The emergence of pottery in Africa during the 10th millennium calBC: new evidence from Ounjougou (Mali)

E. Huysecom¹, M. Rasse², L. Lespez³, K. Neumann⁴, A. Fahmy⁵, A. Ballouche⁶, S. Ozainne⁷, M. Maggetti⁷, Ch. Tribolo⁸, S. Soriano⁹

¹Department of Anthropology and Ecology, University of Geneva, Geneva, CH-1211, Switzerland, eric.huysecom@unige.ch; sylvain.ozainne@unige.ch
²Lab. Ledra, CNRS -UMR IDEES 6228, University of Rouen, Mont St-Aignan, F-76821, France, and lab. AnTET – Arscan UMR 7041 CNRS, University of Paris-X Nanterre, F-92023, France, michel.rasse@univ-rouen.fr;
³Lab. Geophen-LETG-UMR 6554 CNRS, University of Caen-Basse Normandie, Caen, F-14000, France, laurent.lespez@unicaen.fr;
⁴Goethe University, Institute of Archaeological Sciences, D-60323 Frankfurt, Germany, k.neumann@em.uni-frankfurt.de;
⁵Department of Botany, University of Helwan, Cairo, Egypt, afahmy658@gmail.com;
⁶Lab. Environmental Studies on Anthropogenic Systems (LEESA/UA), University of Angers, Angers, F-49000, France, aziz.ballouche@univ-angers.fr;
⁷Department of Geosciences, University of Fribourg, Fribourg, CH-1700, Switzerland, marino.maggetti@unifr.ch;
⁸CRP2A, UMR 5060, University of Bordeaux, Pessac, F-33607, France, ctribolo@u-bordeaux3.fr;
⁹Lab. AnTET – Arscan UMR 7041 CNRS, University of Paris-X Nanterre, F-92023, France, sylvain.soriano@mae.u-paris10.fr.

To whom correspondence should be adressed. E-mail: eric.huysecom@unige.ch

Recent fieldwork at the site Ravin de la Mouche at Ounjougou (Dogon Country, Mali) sheds new light on sub-Saharan Africa at the Pleistocene-Holocene transition, a region and a period of crucial significance for the understanding of African prehistory. At Ravin de la Mouche, a technological complex was found with ceramics and an associated original lithic industry in a stratigraphic context which, since September 2007, is well-dated and can be interpreted in palaeoclimatic and palaeoenvironmental terms. These new data add to the scenario for the emergence of pottery during the 10th Millennium calBC and to establish a
relationship of this important innovation with the climatic changes at the Pleistocene-Holocene transition, including the massive expansion of grasses with edible grains.

1. An early emergence of pottery in Asia and Africa

Archaeological research reveals that in Japan, Siberia and China, prehistoric populations first began to produce ceramic ware between 15,000 and 10,000 calBC, more than five thousand years earlier than in the Near East (Yasuda 2002: 119-142; Kuzmin 2006). The emergence of pottery in Asia is linked with the climatic amelioration at the Pleistocene-Holocene transition and coincides with the appearance of lithic industries marked by distinctive small bifacial arrowheads (Habu 2004: 26-36). This technological complex is usually regarded as an expression of the intensified exploitation of plant and animal resources, often including small-seeded grasses (Richerson et al. 2001).

In Africa, the earliest pottery has been found in the large mountain massifs of the Central Sahara, in the Eastern Sahara and the Nile valley. About 30 $^{14}$C and luminescence dates place the emergence of ceramics in the Sahara and the Nile valley between the end of the 10th millennium and the beginning of the 9th millennium calBC (Close 1995: 24-27, Roset 2000, Jesse 2003: 40-42, Haaland 2007:171-175). This is related to the sudden onset of a warmer and wetter climate in the Early Holocene that enabled the re-settling of the Sahara after the hyperarid phase of the last glacial maximum, the "Ogolien" (Nelson et al. 2002: 97-99). The origin of the earliest African pottery is controversial and has been much discussed, with three hypothetical scenarios proposed. The first theory places the emergence of ceramics in the Nile Valley, based principally on the earliness of the exploitation of aquatic resources and wild cereals in this region (Haaland 1992: 47). The second suggests an origin somewhere south of the Sahara (Close 1995: 23), but until recently, the oldest finds of sub-Saharan ceramics were only dated to the 8th millennium calBC, both at Lothagam in Kenya (Robbins 1974), and in the Ravin du Hibou at Ounjougou in Mali, for phase II of its Holocene occupation sequence (Huysecom et al. 2004: 584). A third assumes that pottery was invented by relict populations who had survived in ecological refuge zones of the Sahara during the hyperarid Late Pleistocene (Jesse 2003: 43). Within the framework of the international research project Palaeoenvironment and Human Population of West Africa (Huysecom 2002), the recent discovery of ceramic sherds at the site of Ravin de la Mouche at Ounjougou, associated with an original lithic industry and in a stratified context well-dated before the end of the 10th
millennium calBC, brings new data concerning the chronology of the emergence of ceramics in Africa, as well as its environmental context.

2. The Early Holocene sequence at Ounjougou and ceramics associated

At Ounjougou (14°20' N, 3°30 W), the force of recent incisions in holocene formations of the Yamé Valley led us, since 2004, to undertake new research in two parallel ravines named *Ravin du Hibou* and *Ravin de la Mouche*, where several ceramic sherds were discovered in layers that could be attributed to the initial phases of the Holocene (Figure 1). In September 2007, our latest field season established the definitive chronostratigraphic sequence for these two ravines, as well as clarified the position of the pottery and the associated lithic assemblage. In general, the Holocene sedimentary sequence here is primarily composed of channel infilling, evidencing concentrated high-energy flow, strongly contrasting with the underlying Pleistocene silts and more recent Holocene silty formations (Rasse et al. 2006). It is now possible to divide the Early Holocene into five large chronostratigraphic units, identified from top to bottom as HA4 to HA0. The chronological ranges in the titles of the next sections are based on Bayesian analysis results of $^{14}$C and OSL dates$^1$.

**The HA4 formation (6,700 - 8,100 calBC)**

The most recent formation, HA4, of fine-grained particle size and particularly well-developed in the *Ravin du Hibou*, has yielded artefacts from cultural phase 2 of the Holocene occupation at Ounjougou, dated to the 8th mill. calBC by five $^{14}$C dates on charcoal and two OSL dates (between 8,080 ± 55 BP and 8,700 ± 75 BP, Figure 1, Table 1). The material culture is characterized by a microlithic quartz industry, with geometric segments, associated with ceramics and grinding tools (mortar and pestles), in a Sudanian savanna context combined with *Syzygium* gallery-forests (Huyssecom et al. 2004; Eichhorn & Neumann in press).

**The HA3 formation (8,100 - 9,000 calBC)**

In *Ravin de la Mouche*, below HA4, unit HA3 comprises a succession of several coarse sand lenses and grey sandy silt layers with organic remains. This indicates a meandering river, with a coarse load, flowing in a floodplain with permanent ponds. Six $^{14}$C dates and one OSL date allow us to place this formation of HA3 between 8,100 and 9,000 calBC (between 9,150 ± 70 BP and 9,610 ± 70 BP, Figure 1, Table 1). Charcoal, pollen and phytoliths in this layer indicate the existence of open grassland with a few Sahelo-Sudanian tree species and a dense
gallery forest with the riverine tree *Syzygium*. Uapaca, Celtis, Palms, and Marantaceae in the undergrowth were also constituents of the denser woody vegetation along the watercourses. It points to the existence of a permanent water source, which is essential for palm growth (Strömberg 2004), and for Uapaca (Arbonnier 2000). There is some evidence of fire, but only in the gallery forest (Neumann et al., in press).

With its coarser and finer laminae, HA3 represents the earliest Holocene rhythmic sediments resulting from alternating wet and dry season alluvial sedimentation. The archaeological finds of HA3 are characterized by some isolated quartz flakes and two small rounded ceramic fragments (diameter 15 mm, thickness 7-8mm) which might represent a re-deposition of older material.

*The HA2 formation (9,000 - 9,400 calBC)*

Under HA3, unit HA2 is composed of silty sandy alluvial sediments with grey Pleistocene silty blocks, particularly at the base of the unit (HA2/a-b), which indicates an important incision of the meandering river and river bank erosion into the Pleistocene deposits (Lespez et al. in press). These alluvial sediments experienced a slight pedogenesis, particularly visible in the upper part of the unit (HA2/c-d). Two $^{14}$C dates place the HA2 sequence, which is archaeologically sterile, between 9,000 and 9,400 calBC (9,510 ± 70 BP and 9,785 ± 70 BP, Figure 1, Table 1). HA2 is a fossil soil with a massive structure and few channels with clay coating, and phytoliths originating from vegetation developed *in situ* on the ancient land surface. The spectrum of Poaceae short cell phytoliths points to a grassland similar to the modern northern Sahel, with dominating annuals (Neumann et al. in press; Barboni et al. 2007). Among the Poaceae, short cell phytoliths identifiable to subfamily level - panicoid morphotypes - (Piperno 2006) are well represented. The grass subfamily Panicoideae comprises numerous annual species with edible grains which are commonly collected in the Sahel today (Harlan 1989) and were also used by prehistoric populations in the Sahara during the Early and Middle Holocene (Fahmy & Barakat 1999, Wasylikowa 2001). The phytolith samples also contain an allochtonous component originating from episodic flooding of the fossil soil, with morphotypes from Marantaceae and palms indicating a dense gallery forest with a shade-tolerant undergrowth.
**The HA1 formation (before 9,400 calBC)**

Below HA3 and HA2, unit HA1 is 2 to 5 meters thick and consists of several sequences composed of red to ochre cross-bedded coarse sand and gravel with grey Pleistocene silt blocks, suggesting high-energy flows running through a braided river (Lespez et al. 2008). The phytolith samples in HA1 are very poor, due to the low amount of silt, and are therefore not interpretable in terms of the vegetation during this period. Only a few micro-charcoals were found in HA1, and gave a Pleistocene age, showing the importance of redeposited sediments. OSL dating failed in the coarse and badly (if at all) bleached sediments. However, the $^{14}$C and OSL dates of units HA2, HA3 and HA4 constitute a reliable *terminus ante quem* of 9,400 calBC for unit HA1 and the re-deposition of the archaeological material (Figure 1, Table 1). The archaeological remains of HA1 include the oldest ceramic sherds and a rich lithic industry. The artefacts, although out of archaeological context and reworked, were discovered in a well-characterized sedimentary sequence, accurately positioned in the stratigraphic sequence between the Pleistocene deposits and the first dated early Holocene sediments (HA2). They represent a former occupation on the river banks, the sites having been eroded by fluvial activity and their material re-deposited in HA1. The good preservation of two ceramic sherds and the slight wearing on the ridges of the lithic material show clearly that they had not been transported over long distances.

The lithic assemblage of unit HA1 numbers 479 objects, primarily knapped from quartz cobbles. It is characterized by small bifacial fusiform or oval foliate points (Figure 2), obtained by bifacial shaping, in some cases by pressure flaking, and by the absence of geometric microliths. Among the other retouched tools are drill bits, borer, burins and endscrapers. This toolkit, although in secondary position, can without risk be attributed to the Early Holocene, since these types are significantly absent in the MSA industries of the region, particularly drill bits, borers and bifacial points. The latter, based on their size, morphology and shaping technique, are quite different from those recovered in the recent phases of the MSA at Ounjougou (Robert et al. 2003). Moreover, retouched tools are rare or absent in MSA industries at Ounjougou, although here they represent 6.2% of the entire assemblage. The other retouched tools within HA1 unit (sidescrapers, retouched flakes, scaled pieces and denticulates) could also be observed in MSA industries so they could not be securely attributed to Early Holocene.
Three ceramic sherds from the base of the stratigraphic unit HA1A (Figure 3) are associated with this industry (their dimensions are respectively 10, 3.5 and 1.5 cm). Their thickness ranges from 4.5 to 7 mm. Only one form could be reconstituted as a hemispherical bowl with a simple rim and a diameter of 21 cm. One sherd shows a decor of impressions which could not be precisely identified. Microscopic analysis of two samples shows a silicate matrix, free of carbonates, with 20-30% of the volume being non-plastic inclusions. These are mainly well-rounded quartz monocrystals with a thin recrystallization border, very similar to those observed in local sandstones and clays. Therefore, a local to regional origin of the analyzed samples can be inferred. Mineralogical analyses by X-ray diffraction of the clays from the closest outcrops confirm the presence of kaolinite, which is lacking in the studied material. This points to firing temperatures higher than 550°C, because kaolinite is not stable above this temperature in oxidizing firing conditions. Evidently, the studied samples are not fragments of a hardened clay, but of a fired clay, i.e. of a true ceramic object.

The HA0 formation (before 9,400 calBC)

At the base of Ravin de la Mouche, the earliest sedimentary sequence (HA0) of the Pleistocene-Holocene transition is composed of reworked Pleistocene silts. This unit was directly cut into a channel developed within the yellow Pleistocene silts of formation U4, dated by OSL between 45 and 40 ka (Rasse et al. 2004), and reflects a brutal hydrologic incision with significant reworking of the banks of the Yamé. It is archaeologically sterile.

3. Discussion: Emergence of pottery south of the Sahara

At Ounjougou, new stratigraphic and chronological data for the beginning of the Holocene support a terminus ante quem of 9,400 calBC for an archaeological assemblage characterized by the presence of ceramics and small bifacial armatures. From an archaeological viewpoint, if we consider all of the 14C dates for African sites with ceramics and contemporaneous with the HA1, HA2 and HA3 formations at Ravin de la Mouche (Figure 4, 5; Table 2), it can be observed that few of them have been dated earlier than 9000 calBC. They are concentrated in two different region: in the large mountain massifs of the Central Sahara (Adrar Bous 10 and Tagalagal; Roset 2000) and in the Eastern Sahara and the Nile valley (Bir Kiseiba E-79-8, Sarurab 2 and Wadi el Akhdar; Connor 1984, Khabir 1987, Schön 1996). After a review of the evidence, we have decided to exclude a series of dates, lacking a clear stratigraphic context, from the discussion: the earliest 14C date of Uadi Ti-n-Torha in Libya
9080 ± 70 BP (R-1036, Barich 1974: 149), Tamaya Mellet in Niger 9350 ± 170 BP (Gif-1728, Paris et al. 1993: 385), Bir Kiseiba E-80-4 in Egypt 9220 ± 120 BP (SMU-925, Close 1984: 347) and finally the Site Launey AK-AF 094-18 in Algeria 9,210 ± 115 BP (UW-97, Maître 1971: 57; Maître 1974: 101). The discoveries of Temet in Niger are not included in this discussion either. The excavation of the lacustrine deposits of Temet yielded a date indicating the contemporaneity of this site with the HA2 formation at Ounjougou, at the junction of the 10th and 9th mill. calBC (9,550 ± 100 BP; Roset 1983, 1996). This is also one of the few sites that contain bifacial armatures comparable to those found in formation HA1 of Ravin de la Mouche, indicating a clear relationship between the two areas. However, Temet contains only whole or broken fibrolite recipients. The use of pottery here is only suggested by a fragment of a short, toothed object, on a plaquette of chloritic schist. This object was interpreted as a potter's comb after the observation of impressed motifs on surface-find sherds (Roset 1983: Fig.15). These sherds cannot, however, be reliably correlated with the occupation of the site during the Early Holocene. In addition, this object may also be a fragment of a disc decorated with incisions, without any connection to ceramic production. Until proof of the contrary, the populations of Temet appear to have opted for the use of carved and polished stone and not fired clay for the fabrication of some of their containers. Only one comparable site can be seen as potentially contemporaneous with the appearance of ceramics at Ounjougou, before the HA1 / HA2 transition: Bir Kiseiba, in the southern part of the Egyptian Sahara, this site having also yielded grinding equipment. The site E-79-8 of Bir Kiseiba yielded three sherds discovered during the excavation of sandy sediments (Connor 1984), found just below ground surface, as well as at depths of 10 and 60 cm. In the publication, the excavator indicates for the deepest sherd: "it is possible that the sherd might have been moved to this depth by traffic over the surface of the site" (Connor 1984: 240). Three other sherds were nearby surface finds. The seven 14C dates obtained on charcoal, unfortunately, have large error margins and as a result a broad range for the calibration, which ranges from the end of the 11th mill. to the beginning of the 8th mill. calBC (between 9,820 ± 380 BP and 8,920 ± 130 BP). Without stratigraphic context to clearly correlate the three sherds and the dates, it is not possible to go further in the interpretation of this site in terms of dating the emergence of ceramics.

From an palaeoenvironmental viewpoint, geomorphological and sedimentological analyses in Ravin de la Mouche indicate a powerful hydrologic regime for this period that remodeled the landscape on the valley floor. This allows us to identify a relationship between the emergence of this techno-typological complex with one of the humid phases of the
Pleistocene-Holocene transition recently recognized in West Africa (DeMenocal et al. 2000, Lézine et al. 2005, Duplessy et al. 2005). This corresponds most probably to the abrupt resumption of the African monsoon after the Younger Dryas, between 10,050 and 9,350 calBC, the early Holocene monsoon front reaching 14°N around 9,500 calBC in West Africa (Garcin et al. 2007). The palaeoenvironmental data from Ounjougou and other terrestrial sites in the Sahel (Neumann et al. in press, Waller et al. 2007) show that the onset of the monsoon had an immediate effect on the landscape. A vast tropical grassland spread across the former desert areas, and panicoid grasses with edible grains became available in abundance. As in the Near East (Hillman 1996, Haaland 1995, 2007) and in East Asia, the massive presence of wild cereals triggered the development of new resource exploitation behaviour, linked with technological innovations for collection, storage and processing. Heat treatment of the wild cereals before consumption increases the digestibility of the starch-rich grains by amylase in the human body (Stahl 1989). While bread baking became the predominant form of processing in the Near East, we hypothesize that the small grains of the tropical African Panicoideae were boiled in a container, as practiced today in the Sahel. Comparably with East Asia, African ceramics were part of a new technological complex, together with the production of small bifacial arrowheads for hunting in the open tropical savannas.

Thus, with a solid stratigraphic and chronological context at Ounjougou, there is no doubt that ceramics appeared in sub-Saharan West Africa at least as early as in the Nile Valley, some time before 9,400 calBC. This innovation must be coupled with the re-establishment of the tropical grassland during the Early Holocene. Starting in the middle of the 10th mill. calBC, the new technological complex may have rapidly diffused northwards, together with the advancing monsoon front, the greening of the Sahara and the massive expansion of edible Panicoid grasses.

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Note

1 After calibration of the $^{14}$C data (IntCal04), OSL and $^{14}$C data sets have been treated together with the Bayesian statistical method. This method consists in using secure stratigraphic information ("such event must come before such other") to recalculate the probability density functions (pdf) for each sample (Bronk Ramsey 2000). In short, it allows pointing out the most likely part of each pdf (called "posterior" data, often referred to as "highest posterior density " or hpd) when considering the stratigraphic relationships. The direct and interesting consequence is a reduction of the uncertainty for each individual value and thus an increase of the chronological resolution (Figure 1).

All calculations have been done with the Oxcal 4.0 software (Bronk Ramsey 2008). OSL data have been integrated to the C14 ones following the recommendations of Rhodes et al. (2003). The A index gives an indication of the consistency of the data within the data set: when lower than 60%, the data is considered as an outsider and can be discard. In complement to the posterior for each data, one can calculate the most likely interval for the transitions between the phases. The general chronological ranges used to describe the HA4-HA0 units are based on the intervals calculated for those transitions (68.2% confidence interval and $\mu$). In particular, this allows concluding that the transition between HA1 and HA2 occurred between 9,477 and 9,152 calBC with 68.2% confidence interval (between 9,959 and 8,932 with 95.4% confidence interval; $\mu=9376$. See Table 1).
References


SCHÖN W. 1996. *Ausgrabungen im Wadi el Akhdar, Gif Kebir (SW-Ägypten)*. Africa Praehistorica 8, Cologne: Heinrich-Barth-Institut.


**Figure captions**

Figure 1. A. Location of the site of Ounjougou. B. General stratigraphic sequence for the Holocene of Ounjougou. C. Stratigraphic sequence of the Early Holocene, with the position of the potsherds and $^{14}$C and OSL samples. D. OxCal plot of the series of $^{14}$C and OSL dates for the Early Holocene sequence (OxCal v. 4.0.5: Bronk Ramsey 2008. IntCal04 atmospheric curve). Figures in light grey represent the prior distributions for each sample, those in dark grey the posterior modeled distributions (hpd). Indicated on the left for each sample, are: laboratory ID, BP age or raw OSL age (in parentheses), and the individual agreement index (A) (in parentheses). The model agreement index (Amodel) for the data series is 99.6% (see Note).

Figure 2. Bifacial arrowheads from unit HA1, directly associated with the sherds.

Figure 3. Ceramic sherds from stratigraphic unit HA1, older than 9,400 calBC, including a bowl fragment (A) and a decorated sherd (B).

Figure 4. Summary of $^{14}$C dates from African sites with ceramics contemporaneous with the HA1, HA2 and HA3 formations at *Ravin de la Mouche* at Ounjougou, in chronological order. The *Ravin de la Mouche* $^{14}$C dates are here represented as simple calibrations.
Figure 5. Map of African archaeological sites with ceramics contemporaneous with the HA1, HA2 and HA3 formations at Ounjougou. 1. Ounjougou/Ravin de la Mouche. 2. Tagalagal. 3. Adrar Bous 10. 4. Wadi el Akhdar. 5. Bir Kiseiba E-79-8. 6. Sarurab 2. (Map Data: SRTM and FAO).
**Table 1:** Radiocarbon and OSL dates, with details of the OxCal plot results. The columns on the right of the table give the $1\sigma$ and $2\sigma$ ranges of Bayesian hpd (highest posterior density), the mean ($\mu$), the agreement indice for each date ($A$) and the agreement index for the whole model ($A_{model}$). See also Note 1.
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Table 2: Summary of $^{14}$C dates and calibrations from African sites with ceramics contemporaneous with the HA1, HA2 and HA3 formations at Ounjougou. *Ravin de la Mouche* dates appear here as simple calibrations in chronological order.
Fig. 1

Sandy silts with organic remains

- Sand
- Coarse sand and gravel
- Silty sands with pedological features
- Pleistocene silty blocks
- Pleistocene sediment

OxCal v4.0.5 Bronk Ramsey (2007); r5 IntCal04 atmospheric curve (Reimer et al 2004)

**Sequence HA4**

- **Boundary Transition HA3/HA4**
  - ETH-27144 [9150±70] (92.6)
  - ETH-27143 [9365±70] (104)
  - ETH-27142 [9500±75] (101.9)
  - 04/21/3 [10700±900] (133.8)
  - Phase HA3-BC
  - ETH-28745 [9515±70] (108.7)
  - ETH-31278 [9610±70] (97.6)
  - Phase HA3-Aa2
  - ETH-23540 [9590±70] (110.9)

**Sequence HA3**

- **Boundary Transition HA2/HA3**
  - ETH-31279 [9510±70] (84)
  - ETH-28746 [9785±70] (87.1)

**Phase HA2**

- **Boundary Transition HA1/HA2**

**Sequence Mouche Hibou**

- **Phase HA1**

**Phase HA0**

Mali

Mopti

Ounjougou

Niger River

300 m

0 25 50 km