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Iron Age Landscapes of the Benue River Valley, Cameroon

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Abstract:	Iron Age settlements of northern Cameroon were dispersed across the landscape, taking advantage of different eco-climatic zones to exploit a variety of natural resources. Situated at the cusp of high and low terraces of the Benue River, mound sites in the area around Garoua have occupation histories spanning multiple centuries. The site of Langui-Tchéboua displays evidence for rapid accumulation of sediments approximately 700 years ago, which may have been a deliberate construction strategy that would have allowed the site's inhabitants to exploit resources in both floodplain and dryland contexts. The combined use of multiple dating methods and micromorphology provide novel insights into both the mechanisms of anthropogenic landscape change and possible motivations governing those choices.
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Iron Age Landscapes of the Benue River Valley, Cameroon

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Abstract

Iron Age settlements of northern Cameroon were dispersed across the landscape, taking advantage of different eco-climatic zones to exploit a variety of natural resources. Situated at the cusp of high and low terraces of the Benue River, mound sites in the area around Garoua have occupation histories spanning multiple centuries. The site of Langui-Tchéboua displays evidence for rapid accumulation of sediments approximately 700 years ago, which may have been a deliberate construction strategy that would have allowed the site's inhabitants to exploit resources in both floodplain and dryland contexts. The combined use of multiple dating methods and micromorphology provide novel insights into both the mechanisms of anthropogenic landscape change and possible motivations governing those choices.

Introduction

Settlement mounds and mound clusters are widely distributed across western Africa (FIG. 1), in circumstances that seem to be associated with increasing sedentism and intensive forms of land management during the Iron Age (Connah 1981; Klee and Zach 1999). Mounds are variable physically, encompassing a wide variety of different sizes and shapes, and occurring singly or in clusters that may include many smaller mounds. The dynamics of this differentiation is not well-understood, although it probably relates to local settlement patterns, architectural forms and soil types (Connah 1981: 53-56; Holl 2014: 3-10; McIntosh 1999).

In the late 1960s, Nicholas David undertook an intensive archaeological survey and series of excavations in the Benue River Valley of northern Cameroon (David 1968, 1981). Thirty-nine settlement mounds and mound complexes were identified during the survey (FIG. 2; David 1968, 1981) and three of these, Nassarao, Douloumi and Bé, were subject to screened excavations and radiometric dating. Unfortunately, most of the radiocarbon samples were destroyed in transit from Cameroon to the USA (David 1968), so little is known of the chronology of settlement in this area. Two radiocarbon ages analyzed place the initial occupation of Douloumi at 538±50 ^{14}C B.P. (505–650 CAL B.P.; P-1764) and an occupation at Bé at 150 cm above the initial settlement of the mound dated to 1061±35 ^{14}C B.P. (930–1055 CAL B.P.; P-1767) (David 1981). Subsistence foods were reported as including sorghum (*Sorghum* sp.), eleusine (*Eleusine* sp.), cattle (*Bos taurus*), goats (*Capra hirca*) and various species of fish (David 1981).

Cultural sequences from the Benue River Valley have not been examined over the 35 years since David's (1981) work. Given this region's potentially important role as a line of communication between the Niger River and Lake Chad-Logone-Chari hydrographic systems, thus articulating riverine access through much of West and Central Africa, its prehistoric chronology of human settlement deserves more archaeological research. In this article, we present the results of further research in the Middle Benue River Valley, focusing on formation processes of one of the mounds bisected by an ephemeral stream. We argue for purposeful aggradation of mound sediments at the site of Langui-Tschéboua (GRA-4) in a relatively short time-span, possibly in an attempt to elevate the settlement above the floodplain and to improve access to a diverse array of resources within the two geomorphic zones. This sequence represents a significantly different formation process than the traditionally espoused model of slow aggradation through repeated occupation and housing melting (e.g., Friedel 1978; Van Beek and Van Beek 2013). Optimal settlement proximal to Vertisols that supported *karal* agriculture (a subsistence strategy still practiced in the region today) is hypothesized to be a crucial factor in the construction of anthropogenic mounds.

The Study Region

The project area is located in the Benue River Valley, which drains the Mandara Mountains to the north and the Adamawa Plateau to the south (FIG. 1). The Benue River forms the lowland trough of the Yola Rift, with headwaters originating more than 200 km to the south of the project area in the Adamawa Plateau. Two fluvial terraces were identified in the area directly east of the city of Garoua, one of which was partially flooded at the time of the investigation. The first terrace (T-1) is located at approximately 200 m.a.s.l. and is comprised of seasonally-inundated, clay-dominant sediments in strongly-developed Vertisol (clay-rich grassland) soils. The second terrace (T-2) crests approximately 5 m above the first terrace and is comprised of a sandier fraction (mostly well-sorted fine to medium sands); it is currently being episodically incised by secondary drainages feeding the Benue River. T-2 articulates into the pediment zone of the Fali Mountains that lie to the north of the floodplain, and is variably overlain by associated alluvial fan sediments with weak, lateritic soils that can generally be classified as Lixisols (FAO)/Alfisols (USDA). Laterites (FAO)/plinthites (USDA) typically form in subhumid tropical ecosystems in which native tree species have been removed, mobilizing iron precipitates and indurating the subsoil. Anthropogenic mounds were located along the Middle Benue River floodplain and adjacent terraces (FIG. 2).

Throughout the Iron Age, sorghum and millet (*Pennisetum glaucum*) were important staple crops of the inhabitants of the subhumid regions in the southern Sahel where the Benue River is located (Kahlheber and Neumann 2007). Farming systems introduced during the Iron Age concentrated settlement in the valley bottomlands of the Benue River, which remains the most densely populated ecozone of the region as a whole. Today, the region is occupied by a great diversity of ethnic groups. In precolonial times, this included a large number of different farming populations (including the Fali, Mbum, Mambay, Dama and Sara), as well as Islamic populations that included both pastoralists (Fulani/Mbororo, along with some Shuwa Arabs), and farmers and traders (Kanuri and Hausa) (Gauthier 1969). In the last half of the 20th century, the availability of unclaimed land around the Benue Valley attracted immigrants from other areas of northern Cameroon, increasing ethnic diversity still further. The abundance of fertile soil and available water continues to draw people to the region today.

The local farming economy engage in variants of *karal* agriculture, in which *mouskwari* and related forms of sorghum are seasonally cultivated in the dry soils during the rainy season, then transplanted to the clay-rich Vertisols located on the lower aspects of the floodplain during the dry season (Kenga *et al.* 2003). Pastoralism and other extensive forms of land management switch accordingly from flooded to dry landforms based on the *karal* rotation. This form of economic diversification buffers subsistence systems against crop failures associated with extremes in precipitation availability.

Survey methods and results

Archaeological research undertaken northeast of Garoua, Cameroon in June and July 2014 was focused on locating and evaluating archaeological sites for longer-term research, and providing more detailed data for reconstructing Iron Age settlement of the region. (Our initial plan was to evaluate terrace systems in the Mandara Mountains further to the north in Cameroon (MacEachern 2012a, 2012b), but the Boko Haram insurgency directly across the border in Nigeria made that impossible.) The research project focused on revisiting an area of archaeological interest initially investigated by Nicholas David along the Benue River, and potentially adding more sites to the inventory that he produced. Documentation of site locations and attributes were made using a Trimble XH GPS unit.

David's (1981) map was georectified in ArcGIS 10.1 against satellite imagery and vector-based points were created in a database identifying the locations of mound sites. Nine archaeological sites in the Benue River floodplain were recorded, of which four sites were relocated from David's (1981) study (FIG. 2). Following the 2014 field season, buffers of 100 m, 200 m, 300 m and 500 m were created in ArcGIS around the T-1/T-2 interface in order to determine the numbers of sites that occur within each buffer. Based on the georectified image (and the four redundantly mapped sites from our field reconnaissance), six sites fall within 100 m, 12 within 200 m, 16 within 300 m and 28 out of a total of 39 mound sites occur within 500 m of the T-1/T-2 interface.

Four of these sites are particularly worthy of attention in the context of the project objectives. Percussion auger samples of the sediments from T-1 and T-2 of each site were taken for geochemical and botanical analysis, which are presently in progress, but the focus of the present paper will be on formation processes of the Langui-Tchéboua mound and connections between past and present agricultural systems. Brief descriptions of the three largest sites follows.

Langui Tchéboua (GRA-4). Langui-Tchéboua is a mound feature bisected by the shifting course of the Mayo Badjouma seasonal stream (FIGS. 3, 4). It appears that the original elevated area of the mound was approximately 100 m in diameter, although cultural materials interpreted as secondary deposits were found protruding from the cut bank beyond that elevated area as well. The fluvial incision appears to have removed approximately half of the total area of the mound, leaving a flat scarp face, with continuous cultural deposits exposed to a depth of up to 5.4 m along the approximately 100 m of exposure. The mound unconformably articulates into an adjacent fluvial terrace, which is also exposed in section. Our research team took the opportunity to document the stratigraphy and soils and collect samples from three distinct areas of this site. A total of five sub-features were documented in the mound fill, including the remains of a pot burial eroding from near the base.

Bé. Originally documented by Nic David (1981), this site is comprised of a minimum 25 ha area that extends from a ~10 m high anthropogenic fill zone of definite archaeological provenience into the eponymous modern settlement, in which mound construction continues unabated by the modern inhabitants. All portions of the mounds are currently under cultivation. One 2 m deep core was extracted 14.2 m NW of David's (1981) unit, and two 2-m deep percussion cores were extracted from the clayey sediments on the adjacent lower terrace floodplain, where seasonal floodplain (*karal*) sorghum farming is still taking place. Laminated clays within the cores extracted from T-1 are consistent with slackwater, overbank flooding and almost no sandy intraclasts were recorded in the sediments.

Loumbou (GRA-8). This site was originally mapped by Nic David (1981), but a detailed description was not made. Minimally measuring 20 ha, this site is also currently occupied and extensively farmed, and is positioned at the intersection of the upper and lower terraces of the Benue River. The anthropogenic fill provides relief to the site in relation to the lower terrace, and, as at Bé, a mixed regime of dry (upper terrace) and *karal* (lower terrace) agriculture is practiced today. This site warrants further investigation, with potentially equal stratigraphic complexity and cultural-historical significance to that of Langui-Tchéboua and Bé.

Langui-Tchéboua (GRA-4): Methods

Documentation.

Profiling and sampling of the Langui-Tchéboua mound and field site were undertaken by cleaning the scarp face with sharp tools sufficient to expose and systematically map the stratigraphic positions of soils and sediment fractions within the profile. Our team collected sediment samples for Optically Stimulated Luminescence (OSL) and charcoal for accelerator mass spectrometry radiocarbon (AMS ^{14}C) dating during the profiling. The mound was subjected to three-dimensional mapping to record lateral and vertical distribution of material culture remains. Archaeological features were documented in the site fill, and lithological units traced across the site area and to the surrounding terrace surface exposures. Artifacts were not systematically collected, but were photographed and documented when disturbed from *in situ* contexts during profiling. Site documentation extended to the adjacent terrace regions to connect mound activity areas with possible concurrent agricultural activity areas.

Sampling.

Seven sediment samples were collected from the profile for OSL dating. OSL dating measures the last time that sand grains were exposed to light vis-à-vis the accumulation of beta radiation in the defects of the crystal matrix of minerals. Samples are collected in light-free containers and when extracted and exposed to light in controlled laboratory circumstances, accumulated electrons are counted in a photomultiplier tube later followed by experiments to reconstruct the time it took to accumulate the stored energy (a simplified explanation of the method can be found in Wright 2016).

For Langui-Tchéboua, quartz grains with diameters of 180-250 µm were prepared in the laboratory using wet sieving, acid treatments (10% HCl, 10% H_2O_2 and 40% HF) and density separation and were analyzed using a TL/OSL-DA-20 Risø reader. The Single Aliquot Regeneration (SAR) protocol (Murray and Wintle 2000; Murray and Wintle 2003) was followed. The measured equivalent dose (D_e), which is the reconstructed total amount of stored energy, was determined to be independent of the preheat temperatures between 250 and 295°C based on plateau tests (FIG. 6). Dose rates (D_r) of the samples, which are the rates of radioactive decay within the minerals' environment, were estimated using a Canberra BEGe 5030 low-level high-resolution gamma spectrometer. OSL signals were measured based on aliquots composed of several tens of quartz grains (small aliquots), and the final ages were derived using the central age model (Galbraith and Roberts 2012; Galbraith *et al.* 1999a).

Undisturbed soil samples were also collected for micromorphological analysis. All water was removed from the samples through acetone exchange. The samples were then impregnated using polyester ‘polylite 32032-00’ resin. Impregnated soils were cured, and then sliced, bonded to a glass slide and precision lapped to 30µm thickness to produce a soil thin section. By following procedures laid out in the International Handbook for Thin Section Description (Bullock *et al.* 1985) and Stoops (2003), soil properties were recorded semi-quantitatively. The thin sections were analyzed using a Zeiss’ AxioLab.A1 with rotary stage, plane polarised light (PPL), crossed polarized light (XPL) and oblique incident light (OIL). Each of these instruments allow identification of specific microscopic features, such as mineral and organic components, pedofeatures and burnt residues.

Langui-Tchéboua (GRA-4): Results

A total of five sub-features were documented in the Langui-Tchéboua mound fill, including the remains of a pot burial eroding from near the bottom of the mound (FIG. 4c). Sediments in the mound were primarily comprised of alternating lenses of poorly sorted sandy loam and loamy sand devoid of bedding structures. Clay-rich lenses in Units 12, 17 and 24 as well as ashy fill layers in Units 10, 12 (within the sandy clay loam matrix), 20, 26 and 28 indicate that the sources of anthropogenic fill were variable (FIG. 5). A full description of the sedimentology of the mound fill and adjacent floodplain deposits are provided in Supplementary Material 1.

An OSL sample was analyzed from the burial sub-feature fill in order to constrain the early occupation of the site and yielded an age of 1100±100 years (FIG. 5; TABLE 1). Radiocarbon ages on charcoal from the stratigraphic section with dates constrain ~1.5 m of primary mound fill as aggrading between 670-730 cal. B.P. (FIG. 5; TABLE 2), indicating rapid accumulation of mound sediments during this time. An OSL age at 900±100 years from approximately 90 cm below the modern ground surface overlaps the radiocarbon chronology when factored to 2-σ (FIG. 5). Investigation of the adjacent exposed terraces showed that the floodplain deposits post-date habitation of the mound by more than 500 years. We infer that significant scouring and filling by fluvial channels in a dynamic floodplain environment have eroded Anthrosols from the Iron Age that may have existed south of the site.

Over-dispersion tendencies of OSL of small aliquots (Arnold and Roberts 2009) demonstrate centrality in dispersion and mixing thresholds below 35% (TABLE 1). Such distributions of data have been used to argue for sample efficacy and relatively low stratigraphic mixing of grains in a variety of depositional settings (Alexanderson and Murray 2007; Armitage and King 2013; Duller 2003; Forman 2015; Rowan *et al.* 2012). The highest over-dispersion measures from the project came from paleosols interpreted as anthropic in origin and likely had some degree of intentional mixing associated with plant cultivation, which was confirmed by micromorphological analysis of the soils (see below). The low over-dispersion (22.3%) for CAM-GRA14-OSL6 is consistent with alluvial sediments that underlie the primary mound, because the measure is similar to the natural value of 17.4% taken from the channel bottom sediments for CAM-GRA14-OSL7. This could also account for the anomalous age (5800±400 years) of the sample, if it had not been subjected to solar reset.

Micromorphologic analysis of Langui-Tchéboua mound sediments demonstrates three primary taphonomic features of mound accumulation (TABLE 3). First, the primary occupation of the mound included small fragments of bone associated with Sub-feature 1, supporting the field interpretation of a burial feature (FIG. 7a). The sedimentology shows a clear stratigraphic unconformity consistent with an excavated pit. Second, there is little evidence for post-depositional mixing of sediments within the mound, and the strata are in their primary depositional aspect (FIG. 7a, b). Third, accumulation of the primary occupation of the site that occurred ca. 700 years ago was rapid, containing no evidence for burning, daub or other structural materials in the analyzed samples (FIG. 7b). Micromorphological sampling also appears to have not captured the charcoal present in the fill.

Although the adjacent terrace tested in 2014 post-dated the occupation of the mound by >500 years, the micromorphology informs land management from the last 140 years (TABLE 3). The evidence shows that some fields were burned with microscopic flecks of charcoal in the soil (MM3A, MM5), but another soil showed no evidence for agricultural activity (MM4) and may have been used more extensively by pastoralists. As is typical for floodplains, redoximorphic (iron-rich, water-logging) features in the sediments are indicative of fluctuating groundwater conditions (MM3, MM3A, MM4, MM5). Limited burrowing by microfauna also disturbed the primary depositional context, confirming the high over-dispersion results derived from OSL analysis.

Discussion

On the Langui-Tchéboua site in the Benue River floodplain, archaeological settlement is recorded from the end of the first millennium A.D. and appears to have focused on use of the upper to lower terrace ecotones for agricultural purposes. A human burial excavated into the basal cultural fill zone at the site was approximately 25 cm above the floodplain. Following initial site occupation, rapid sedimentation of the mound feature is indicated by both radiometric ages and micromorphology, suggesting an intent to raise the elevational aspect of the site above the floodplain around 700 years ago. Unlike settlement mounds documented in southwest Asia and Mesoamerica (e.g., Friedel 1978; Van Beek and Van Beek 2013), at least a significant proportion of the cultural fill at Langui Tchéboua was not the byproduct of incremental weathering, destruction and reconstruction of habitation structures. Instead, much of the sediments on the mound feature appear to have been dredged from adjacent alluvium, as is indicated by the OSL age of sample CAM-GRA14-OSL6 (5800±400 years), corresponding very closely to the OSL age for the sandy substratum of the mound (5900±300 years; CAM-GRA14-OSL7). The CAM-GRA14-OSL6 sample is interpreted as not having undergone solar reset during transport and deposition, which probably occurred as basket fill. Although there may have been alternative means of constructing the mound, the data suggest at least one episode of deliberate and rapid accumulation of sediments above the floodplain.

The paired use of micromorphology and OSL as tools for understanding the formation of anthropogenic landforms can provide archaeologists with exceptional insights into the timing and methods associated with mound construction. Selection of sampling locations differ for the two methods: OSL samples should normally only be collected from homogenous, non-pedogenic horizons with solid evidence for solar resetting prior to burial and micromorphological samples are best collected in heterogeneous depositional and/or pedogenic contexts. In some cases, OSL and micromorphological samples should be collected in tandem when depositional and/or taphonomic circumstances are enigmatic. In other West African Iron Age mound sites such as Gao Saney (Cissé *et al.* 2013) and Mouyssam II (Togola 1996), rapid formation processes are inferred from radiocarbon dates. However, radiocarbon ages do not date sediment deposition events and in the absence of datasets such as OSL or micromorphology that explain post-depositional disturbance agents, the mechanisms and trace inclusions associated with formation are not apparent.

Based on the results of David's (1968, 1981) survey, augmented with a better understanding of the formation processes associated with mound construction from Langui-Tchéboua and satellite reconnaissance of the Benue River Valley more broadly, the locations of Iron Age mounds appear to be situated to take advantage of variable resources within adjacent dryland and seasonally flooded landforms. Although it is not known whether the mound sites documented by David (1981) were occupied simultaneously, there appears to have been dense Iron Age settlement of the middle Benue River region, which would explain why local labor resources would be invested in situating a site in an optimal environmental context. This raises the question of placement of this region in a broader regional cultural history, a process that has at this point barely begun.

Early settlement of the Benue River Valley has been hypothesized to have been the result of migrations of Iron Age agro-pastoralists arriving from the north (David 1981). The different forms of roulettes and burnished red slips (FIG. 8) on surface ceramics examined during 2014 fieldwork are generally similar to pottery documented in the southern Lake Chad Basin (FIG. 9; MacEachern 2012b). The presence of the pot burial at Langui-Tchéboua (FIG. 4c), as well as what appears to be a Type 1 ceramic tamper used in pot-forming (FIG. 8d; Sterner and David 2003) on the surface at Bé, hitherto known only in the Lake Chad Basin, provide more specific northern links. Cultural developments in the southern Lake Chad Basin during the first millennium A.D. may have led to the spread of farming populations to the south (Magnavita *et al.* 2010). It is quite possible that one axis of such a population expansion would have been riverine populations moving down the Logone and from there into the Benue drainage and so to the survey area.

Conclusions

Iron Age habitation of the Middle Benue River region is identified initially in the form of a pot burial at the site of Langui-Tchéboua occurring 1100±100 years ago and then took the form of a rapid accumulation of sediments around 700 years ago. These ages are in general temporal agreement with David's (1981) report of Iron Age occupations at Douloumi (ca. 600 years ago) and Bé (ca. 1000 years ago). The degree to which the builders of these sites were ethnically and/or economically interrelated is difficult to ascertain at this point. However, the presence of similar pottery types at all locations studied implies that none of these settlements existed in isolation.

The rapid later-phase construction of Langui-Tchéboua challenges traditional understandings of mound sediment accumulation. Instead of being the byproduct of centuries or millennia of aggrading habitation debris, this mound appears to have been quickly, and presumably thus deliberately, raised above the floodplain. Distinct fill zones and cultural debris in the sediments attest to variable sources of materials besides sandy channel alluvium. Ultimately, the motivations behind this intentional building up of a mound are not known. However, the present-day *karal* crop rotation system of the region provides a reference point for understanding the value of flexible land management practices, which is supported by the more recent archaeological evidence from the floodplain deposits adjacent to the Langui-Tschéboua mound. Regional paleoclimatic reconstructions show variable precipitation during the early-/mid-first millennium B.P. related to the transition from the so-called Medieval Warm Period to the Little Ice Age (Maley and Vernet 2013, 2015).

Thus, the accumulation of the mound at the beginning of the Little Ice Age, probably associated with lake-level increases and riverine flooding, may be a cultural response to maintain productive *karal* (or precedent) farming within a fluctuating ecosystem. At the very least, mounded locations overlooking floodplains provided a wide range of economic opportunities, from fishing to pastoralism to diverse modes of agriculture and foraging, as evidenced in the archaeological data recovered by David (1968, 1981). Strategic mound settlement in relation to diverse resource bases have been identified elsewhere in western Africa (Connah 1981; Höhn and Neumann 2012; Holl *et al.* 1991; Klee and Zach 1999; Van Neer 2008), but the formation model of Langui-Tchéboua presented in this paper using multiple sedimentological proxies highlights purposefulness in the creation of mound features that involved mobilization of large amounts of labor for some perceived economic or social benefit.

The Iron Age in western Africa is characterized by the evolution of greater social interconnections, agricultural intensification associated with population increases and forms of political complexity to manage these systems (MacEachern 2005; McIntosh 1999). The Middle Benue River Valley was clearly a component of this wider system and warrants significantly more research than it has received. The density and diversity of settlements suggest the presence of large prehistoric populations engaged in variable economic activities (see also David 1981). We look forward to undertaking more research along the Middle Benue, to further elucidate the trajectory of settlement patterning, economic change and political developments in this fascinating region.

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Figures

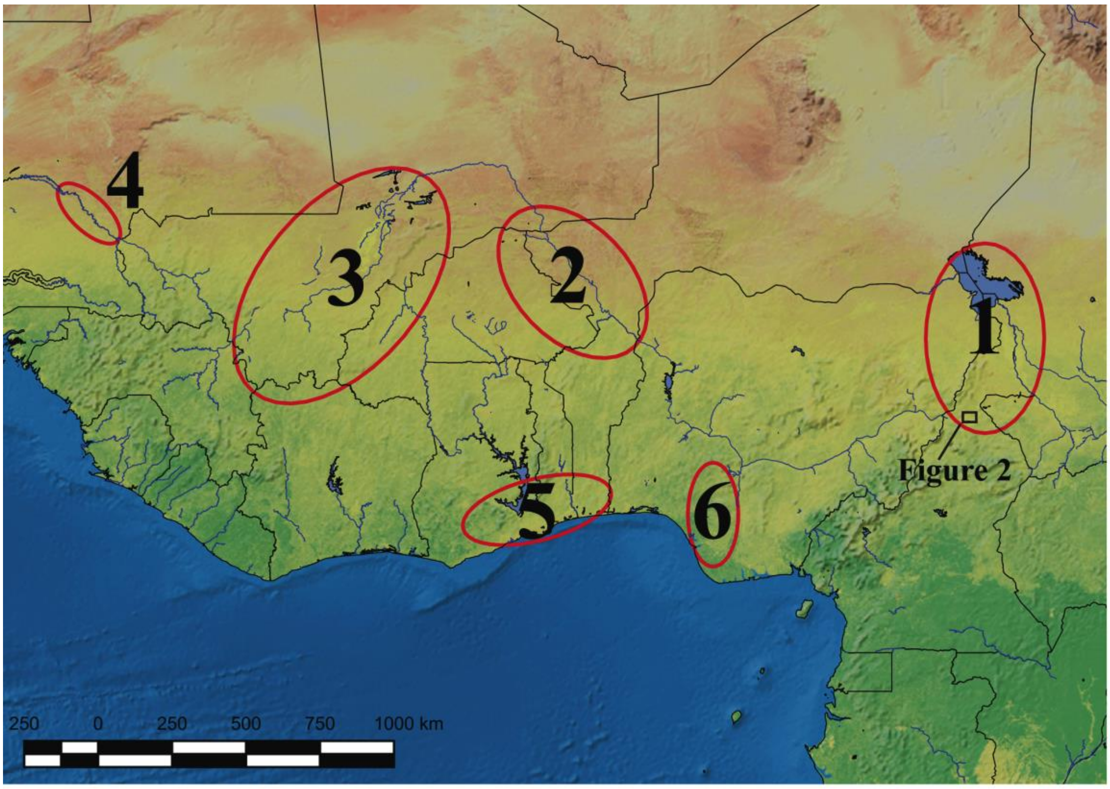

Figure 1 Location of mound sites across western Africa. (1) Lake Chad Basin and Benue Valley (Connah 1981; David 1968, 1981; Holl 2002; MacEachern 2012a); (2) Middle Niger River Valley and Oudalan Province (Albert *et al.* 2000; Cissé *et al.* 2013; Gado 1993, 2004; Mayor *et al.* 2005; Neumann *et al.* 2001); (3) Inland and Upper Niger and Mouhoun Bend (Filipowiak 1979; Holl 2014; McIntosh 2005; McIntosh and McIntosh 1981; McIntosh 1995; Raimbault and Sanogo 1991; Togola 1996); (4) Middle Senegal River Valley (McIntosh *et al.* 2015; McIntosh 1999; McIntosh *et al.* 1992; Van Neer 2008); (5) coastal Ghana-Togo-Benin (Monroe 2014); (6) Ife-Benin (Ogundiran 2002).

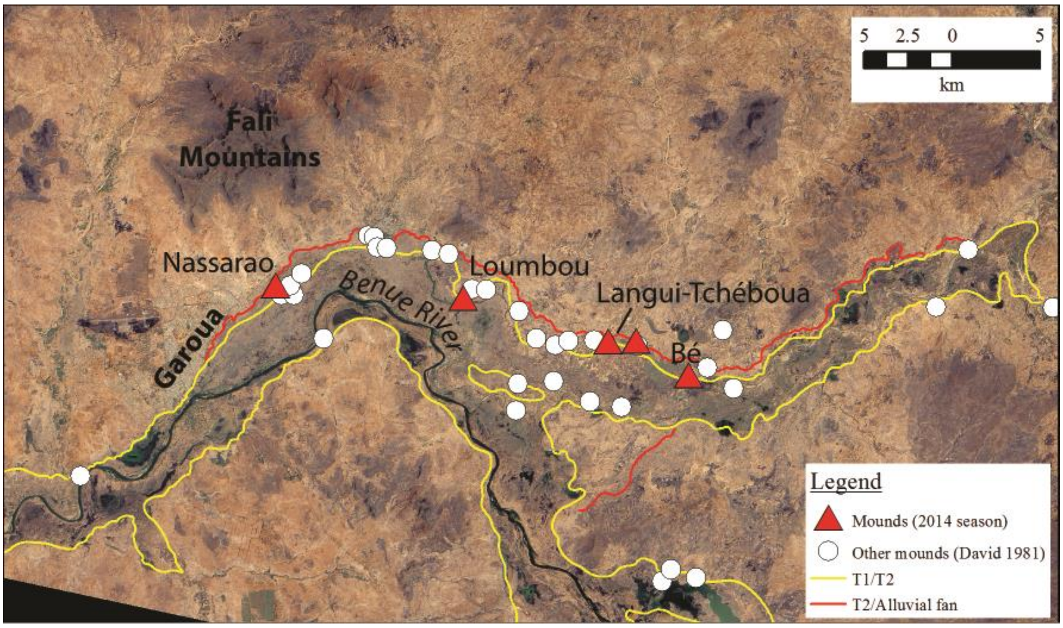

Figure 2 Project area showing locations of sites mentioned in the text. Landsat 8 satellite image downloaded from USGS (http://earthexplorer.usgs.gov). Mound locations plotted from georectified image (David 1981: Map 1).

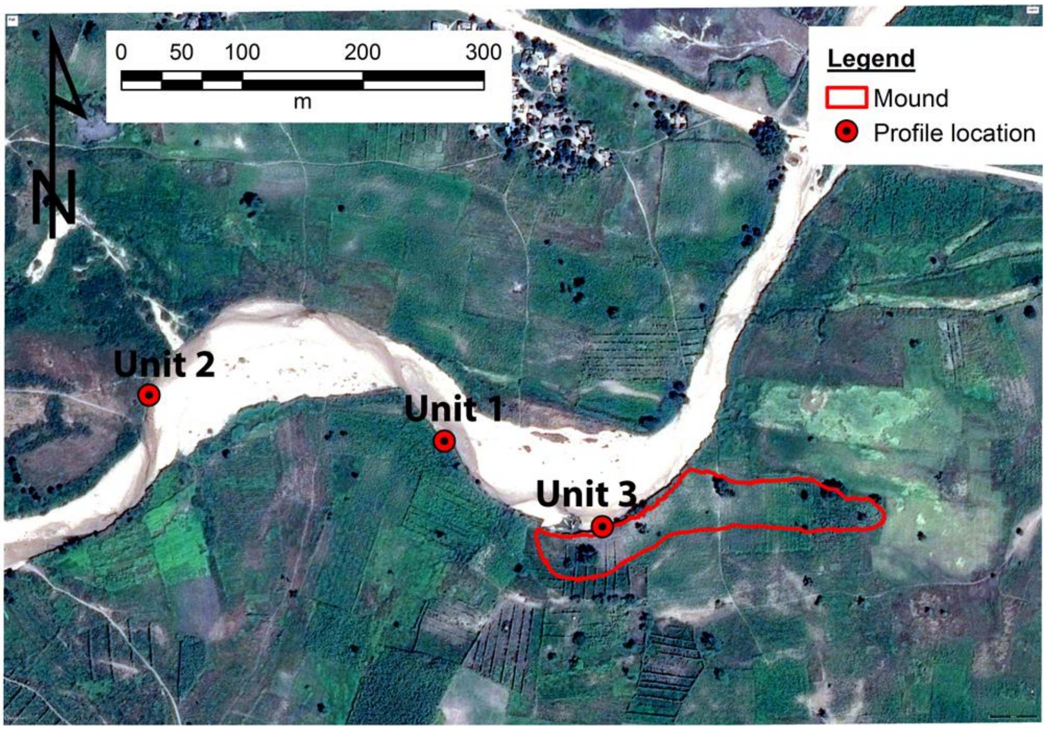

Figure 3 Plan map of Langui-Tchéboua.

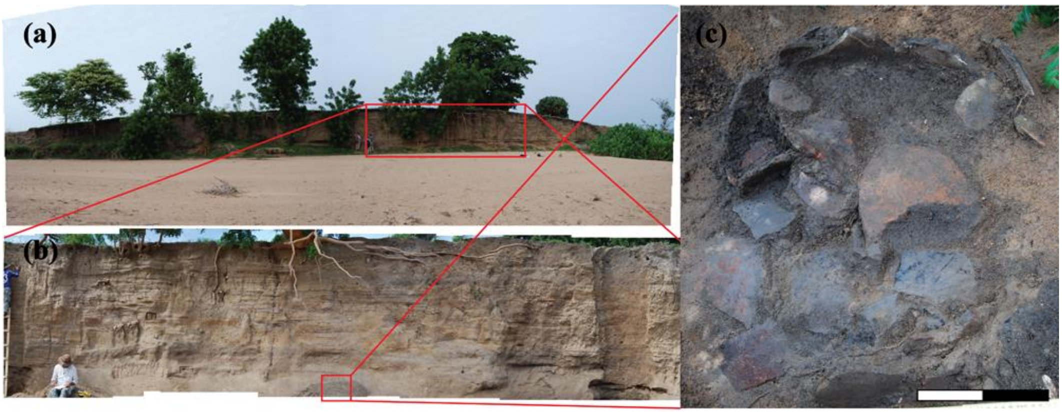

Figure 4 Photos of Langui-Tchéboua. (a) View of Feature 1 (mound) looking south; (b) Close view of mound sediments with profiled (Unit 3) on the far left; (c) Close up of pot burial with 20-cm scale.

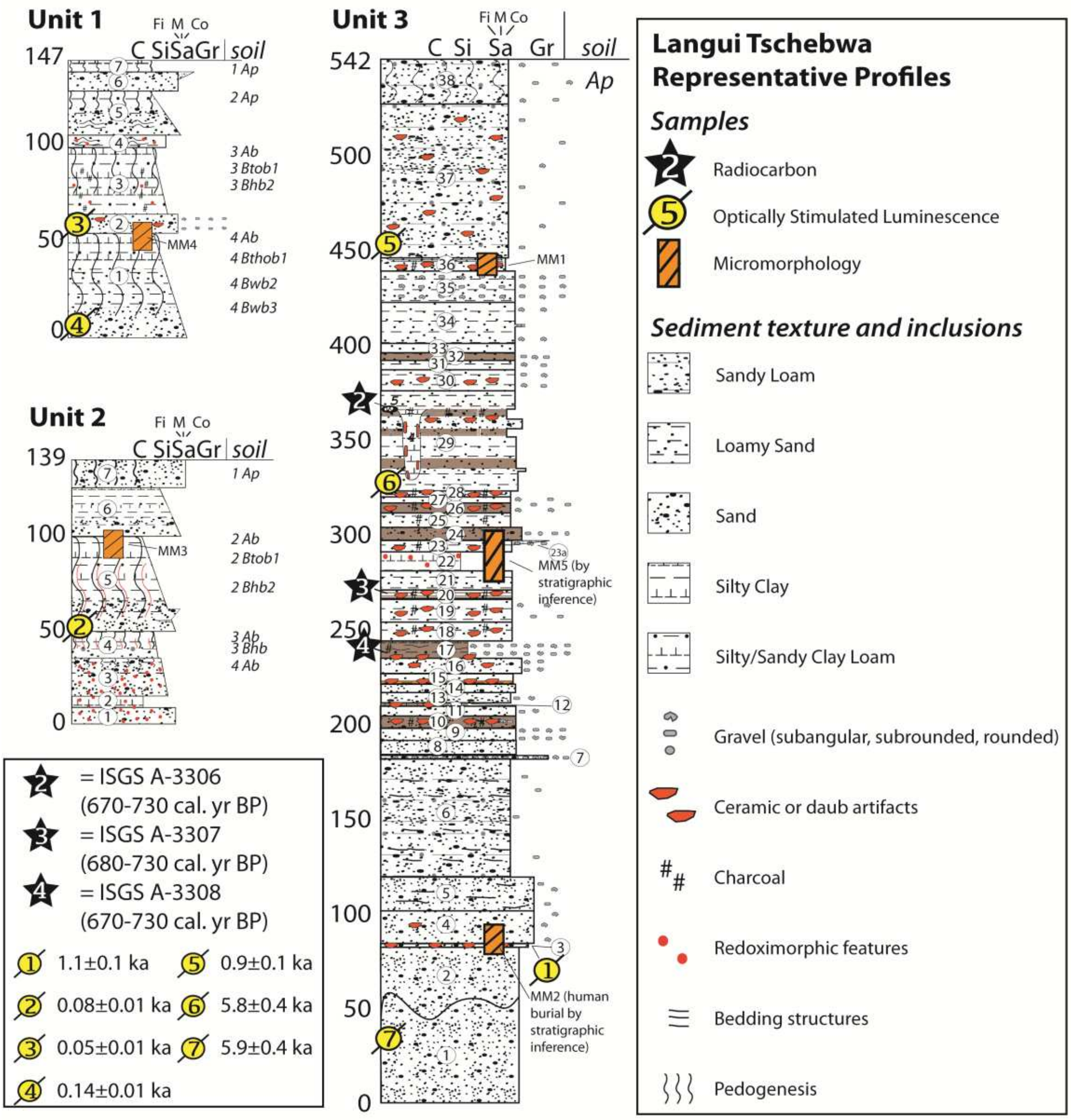

Figure 5 Preheat tests from CAM-GRA14-OSL3 and CAM-GRA14-OSL7. Relative proportions of clay (C), silt (Si), Sand (Sa, separated into Fine, Medium and Coarse fraction) and gravel (Gr) are shown for each test unit. Soil formation properties and pedofeatures are classified according to Schoeneberger *et al.* (2012).

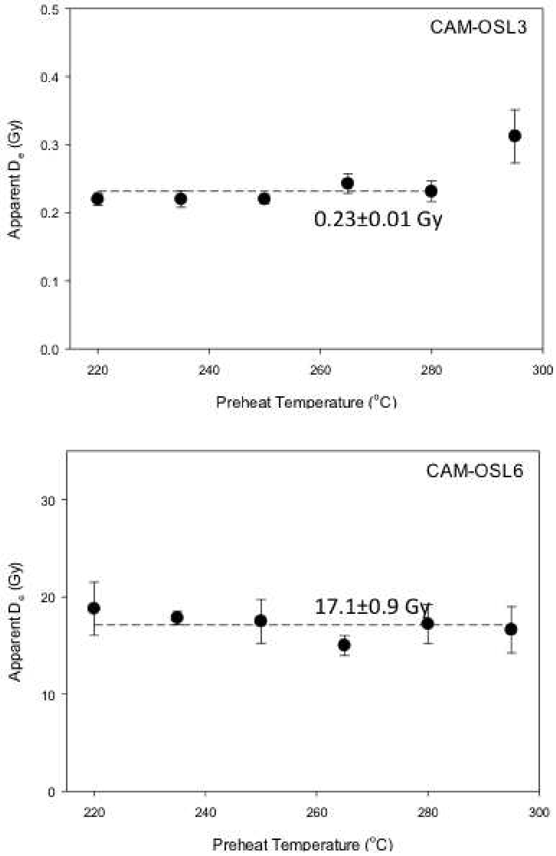

Figure 6 Profile of Langui-Tchéboua and adjacent fields showing sampling locations.

Figure 7 Location of the undisturbed soil samples with soil thin sections and micrograph: (a) Sub-feature 3 (burial) displayed alternating micro-laminations, Area 1 with organic matter (OM) and Area 2 containing calcitic bone deposits, the micrograph displaying bone (BL), calcitic intercalations and coatings (Cal) and amorphous organic matter (Aom) identified in cross-polarized light (XPL); (b) Aggraded sediments in Unit 3, Feature 1 exhibiting a weakly developed microstructure in soil thin section; (c) Easily identified micro-lamination at the sample site and weakly defined micro-laminations in the soil thin section.

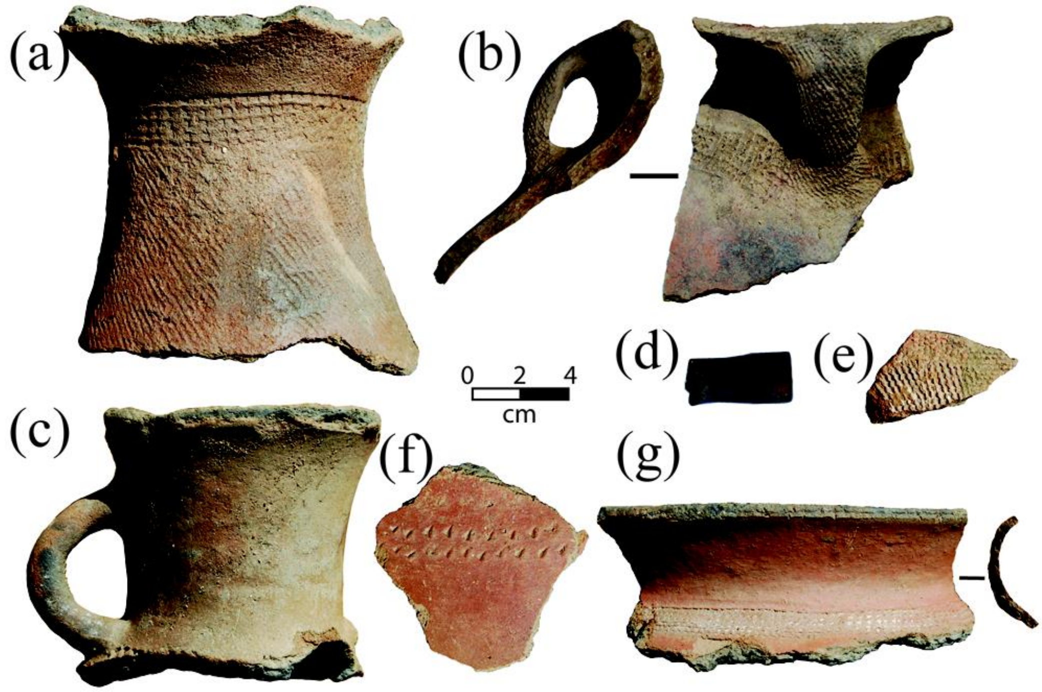

Figure 8 Selected ceramics from Langui-Tchéboua. (a) Cord-marked jar neck, with a band of comb-stamping; (b) jar rim with lug handle, with braided-strip roulette on handle and comb-stamped band on body; (c) bottle neck and rim with lug handle, with punctate design at the base of the neck; (d) incised pipe stem, possibly burnished, with multiple incised lines around circumference; (e) braided-strip roulette decorated body sherd; (f) body sherd with a linear punctate design; (g) comb-stamped neck and rim of a jar.

<u>*NOTE: This image looks much darker when pasted into the word processing document than the original tiff.</u>

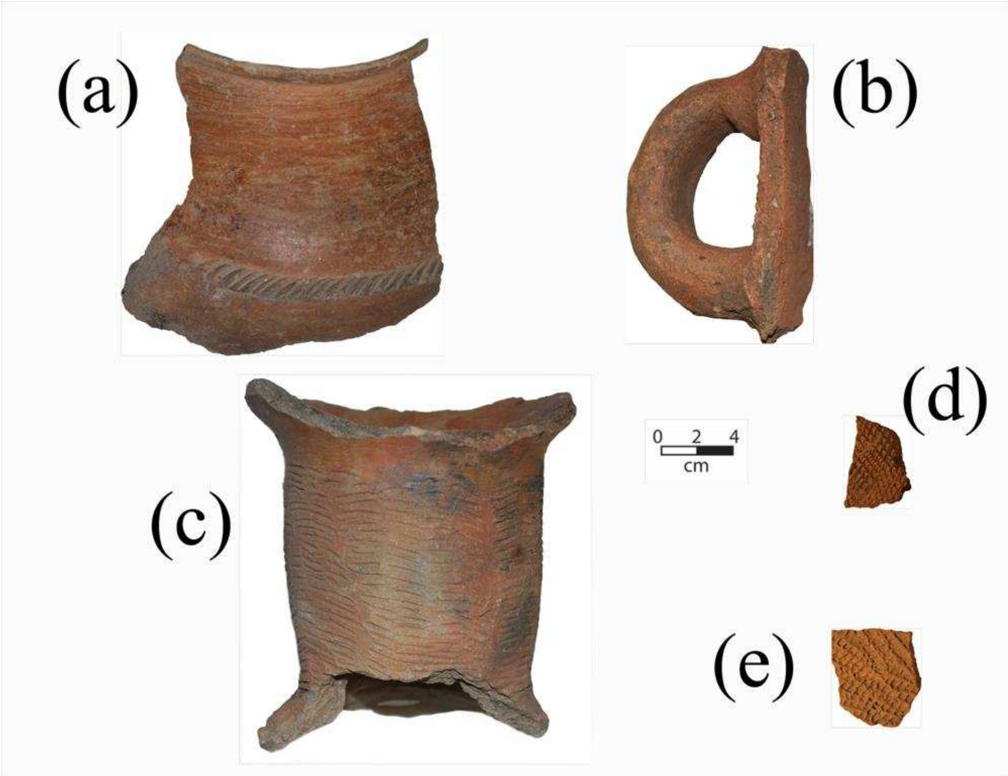

Figure 9 Ceramics from the southern Lake Chad Basin, with similar decorative styles to Benue ceramics (FIG. 8). Originating sites: (a), (b) and (d) Ghwa Kiva (PMW-744); (c) Liga SW (PMW-710); (e) Dugjé Gaya (PMW-761).

Tables

Table 1 Equivalent dose, dose rate and OSL ages of samples from Langui-Tschéboua, Cameroon

Sample	Depth* (cm)	Water content† (wt. %)	^{238}U (Bq·kg^{-1})	^{226}Ra (Bq·kg^{-1})	^{232}Th (Bq·kg^{-1})	^{40}K (Bq·kg^{-1})	Dry beta‡ (Gy·ka^{-1})	Dry gamma§ (Gy·ka^{-1})	Cosmic ray** (Gy·ka^{-1})	Total dose rate (Gy·ka^{-1})	D_e (Gy)	*n*	Over-dispersion (OD) %^{c}	Age†† (ka)	Context
CAM-GRA-14-OSL1	410	1.3	10.9±3.3	11.0±0.4	20.8±1.2	776±16	2.14±0.08	0.95±0.02	0.10±0.01	3.14±0.08	3.3±0.2	24	23.3	1.1±0.1	Human burial fill
CAM-GRA-14-OSL2	88	15.5	21.1±6.2	18.6±0.6	65.8±1.6	1075±22	3.26±0.12	1.79±0.03	0.18±0.02	4.43±0.11	0.36±0.03	21	30.4	0.08±0.01	Fluvial terrace
CAM-GRA-14-OSL3	86	1.6	12.8±5.5	14.2±0.6	35.0±1.5	1283±23	3.50±0.13	1.55±0.03	0.18±0.02	5.14±0.13	0.23±0.01	20	9.0	0.05±0.01	Fluvial terrace
CAM-GRA-14-OSL4	147	8.1	7.8±3.4	7.0±0.4	16.3±1.1	967±20	2.55±0.10	1.02±0.02	0.16±0.02	3.41±0.09	0.49±0.04	22	35.3	0.14±0.01	Fluvial terrace
CAM-GRA-14-OSL5	96	3.0	18.9±5.9	18.8±0.5	34.3±1.5	869±17	2.52±0.10	1.24±0.02	0.18±0.02	3.81±0.10	3.5±0.2	22	23.2	0.9±0.1	Mound sediment
CAM-GRA-14-OSL6	221	1.8	9.5±3.7	10.9±0.5	17.9±1.2	719±17	1.98±0.08	0.87±0.02	0.14±0.01	2.93±0.08	17.1±0.9	23	22.3	5.8±0.4	Mound sediment
CAM-GRA-14-OSL7	511	13.5	7.4±3.0	8.4±0.4	14.9±1.0	607±14	1.66±0.07	0.72±0.02	0.09±0.01	2.14±0.06	12.6±0.6	24	17.4	5.9±0.3	Fluvial terrace

* Depths of the samples are the vertical distance from the modern ground surface.

† Present water content.

‡ Data from high-resolution low level gamma spectrometer were converted to infinite matrix dose rates using conversion factors given in Olley *et al.* (1996).

§ Cosmic ray dose rates were calculated using the equations provided by Prescott and Hutton (1994).

** Over-dispersion calculated according to Galbraith *et al.* (1999b)

†† Central age (±1-σ error).

Table 2 Radiocarbon ages from Langui-Tchéboua.

Sample (ISGS #)	Depth (cm)	Material	$\delta^{13}C$	Fraction MC	±	$\Delta\ ^{14}C$	±	^{14}C B.P.	cal. B.P.*, †	Context
A-3306	189	charcoal	-10.9	0.9091	0.0019	-90.9	1.9	765±20	670-730	Mound sediment
A-3307	270	charcoal	-25.4	0.9070	0.0018	-93.0	1.8	785±20	680-730	Mound sediment
A-3308	307	charcoal	-22.6	0.9074	0.0023	-92.6	2.3	780±25	670-730	Mound sediment

* Radiocarbon ages calibrated using CALIB 7.1 (Reimer *et al.* 2013)

† Ages ±2-σ error

Table 3 Summary of micromorphological analysis.

Thin Section	Related distribution	$c/f^{(50\mu m)}$ distribution (ratio)*	Coarse material* Mineral	Coarse material* Organic	Limpidity/*b*-fabric	Microstructure	Pedofeatures
MM1	Chitonic	*2:3*	Quartz (50%), Plagioclase (10%), Microcline (5%), Feldspar (5%)	Plant (5%), Charcoal (5%)	Cloudy/speckled	Channel	Irregular shaped aggregate redoximorphic nodules in the fine matrix (50-1000µm).
MM2							
Area 1	Chitonic	*2:3*	Quartz (50%), Plagioclase 30%), Microcline (10%), Feldspar (10%), Quartzite (5%), Hornblende (2%)	Plant (5%), Charcoal (5%), Bone (2%)	Dotted/grano-, poro- and partial striations	Channel	Typic and aggregate redoximorphic nodules (5%) in the fine matrix, with calcite coatings (5%) on the surface of the channel voids (looks like link coatings).
Area 2	Gefuric	*3:2*	Quartz (50%), Plagioclase 30%), Microcline (10%), Feldspar (10%), Quartzite (5%), Hornblende (2%)		Dotted/ speckled	Channel/chamber	Calcite coatings (5%) within the vughs and chamber voids.
MM3							
Area 1	Enaulic	*1:4*	Quartz (50%), Plagioclase (10%), Microcline (5%)	Plant (5%), Charcoal (10%)	Dotted/speckled	Channel/chamber	Typic redoximorphic nodules located in the fine material (5%). Hypo-coatings around the edges of thee sub-angular peds.
Area 2	Chitonic	*7:3*	Quartz (50%), Plagioclase (10%), Microcline (5%), Feldspar (5%)	Charcoal (5%)	Dotted/speckled	Granular	Dense, complete infillings
MM3A							
Area 1	Enaulic	*7:3*	Quartz (50%), Plagioclase 30%), Microcline (10%), Feldspar (5%)	Plant (2%), Charcoal (5%)	Dotted/speckled and partial striations	Channel/chamber	Typic redoximorphic nodules in the fine matrix (2%).
Area 2	Chitonic	*1:4*	Quartz (50%), Plagioclase (10%),	Charcoal (5%)	Dotted/speckled	Channel	Hypo-coatings formed at the edges of the sub-angular peds
Area 3	Chitonic	*1:4*	Quartz (50%), Plagioclase (10%),		Dotted/speckled	Granular	Typic redoximorphic nodules in the fine matrix (2%).
MM4							
Area 1	Chitonic	4:1	Quartz (50%), Plagioclase (10%), Microcline (5%), Quartzite (5%)	Charcoal (5%)	Speckled/speckled	Granular/chamber	Rounded aggregate redoximorphic nodules in the fine material (100-2000µm).
Area 2	Enaulic	*1:4*	Quartz (50%), Plagioclase (10%), Microcline (5%)		Dotted/speckled	Channel/chamber	Hypo-coatings formed at the edges of the sub-angular peds
Area 3	Gefuric	*3:2*	Quartz (50%), Plagioclase (10%), Microcline (5%),	Plant (2%), Charcoal (5%)	Speckled/speckled	Channel	Rounded aggregate redoximorphic nodules in the fine material (100-2000µm). Hypo-coatings formed at the

			Quartzite (5%), Feldspar (5%)				edges of the sub-angular peds
MM5	Gefuric	*1:1*	Quartz (50%), Plagioclase (10%), Microcline (5%), Quartzite (5%), Feldspar (5%), Quartzite (5%), Biotite (5%), Glauconite (2%)	Plant (2%), Charcoal (5%)	Cloudy/grano-, poro- and partial striations	Channel	Typic and aggregate redoximorphic nodules (5%) in the fine matrix, with calcite coatings (5%) on the surface of the channel voids.

Biographies

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