first drained into the Indian Ocean, close to the present Rufiji Delta in Tanzania. We then track the changing river patterns from this hypothetical scenario to the present day.

2. Drainage pattern of contemporary Central Africa

The drainage pattern observed today in Central Africa and its surroundings is shown in Fig. 1. This figure is generated from the CIGCES Africa database (recently renamed to AEON Africa Database, de Wit and Stankiewicz, submitted for publication). This large GIS database includes all rivers and lakes in Africa, manually digitised from topographic maps. Fig. 1 does not show the database's full resolution. The average stream separation (ratio of land area to total stream length) of the database is 15 km, and this corresponds to approximately 200,000 km of digitized rivers. All streams have also been classified as either perennial or non-perennial, and all river networks ordered according to the Horton–Strahler ordering scheme (Horton, 1945; Strahler, 1957). The database also includes other parameters, such as climatic conditions over the African continent, vegetation and soil types, geology, elevation above sea level, and many others (Stankiewicz and de Wit, 2005a,b; de Wit and Stankiewicz, submitted for publication).

Central African drainage is dominated by the Congo river (Fig. 2) with its sub-circular basin. This is, however, not a classic centripetal drainage pattern one would expect from a circular depression, as there is no convergence of drainage into a central point. In the southern one-third of the basin most of the drainage is directed north. These streams show very little convergence, and mostly join west-flowing streams. The main Congo stream, and the lower reaches of Oubangui and Zaire before their confluence, flow south-west. The areas where eastwards

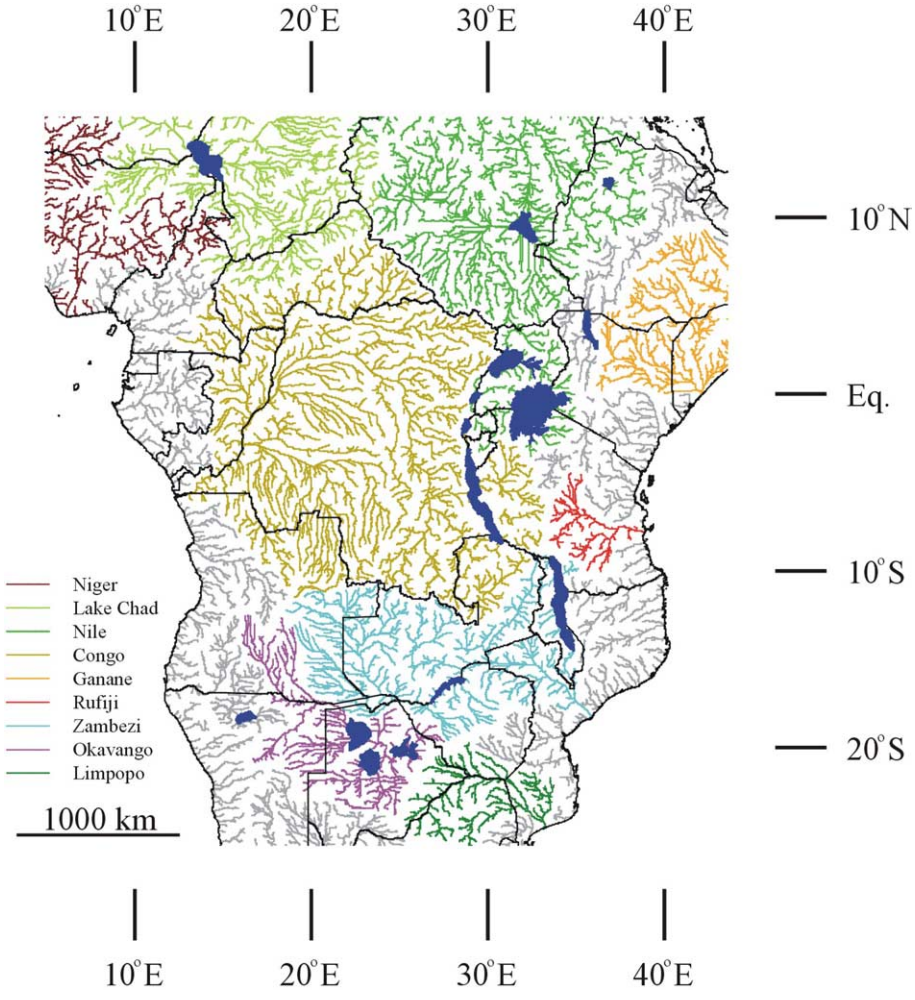

Fig. 1. Major drainage basins in Central Africa (AEON African river database based on data from De Beers Exploration). Rivers in Figs. 2a, 5 and 8b are from the same database.