U-Pb single zircon grain dating of Present fluvial and Cenozoic aeolian sediments from Gabon: consequences on sediment provenance, reworking, and erosion processes on the equatorial West African margin

MICHEL SERANNE¹, OLIVIER BRUGUIER¹ and MATHIEU MOUSSAVOU²

Key-words. – West Africa margin, Continental margin, Denudation, Cenozoic, Sedimentary sources, Detrital sediment.

Abstract. – U-Pb ages obtained from detrital zircon from terrigenous sediments are used to determine the sources. Present fluvial sand-bars of the Ogooué river yield age spectra of detrital zircons in agreement with Archean and Early Proterozoic sources found in the drainage. The large proportion of Late Proterozoic zircons cannot be derived from primary erosion of the watershed basement rocks, since there is no formation of that age in the area.

This later group of zircons is in good agreement with reworking of the aeolian Paleogene Batéké Sands, by regressive erosion in the upper reaches of the Ogooué river, as they contain a majority of Late Proterozoic age zircons. The sources of Late Proterozoic zircons in the Batéké Sand are very distant, and transported and reworked – at least in part – by aeolian processes. Our results, together with the widely distributed Paleogene sediments over continental Africa, suggests that Paleogene was a time of subdued erosion of the cratonic areas and extensive reworking, transport and deposition within continental Africa. In contrast, our results from the Ogooué river indicate active present incision of the cratonic area, erosion of the previous continental sediments, and export of the river bed-load to the continental margin. This temporal evolution of erosion-transport-deposition is correlated with the drastic climate change that occurred during the Cenozoic, leading to a more efficient mechanical erosion, and it correlates with the increase of terrigenous flux to the margin, observed during the Neogene.

INTRODUCTION

The occurrence of large terrigenous depocenters on continental passive margins give rise to the question of sediment provenance. Erosion of elevated and active orogens can easily account for large sediment flux to continental margins, as for example the erosion of the active Himalaya feeds the Indian continental margins and the Indus and Bengal deep-sea fans (e.g. [Clift et al., 2001]. On the equatorial west African margin, the size of the Congo deepsea fan and associated passive margin sedimentary sequences, is surprisingly large with respect to the tectonically stable hinter-
land (fig. 1) [Leturmy et al., 2003]. Discussions on the mass balance bear on 1) long-term geodynamics of continental margins, allowing renewed uplift of the hinterland [Luzerzeau et al., 2003], 2) tracing the respective contribution of major, versus numerous small rivers [Bentahila et al., 2006], and 3) on the temporal evolution of sediment flux to the margin, due to the interaction of climate and tectonics [Lavier et al., 2001; Séranne and Anka, 2005].

U-Pb ages obtained from detrital zircon from sediments yield results that can be interpreted in term of signature of sedimentary sources (e.g. [Bruguier, 1996; Bruguier et al., 1997; Avigad et al., 2003]). Analysis of zircons from clastic formations of different ages and different depositional environment, within a river drainage allows : a) to trace the sedimentary sources, b) to document temporal evolution of the sources, and c) to infer changes in erosion-transport-deposition processes within the margin hinterland.

The Ogooué river basin (fig. 1), adjacent to the giant Congo river, is the third African fresh-water hydrological source to the Atlantic [Mahé et al., 1990], and a significant contributor to the sedimentation of the equatorial West African margin [Mougamba, 1999]. Sandy alluvium of the lower reaches of the Ogooué river gives a representative sample of the different lithologies found within the drainage, modulated by varying erosion processes. Such fluvial sediment provides information on the erosion-transport processes that presently feed the equatorial West African margin. Similarly, analyses of the older continental sandstones formation found in the drainage basin, yield information on the sources during ancient (Cenozoic) times. The aim of this contribution is to investigate consequences of the temporal variations of sedimentary sources and the evolution of the erosional-depositional cycle during the Cenozoic, on the continental margin hinterland.

GEOPHYSICAL AND MORPHOLOGICAL SETTING

The structural framework of equatorial west Africa consists of an Archean basement (the Congo craton) surrounded by Early and Late Proterozoic belts, and unconformably overlain by a Phanerozoic sedimentary cover. The latter can be split into a pre-Cretaceous sequence (with very scarce exposures), and a younger sequence linked to the rifting of Gondwana. The Cretaceous to Present coastal basin records the Atlantic rifting and continental margin development [Reyre, 1984; Teisserenc and Villemin, 1989; Séranne et al., 1992], while the internal Congo basin (« Cuvette Centrale ») records the long-term evolution of the intra-cratonic zone [Giresse, 1982; Giresse, 2005].

The morphology of the onshore part of the Gabon continental margin is dominated by a lowland coastal plain occupied by the wide Ogooué delta, downstream of Lambaréné (fig 2). The Congo craton and Proterozoic orogenic belts present NW-trending ridges up to 1000 m altitude (Mont de Cristal and Chailu). Most of the Ogooué river drainage is set over this basement. To the East, the edge of the Batéké plateau makes the water divide between the Ogooué and the Congo watersheds, and the western boundary of the “Cuvette Centrale”. This relief is gently sloping east, toward the Congo river, whereas it is highly dissected to the west by active headward erosion of numerous tributaries of the Ogooué river. Ogooué drainage basin is about 215,000 km² and includes the Ivindo and the Ngounié rivers as main...
tributaries. At the city of Lambaréné, where the river enters the coastal plain for its final track, it has an average yearly discharge of 4700 m$^3$/s (although highly variable throughout the year) and an average suspended sediment load of $19.7 \times 10^6$ t/y [Syvitski et al., 2005]. In spite of an average discharge one order of magnitude smaller than the Congo, the Ogouâ has a comparable sedimentary flux ($22.7 \times 10^6$ t/y for the Congo). These values suggest that the Ogouâ watershed is a zone of active erosion and thus a significant present-day source of terrigenous sedimentation on the equatorial west African continental margin. This might not have been true throughout geological time (e.g. [Séranne and Anka, 2005]).

The Batéké Sands unconformably overly the Archean craton and its Late Proterozoic cover, as well as the Late Proterozoic Panfrican metasediments. River incision in the Cuvette Centrale shows that they are also unconformable over Late Cretaceous terrigenous sediments, and are covered by Quaternary fluvial-lacustrine sediments. They belong to the Kalahari system [De Ploey et al., 1968] which extends across Africa south of the Equator, and they are correlated with the Cenozoic formations “Continental Terminal” of western Africa [Lang et al., 1990]. Two major sedimentary sequences have been distinguished within the continental Batéké formation: the Grès Polymorphes and the Sables Ocres [Cahen, 1954; Le Marechal, 1966]. More recent unconformable formations are described in the Cuvette Centrale [Giresse and K’vadec, 1971] and in the coastal area of Gabon [Peyrot, 1998] and Congo. These younger unconsolidated sand deposits characterise fluvio-lacustrine environments more or less reworked by aeolian processes; they are not present in the studied area. Dating such continental formations is difficult due to the scarcity of preserved fossils and pollen. However there is an agreement on a post-Late Cretaceous and Pre-Miocene age (i.e. Paleogene) for the Grès Polymorphes and a Neogene age for the Sables Ocres [Cahen, 1954; Le Marechal, 1966; De Ploey et al., 1968].

**SAMPLING**

**Ogouâ sands** were sampled at Lambaréné (fig. 2), on the surface of a sand bar in the active bed of the river. It consists of medium to coarse, well sorted sand, that is classically transported as bed load and accumulated as sand bars during the two yearly high water periods (May – June and November – December). Such bars are formed, migrate and disappear frequently, which indicate that the sediments sampled are typical of the current sediment bed-load of the river. Lambaréné being located downstream of all the major tributaries of the Ogouâ, this sample is thought to represent a reasonably good mix of all the different sources of the drainage area.

**Batéké sands** were taken from the Léoni canyon, located close to the Ogouâ eastern water divide (fig. 2). The site is a tourist attraction due to the circa 150 m-incision by regressive erosion of the steep edge of the plateaux Batéké (650 m altitude), displaying the reddish-purple to ocre sandstone beds. The unconsolidated sands are being actively eroded and slope processes feed the Léoni river (tributary of the Ogouâ river) with bed-load material.

The sample comes from the top of the Paleogène Grès Polymorphes formation (fig. 3), a white to pink, medium, well sorted and well rounded sand formation that presents several metres high foresets of all the different sources of the drainage area. The sample, the yellow to light brown massive sand formation is attributed to the Neogene Sables Ocres, which is not complete as it is eroded.

**ANALYTICAL METHODOLOGY**

Zircon grains from the sand samples were concentrated by conventional heavy liquids techniques and were subsequently processed by magnetic separation using a Frantz isodynamic separator. Flawless zircons (free of visible inclusions and fractures) from the least magnetic separates were hand-picked under alcohol and then embedded in epoxy resin with chips of a matrix-matching standard material (zircon standard G91500) [Wiedenbeck et al., 1995]. The mount was then slightly polished to expose the internal part of the grains, which in the case of the Ogouâ sand were observed by scanning electron microscope (SEM) using the back-scattered electron (BSE) mode. After repolishing to remove the carbon coating, the mount was then cleaned with soap, ultra-pure MQ water and dried with alcohol before its introduction in the ablation cell. U-(Th-)Pb analyses were performed by laser ablation ICPMS at Geosciences Montpellier, University of Montpellier 2, following the analytical procedure outlined in Bruguier et al. [2001] and given in earlier reports [Neves et al., 2006]. The spot size of the laser beam was 51 µm and the laser was operated using...
an energy density of 15J/cm² at a frequency of 4 Hz, which resulted in a c. 40-50 000 cps on the ²⁰⁶Pb isotope (i.e. 3000 cps/ppm of Pb). Pb/Pb and U/Pb ratios of unknowns were calibrated against the G91500 zircon crystal which was repeatedly measured and used to correct for interelement fractionation and mass bias. Errors measured on the standards and on each unknown were added in quadrature to produce the results quoted in table I. The later reports only the analyses for which ²⁰⁶Pb was not detected (i.e. no common Pb correction).

RESULTS

Ogooué sand

The results of laser ablation U-Pb analyses of 38 detrital zircons (44 spot analyses) from the Ogooué sand are shown in figure 4. The zircon population is constituted by various morphologies, including rounded, sometimes pitted grains, and euhedral to sub-euhedral zircons which suggests a varied provenance. The zircon grains analysed have ages ranging from 580±8 Ma (1σ) to 3062±9 Ma (1σ). The age spectrum is dominated by Archean (2.8-3.1 Ga), Paleoproterozoic (1.95-2.10 Ga) and Neoproterozoic (580-800 Ma) age peaks and also includes one concordant grain at 2455±10 Ma (1σ). Although the above age groups are well constrained by concordant analyses, many zircon grains are discordant, which reflects postcrystallisation disturbances (see fig. 4). This is consistent with the Scanning Electron Microscope (SEM) imaging which reveals that some grains yield complex internal structures such as recrystallized domains or metamorphic overgrowths (fig. 5). Since the spot size was generally larger than the observed zircon domains, it is likely that the discordant analyses reflect straddling by the laser beam of various domains rather than Pb loss from the crystal lattice. The occurrence of low-U zircons with high discordant degree (see analyses 1 and 2) is consistent with this view and pleads against Pb loss enhanced by radiation damage to the zircon lattice [Silver and Deustch, 1963]. These analyses have not been used in the discussion since discordance makes it difficult to determine the age of the source rock from which the zircons derived. However they point to a metamorphic overprint of the source area, possibly, but not exclusively within the Pan-African (550-700 Ma) event. In the cumulative probability diagram of figure 6, where the heavy plain line represents age grouping defined by analyses which are less than ±5% discordant, it can be seen that the main detrital input derived from Archean rocks with a sharp age peak at c. 2.95 Ga. This component constitutes 46% of the concordant zircon grains analysed. The Paleoproterozoic age peak (19%) has a maximum at around 2.0 Ga, whereas Neoproterozoic zircons (31%) fall in three age groupings at 570-600 Ma, 650-670 Ma and c. 800 Ma.

Batéké sand

A total of 44 analyses of zircons from the Batéké sand has been performed. Dated grains range in age from Archean to Neoproterozoic (fig. 7). Three analyses, concordant at 2620±9 Ma, 2669±3 and 2877±8 (1σ), document the occurrence of Archean rocks in the source area. However, in contrast to the present-day Ogooué sand, the age spectrum is dominated by Neoproterozoic zircons, which represent ca. 60% of the analysed grains whereas the proportion of Archean grains is only 7%. The Neoproterozoic component yields major age peaks at c. 700-750 Ma and 800-820 Ma, and a subordinate peak at c. 620 Ma (fig. 8). Other age peaks include Early Neoproterozoic to Late Mesoproterozoic grains (c. 980 Ma and c. 1100 Ma) and Paleoproterozoic grains at c. 1.8 Ga, c. 2.0 Ga and a tight grouping at c. 2.1 Ga. The youngest concordant grain analysed was dated at 576±3 Ma (1σ).

TESTING POSSIBLE SOURCES FOR THE OGOOUÉ SANDS

The Ogooué watershed extends over the Congo Craton formed by Archean and Paleoproterozoic gneisses (fig. 2). It is therefore expected that erosion of the Congo Craton will provide a large proportion of Archean zircons. The Archean gneisses of the Chaillu (southern part of the drainage) the Mont de Cristal (in the north) of the regional basement, which have yielded a variety of ages from 2650 to 3090 Ma [Caen-Vachette et al., 1988; Ledru et al., 1989] account for the oldest zircon grains found in the Ogooué sands. Several somewhat younger orogens and magmatic events are found in the present Ogooué watershed. A regional West Central African belt, extends from Cameroon to Congo [Ledru et al., 1989; Feybesse et al., 1998]. The initial stages of activation of the mobile belt between Archean cratons is marked by emplacement of plutonic rocks between 2515 and
### Table 1. – U-Th-Pb single zircon grain dating of fluvial and aeolian sediments from Gabon

All grains were selected from non-magnetic separates at full magnetic field in Frantz magnetic separator. All analyses have 204Pb below detection limits and the quoted ratios are only corrected for Pb/Pb mass bias and U/Pb inter-element fractionation (uncorrected for common Pb). * stands for radiogenic.

#### Disc. (%) is percentage discordance assuming recent lead losses.

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</table>

**Table 1.** Résultats des analyses U-Th-Pb par ICP-MS ablation laser pour les zircons de l’Ogooué et des sables Batéké. Tous les grains ont été sélectionnés parmi la fraction non magnétique traitée par un séparateur magnétique Frantz. Toutes les analyses ont un 204Pb inférieur au seuil de détection et les rapports ne sont corrigés que de la discrimination de masse pour le Pb/Pb et du fractionnement du rapport inter élément U/Pb. (*) indique les isotopes radiogéniques. Disc. (%) indique les pourcentages de discordance résultant des pertes en plomb récentes.
2435 Ma [Feybesse et al., 1998], and presently cropping out east of Lambaréné. Erosion of these formations may have provided the zircon grains dated at 2455±10 Ma. According to Feybesse et al. [1998], a second stage of plutonic rocks generation occurred as late-orogenic granites emplacement between 2040 and 1920 Ma ago. Erosion of these late stage Eburnean rocks such as the Fougamou and Lecoué granites (Guerrot and Mayaga-Mikolo in Bouchot and Feybesse [1996]) is the most probable source of the 1.95 – 2.10 Ga detrital zircons identified in the Ogooué sands.

From that period onward, the area remained remarkably devoid of younger plutonic events, but recorded deposition of the Middle Proterozoic (Francevillian) sediments dated around 1750 Ma [Weber, 1968]. The later may have reworked older zircons from the neighbouring Congo craton and mobile zones; but they may also include sediments derived from further away and therefore, of unknown age.

The Late Proterozoic Pan-African orogeny and its multiple branches straddling the African continent is characterized in the studied area by reactivation of older structures: the West-Congolian belt reworked older Eburnean (2 Ga) basement [Maurin et al., 1991] and pre-Pan-African rift-related magmatism (1 Ga) [Tack et al., 2001]. However, the later plutonic activity is located south of the study area, outside the Ogooué drainage. The sedimentary basin located in the foredeep of the Pan-African belt, exposed within the Ogooué drainage, may have collected detrital zircons eroded from the thrust nappes of Paleoproterozoic terrains [Caen-Vachette et al., 1988], but the lack of Pan-African magmatic activity in the West-Congolian belt, prevented crystallisation of zircons of Late Proterozoic age.

The source of younger age populations found in the Ogooué sand (570-800 Ma) is therefore questionable, since all magmatic and high-grade metasedimentary rock cropping out in the watershed, are significantly older. One possible source for detrital zircons of Pan African age could be the reworking of younger terrigenous sedimentary formations such as the Cenozoic Batéké Sand, whose 550-750 m altitude plateau makes the easternmost part of the Ogooué watershed.

TESTING POSSIBLE SOURCES FOR THE BATÉKÉ SANDS

Deposition of the Cenozoic Batéké sands partly results from aeolian transport; therefore, the sources are not restricted to a well defined watershed. Analyses of the different detrital zircon age groups suggest possible sources for the sediments.
Similarly to the source for Ogooué sands, the Archean (2.9 and 2.6 Ga) and the Paleoproterozoic (2.1 Ga) age groups may be derived from the Congo craton that is underlying the Batéké sand formation, and from the Eburnean intrusions in the surrounding mobile belts [Caen-Vachette et al., 1988; Ledru et al., 1989; Penaye et al., 2004; Lerouge et al., 2006].

The next age group (1850-1780 Ma), not present in the Ogooué sands, does not correspond to a major episode of continental crust accretion in Africa. However, the Adama-wa-Yadé domains of Cameroon have yielded numerous Paleoproterozoic ages [Toteu et al., 2004]. The migmatite rocks presently making the comparatively small basement exposure of the Lambaréné horst yielded an age of 1840 Ma [Caen-Vachette et al., 1988]. Further away, in southeastern Africa, the basement rocks of the Bangweulu block (N. Zambia, Tanzania, and Zaire) consists of rocks ranging from 2000 to 1800 [Rainaud et al., 2005].

Similarly to the Ogooué sands, the Batéké sands are characterised by a marked lack of ages between 1750 and 1100 Ma, in spite of the large occurrence of granitoids of this age range in Cameroon [Toteu et al., 2004; Tchakounté et al., 2007] and south-central Africa [Johnson et al., 2005].

Neoproterozoic zircons are by far the most frequently found in the Batéké sands. Two small subgroups: the 1100 and 970 Ma age peaks, may correspond to the onset of Rodinia break-up, which generated extension-related magmatism in the western edge of the Congo craton [Tack et al., 2001]. These groups also correlate with magmatic events documented in Cameroon [Toteu et al., 2006]. The largest and youngest group, centred on 750 Ma corresponds to the Neoproterozoic Panafrican orogeny, that led to the assembly of Pangea. Such a widespread orogeny involved thrusting, folding and metamorphisms of marginal sedimentary sequences and reworked older crustal blocks, but did not consistently involve syn- to late-kinematic intrusion of granitoids. In particular, the closest Panafrican outcrops (West Congolian belt and the southern Central African belt, fig. 9) seem devoid of any granitoid of that age. On the opposite, the widespread occurrence of syn- and post-kinematic intrusions in the Central African belts of Cameroon yielded Panafrican ages [Toteu et al., 2001]. Other granitoids of known Panafrican ages are found at a greater distance in the Damara belt, in south-central Africa [Johnson et al., 2005], along the Red Sea basement outcrops [UNESCO, 1986] and in the Hoggar [Caby, 2003]. The actual source of Panafrican zircons found in the Batéké sands is difficult to identify for several reasons:

- Due to the fluvial and aeolian sedimentary environment of the Batéké sands, they can be transported either by the river (and the source can be sought within the Cenozoic river drainage basin), and/or they can be transported by the

![Figure 5](image-url)

**FIG. 5.** – Images au microscope électronique à balayage (MEB) de zircons détritiques des alluvions de l’Ogooué révélant des structures internes complexes, telles que des recristallisations ou des auréoles de croissance. Ces auréoles sont probablement à l’origine des âges discordants observés sur les courbes concordia de la figure 4 (voir texte pour discussion).
wind (and possibly come from outside the river watershed). The Batéké sands belong to the Cenozoic sandstones covering most of the Congo cuvette; since there are no mapped Panafican granitoids within the Congo watershed [UNESCO, 1986], a long-distance aeolian transport must be invoked to account for the Neoproterozoic zircons.

- Alternatively, the Batéké sands rework earlier, post-Panafican, extensive continental clastic formations, derived from the erosion of Neoproterozoic terranes. As a result, zircons reworked from the post-Panafican sedimentary sequences are mixed with zircons delivered by Panafican erosion. This especially applies to the extensive Cretaceous terrigenous formations that are underlying the Cenozoic sandstones of the Congo Cuvette, and has already been documented by [De Ploey et al., 1968]. The problem of the origin of zircons becomes more complex if they are derived from reworked sedimentary formations of pre-Atlantic rifting, as South American plate sources should then be considered. In any case, the Batéké sands are dominantly derived from erosion of several, distant sources, with a minimum of 500 km (for Cameroon source zone).

**IMPLICATION FOR EVOLUTION OF EROSION PROCESSES DURING CENOZOIC**

The contrasted detrital zircon composition of the two studied samples clearly shows a change in the sources for the host sediment. We interpret this change as characterizing a change of erosion and transport processes that led to the deposition of the Batéké Sands during the Paleogene and of the Ogooué Sands in the present time.

The sources of present-day Ogooué sediments are all within the river watershed. Our results give evidence for active mechanical denudation of the craton, while headward erosion of the poorly lithified Batéké Sands provides a secondary source for alluvium. The sources of the Cenozoic Batéké Sands gives evidence for predominant erosion of the Panafican belts and secondary input from Archean craton. These contrasted sedimentary sources reflect a different distribution of exposed Archean, Proterozoic and Panafican terrains. The low proportion of Archean input in the Batéké Sands may be due to more extensive sedimentary cover of the cratons during the Paleogene than presently.

Indeed, headward erosion of the Batéké Sand hills to the east, and of the Atlantic rift margin sediments to the west [Anka, 2004] suggests that at least the margins of the Archean cratons were covered until the Neogene. Unpublished data and ongoing studies on apatite fission track analyses [see Anka, 2004] as well as regional studies of the uplift-erosion of the onshore Atlantic margin [Séranne and Anka, 2005] document erosional denudation of the craton, now appearing as a window between the Congo cuvette and the coastal Mesozoic-Cenozoic basins. In addition, extensive weathering mantles that developed over long-term periods, during the Cretaceous and Paleogene [Tardy and Roquin, 1998; Gunnell, 2003] may have protected the basement from mechanical erosion.

One drastic difference in the Paleogene vs Present erosion-transport-deposition systems comes from the obvious observation of extensive Paleogene sediment distribution over wide areas of continental Africa [Lepersonne, 1961; Guiraud et al., 2005; Haddon and McCarthy, 2005] which suggests that depositional processes were dominant over erosion, and that extensive areas were subjected to deposition or reworking of terrigenous sediments. In contrast, Quaternary continental deposition is restricted to the lower part of the Cuvette Centrale and the lowermost Ogooué delta, while incision and erosion processes dominate morphogenesis of most of the region.

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**FIG. 6.** – Cumulative probability diagram of Ogooué Sands analyses. The heavy plain line represents age grouping defined by analyses which are less than ± 5% discordant. This defines uneven groups: almost half of the zircons are Archean in age, one fifth are Paleoproterozoic and nearly one third are Neoproterozoic (Panafican).

**FIG. 6.** – Histogramme des âges obtenus sur les zircons des sables de l’Ogooué. La ligne continue représente les âges définis par les analyses qui présentent moins de 5% de discordance. Trois groupes sont ainsi définis : quasiment la moitié des zircons sont archéens, un cinquième sont paléoproterozoïques et presque un tiers sont néoproterozoïques (Panafriacain).
Alternatively – or possibly in conjunction with – different forcings on the mechanical erosion and weathering processes active during Batéké Sand deposition can account for the observed change. The increased amplitude of high-frequency climate changes driven by glacial–interglacial successions that occurred during the Neogene, and that drastically increased in Plio-Pleistocene times, may have favoured mechanical erosion [Séranne, 1999; Molnar, 2004]. Geomorphology of equatorial west Africa clearly indicates Neogene river incision, and dismantling of possible old albedo cover [Peyrot, 1998; Tardy and Roquin, 1998].

Geochemical analyses of the Congo river at Brazzaville indicate that present mechanical erosion rates (8 t/km²/y) outweighs chemical erosion rates (5 t/km²/y) in the upstream watershed [Gaillardet et al., 1995]. Similar climate in the adjacent Ogooué basin would suggest a similar proportion of mechanical and chemical erosion. However, the relatively large suspended load (19.7 t/y for an area of 0.14 \(10^6\) km²) presently carried by the river compared with that of the Congo (22.8 t/y for an area of \(3.7\ 10^6\) km²) [data from Harrison, 2000; http://www.wsag.unh.edu/index.html] clearly indicate a denudation rate one order of magnitude higher in the Ogooué than in the Congo watersheds (0.06 mm/y and 0.002 mm/y, respectively). The different proportions of lithologies exposed in the two watersheds considered (dominantly sandy in the Congo, and dominantly cratonic in the Ogooué), and/or the higher mean slope gradient in the Ogooué basin, may account for such a discrepancy. The amount and distribution of erosion in equatorial west Africa during the Tertiary has been analysed by extrapolation of geological relict surfaces [Leturmy et al., 2003]. It shows that the basement in the Ogooué watershed has suffered denudation ranging from several hundreds of metres up to 1 km. Such values of denudation are consistent with the high values gradient for the coastal rivers (such as the Ogooué) compared with the low gradient characterizing the Congo tributaries [Leturmy et al., 2003]. High strontium isotopic ratios from Pleistocene sediments, cored off the Ogooué mouth [Bentahila et al., 2006], are in agreement with a sedimentary source mostly derived from the Archaean craton underlying the Ogooué drainage, and in strong contrast with the much lower values characterizing the strontium isotopic ratio of the rivers draining the Batéké sands. Accordingly, low radiogenic values from the Batéké sands indicate that they have a much younger source, or includes a significant proportion of a younger component. These independant sets of data support

**Fig. 7.** Concordia diagram of the laser ablation U-Pb analyses of the detrital zircons from the Paleogene Batéké Sands (44 grains).

**Fig. 7.** Diagramme concordia des analyses U-Pb par ablation laser des zircons détritiques de la formation paléogène des Sables Batéké (44 grains).

**Fig. 8.** Cumulative probability diagram of Batéké Sands analyses. In the Paleogene Batéké Sands, 60% of the analysed zircons are Neoproterozoic (Panafrican) in age, while the remaining older grains are spanning the Paleoproterozoic and Archean.

**Fig. 8.** Histogramme des âges obtenus par analyse des zircons des sables Batéké. Dans cette formation paléogène, 60% des zircons analysés sont d’âge protérozoïque (Panafricains), alors que les grains plus vieux sont répartis dans le Paléoprotérozoïque et l’Archéen.
CONCLUSION

The U-Pb ages of detrital single zircon grains, from two distinct sedimentary environments related to the Cenozoic to present evolution of equatorial west Africa, provide age spectra that are used to identify the sedimentary sources. In addition, the sources of the sediments can be used to infer varying modes of erosion and transport. Results of the study support the views that erosion and transport processes active in equatorial west Africa have drastically changed during the Cenozoic. In spite of a limited database, which can be increased and associated with other sedimentary source tracers, the results are consistent and lead to the following reconstruction.

During a long period spanning most of the Atlantic post-rift period, through to the Paleogene, the area was subjected to little denudation, which rarely affected the Archean basement, and the cratonic areas were the locus of extensive reworking and deposition of terrigenous sedimentary sequences. Fluvial and aeolian reworking of distant and varied sources account for the detrital zircon age spectra (dominated by Neoproterozoic-Panafrican ages) found in the Batéké sand. The extensive outcrops of continental Cretaceous and Tertiary sequences suggest a rather flat paleogeography with subdued relief (although there is no indication of elevation).

During the Neogene, the previous Cretaceous to Paleogene sedimentary cover is incised by rivers, and the cratonic basement is exposed to erosion, whose rate seems to increase steadily until Present. The poor chronostratigraphy does not allow precise dating of this change, and a higher resolution sampling would be needed to bracket the change. Such change occurs in conjunction with the Tertiary climate change which improved the rate of erosion [Séranne, 1999] and with renewed uplift of the onshore Atlantic margin and of the southern part of the African plate [Lavier et al., 2001]. This evolution of the continental area of equatorial Africa fits with the sedimentary record of the continental passive margin off Gabon - Congo - Angola, which displays an increase in terrigenous sedimentation during Neogene, and the growth of the Congo deep-sea-fan [Anka and Séranne, 2004; Séranne and Anka, 2005].

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