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Bonfire II: The Return of Pottery Firing Temperatures

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In this paper, I reconsider the problem of pottery firing using a large set of comparable data, most of it collected during extensive fieldwork conducted in Africa and Asia. My main purpose is to assess the actual relationships between the firing procedures (structure, fuel, schedule and scale) and some of the firing conditions (time and temperature). Indeed, if different firing procedures result in different firing conditions, the fired pots might display distinct physical characteristics. I will first characterize the various procedures in terms that are both meaningful for anthropologists and likely to influence the thermal profile of a firing. I will then examine the characteristics of the various firing processes in terms of duration, maximum temperature, heating rate and soaking time.

Keywords: POTTERY, FIRING, FIRING TEMPERATURES, ETHNOARCHAEOLOGY.

Introduction

It is common practice in archaeology to oppose "open firing" and "kiln firing" (Rye, 1981; Gibson & Woods, 1990; Tite, 1995; Kingery, 1997). "Kiln firings" involve a permanent structure with a firebox and are generally assumed to induce high maximum temperatures, slow heating rates and long soaking times allowed by a longer duration. "Open firings" subsume every other type of structures and are generally considered to induce low maximum temperatures, fast heating rates and short soaking times due to their relatively short duration. As a result, the products derived from these two types of "firing technologies" are assumed to be characterized by different degree of heat related alterations. Archaeological sherds may then be assigned a particular "firing technology" on the basis of their physical characteristics. As it appears, this methodology is based on the assumption that the structure is the determinant factor of the thermal profile of a firing. The duration, the maximum temperature, the heating rate and the soaking time are all assumed to depend on its specifications. Serious doubts were cast on the validity of this assumption when, in 1992, Gosselain published a paper in *JAS* questioning the meaning of pottery firing temperatures in archaeology. He insisted on the need to identify firing procedures rather than temperature numbers and criticized the focus put on analytical techniques at the expanse of an archaeological interpretation of the results. Using first-hand and published thermometric data he showed that:

(1) maximum firing temperatures are of no use to differentiate the various firing procedures as documented around the world and characterized by particular structure, atmosphere and fuel;
(2) fuel has no influence on the maximum temperatures reached during a firing;
(3) maximum temperatures are extremely variable within a single firing;
(4) temperature in general is extremely unstable and variable through time and space, within a structure and even on a single vessel.

He thus advocated focusing temperature studies on the heating rate and the time of exposure to temperatures (the soaking time)—two parameters that he thought better means to characterize the various firing processes.

His paper did not close the subject of firing temperatures though. To begin with, Gosselain's work was based on a limited number of first-hand ethnographic data, mainly bonfires, and on a number of published data, sometimes difficult to compare. To go further, one needed more comparable data from various firing procedures. Secondly, his use of the heating rate and time of exposure to temperature were rather vague. Gosselain expressed the feeling that they might serve as a better index of technical diversity, but their relationships with technical behaviours were not clearly assessed nor explicated. In fact, as shown below, Gosselain's assumptions were incorrect. Also, despite being frequently quoted by archaeologists, this paper seems to have been partly misunderstood. For instance, Andrews (1997: 70) quoted it to confirm that the "firing temperatures" of a particular pottery type, which he thought kiln fired, fell outside the range of open firing technologies as defined by Gosselain (see also Herbert, 1993, who quoted it to illustrate the supposed thermal superiority of kilns as opposed to

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open firings). Although recent publications devoted to firing technologies tend to rely more on archaeological or ethnographic data than analytical results (see for instance Tobert, 1984*a*, 1984*b*; Tite, 1995; Balansky, Feinman & Nicholas, 1997; Blinman & Swink, 1997; Kingery, 1997; Pool, 1997, 2000), there remains a great deal of misconceptions regarding pottery firing and its thermal characteristics, some of which are summarized below.

First, one should keep in mind that the thermal characteristics of a firing—its thermal profile—can only be expressed in terms of maximum temperature, heating rate, and soaking time. Firing temperature estimates of archaeological sherds are, as put by Tite (1969), "equivalent firing temperatures". They are associated to standard experimental conditions, and it is admitted that they are not necessarily representative of the characteristics of the original firing (Shepard, 1956; Tite, 1969). This might be common knowledge for material scientists, but it is not the case for most archaeologists; Nicholson (1993: 119) even states that some consider the term "equivalent firing temperature" as redundant or obsolete. Temperature estimates or "equivalent firing temperatures" are generally turned into single numbers or a range of "maximum temperature" without any reference to the duration of the process, the heating rate or the soaking time. Isolated temperature numbers might have a meaning in weather forecast, but they are meaningless without a time dimension when speaking of a firing process.

Second, "firing temperatures" have been improperly used to identify or differentiate past firing technologies. Even if many researchers explicitly aim at characterizing temperature and atmosphere, without attempting any anthropological interpretations (see for instance Shepard, 1956; Hodges, 1963; Matson, 1971), the tendency remains to equate these firing conditions with actual technologies (Perrinet & Courtois, 1983; Heimann, 1982, 1989).

Third, in the many instances where firing estimates are used to assess ancient techniques, the scope of the interpretation is often limited to the distinction between "open firings" and "kiln firings". The common assumption is that "kilns" fire at higher temperatures than "open firings". Besides the fact that such a simplistic view does not take into account the complexity of firing procedures observed in the field, the assumption that kilns display "better" thermal performances as compared to all other types of firing structures was never truly demonstrated. Also, one may wonder how appropriate it is to use costly and time consuming analytical techniques, if the best we can say is that "well fired pottery" was fired in a kiln while "poorly fired pottery" was fired in an "open structures". Snapping a sherd in the field serves that purpose well enough—Tite (1995) actually advocated a reassessment of such simple methods.

In this paper, I intend to reconsider the problem of pottery firing using a large set of comparable data, most of it collected during extensive fieldwork conducted in Africa and Asia. My main purpose is to assess the actual relationships between the firing procedures (structure, fuel, schedule and scale) and some of the firing conditions (time and temperature). Indeed, if different firing procedures result in different firing conditions, the fired pots might display distinct physical characteristics. I will first characterize the various procedures in terms that are both meaningful for anthropologists and likely to influence the thermal profile of a firing. I will then examine the characteristics of the various firing processes in terms of duration, maximum temperature, heating rate and soaking time. In doing so, I hope to:

(1) reassess the notions of firing procedures ("firing technologies") and thermal profiles ("firing temperatures");
(2) assess the validity of Gosselain's hypotheses on the usefulness of the various firing parameters to differentiate firing traditions;
(3) reconsider the meaning of technical variations at this stage of the *chaîne opératoire*.

Data Collection

My approach to firing procedures is drawn from the data collected during 105 firing sessions observed during several fieldwork sessions in Cameroon, Togo, Burkina Faso and Senegal by members of the "Ceramic and Society Project" (Gosselain & Livingstone Smith, 1995; Gosselain *et al.*, 1997; Livingstone Smith, 1997). The thermometric data consists of 62 firings directly monitored in the field and 18 comparable firings published by other researchers (Table 1). All the specifications regarding those firings are given in Appendix 1.

Thermometric data were recorded as part of a standard field procedure. The equipment and monitoring procedure used are almost identical to those described by Gosselain (1992). Recordings were stopped when the first pot was removed or when the temperatures were dropping below 400°C—in the case of slow cooling procedures. The probes placed directly in contact with vessel surface, where set in order to cover the entire structure, or a representative cross-section in the case of large structures. The number of probes is variable due to breakage in the field, or to the fact that probes were sometimes set on the internal surface of vessels.

From a methodological point of view two problems need to be specified. First, it must be noted that probes are not equidistant from one firing to the other, which technically means that we are comparing events that occurred in different positions of the hearth. Furthermore, the position of the fuel with regard to the probes is not always the same. Gosselain (1992, 1995) showed how variable temperatures could be on a single vessel (see also Nicholson & Paterson, 1989; Wotzka, 1991) and it is likely that some variations could be observed on a single firing monitored with two sets of probes. I will rule out these causes of variability or inaccuracy though, as the data recorded is mostly consistent with visible features of the firing. Temperature tends to increase when fuel is added and to decrease when a gust of wind hits the structure, so I will consider these data as a good indication, an index, of the thermal profile of these processes.

A second problem is that it is not possible to give every detail for each firing. Instead, I will directly compare the duration and the expressions of time and temperature traditionally used to describe a thermal profile: the maximum temperature, the heating rate (the average temperature increase per minute until maximum temperature is reached) and the soaking time (the number of minutes the vessels remained above certain temperature thresholds).

To simplify the description and discussion of the data, I will mostly use the soaking time above 700°C (a threshold above which the clay is likely to be altered). Each value represents an average of the data recorded by the various probes.

Firing Procedures: a Technical Characterization

In most technological studies, the structure is the sole parameter taken into consideration. This is not surprising, *a priori*, as it is at the same time socially significant and assumed to be of major influence on the thermal profile of the firing. In fact, as we will see, the categories of firing procedures as characterized by particular structures display dramatically variable thermal profiles. It is therefore necessary to examine the influence of other aspects of the firing process, with a view to assess their actual influence on the thermal characteristics of a firing. These are the fuel, the schedule (based on the way the firing process is ended) and the scale (based on the number of vessels fired at the same time).

Structure

Probably because of its high visibility, the structure is usually considered both in ethnographic and archaeological reports as the major factor of thermal efficiency. As stated in the introduction, most archaeological reconstruction consider two types of structures only: ‘‘kilns’’ and ‘‘open structures’’. ‘‘Kilns’’, characterized by permanent structure with a firebox, are supposed to contain heat and allow higher temperatures, whereas ‘‘open structures’’, every other kind of construction, are deemed poorly efficient in that respect. The structures I will consider here are: bonfires, bonfires with light insulation (a few sherds or metal basins), bonfires with heavy insulation (complete sherd covering), depressions, depressions with heavy insulations, pits, pits with heavy insulation, simple kilns (or updraught kilns without firebox) and kilns (updraught kilns with firebox)—some of which are illustrated by Gosselain (1992).

Fuel

Almost everything that can be set to fire is—or has been—used as fuel: straw, grass, leaves, wood (twigs and lugs), bark, palm fronds, dung, millet husks or stems, or even seaweed to name but a few. The nature and state of the fuel are said to affect the duration, atmosphere and thermal profile of the firing (Shepard, 1956; Lauer, 1974; Rye, 1981; Echallier, 1984). But, except for empirical statements such as ‘‘straw burns faster than wood’’ or ‘‘dung is a slow burning fuel’’, there are few data on the specific effects of various kinds of fuel. Also, one must note that materials are often combined—for instance straw and wood or dung—so that making assumption on their relative influence appears even harder. Here, I have sorted the various fuel combinations into three categories according to the nature of the dominant material: light fuel (dominant material is grass, straw, millets husks or stems, palm fronds etc.), heavy fuel (dominant material is wood or bark) and dung (often considered to have specific properties).

Schedule

The length of the procedure and the way it is ended is rarely taken into consideration in pottery studies. It is generally assumed that ‘‘open’’ firings have short duration and ‘‘kiln’’ firings relatively longer ones (Hodges 1963; Rye, 1981; Nicholson, 1993; Tite, 1995). The ethnographic record shows that things are indeed more complex and that the duration of the process is not correlated to the structure alone.

In fact, a firing may last from several minutes to several hours or several days. During this time, the pottery may refuel regularly or simply let the initial fuel burn out without intervention. The process may be ended when the structure has cooled down or, on the contrary, by drawing the vessels out of the firing while red hot. Here, it is worth pointing out the fact that, whatever the procedure, most potters judge the firing finished when the pots start glowing. It is generally when they notice this phenomenon that they either stop refuelling or start drawing the vessels out of the fire. In the later case, the vessels are often treated with a preparation of crushed organic matter and water (fruits, barks, etc.).

Here, I will consider two types of schedules: (1) interrupted processes and (2) slow cooling processes. Interrupted firings generally fall below 1 h and the vessels are most of the time treated while red-hot. Slow cooling processes generally last more than an hour and

Table 1. Thermal profile (maximum temperature, heating rate and soaking time) of various firing procedures

No.	Schedule No. of pots	Diameter	Height	Interupt.	Post-firing (Sm, Sp, So)	Duration (min.)	Max. temperature (°C) Min	Mean	Max	Heating rate Average (°C)	Soaking time Average (min.) >700	>800	>900	>1000
Bonfire, light fuel														
1	15	2	1	+	Sm	51	719	816	913	35	24	8	2	0
2	11	1	0·6	+	Sp	21	746	829	884	64	13	6	0	0
3	6	2·5	1	+	Sp	38	663	778	944	82	8	3	0	0
4	25	2	1·2	+	—	48	567	677	749	19	11	0	0	0
5	49	2·5	1·3	+	Sp	22	645	755	817	36	7	0	0	0
6	34	2	0·9	+	Sp	42	727	810	879	32	18	5	0	0
7	32	2	0·9	+	—	41	588	613	660	48	0	0	0	0
8	20	2	0·8	+	Sp	40	725	795	840	23	13	3	0	0
9	30	6·5	1·8	+	Sp	24	705	796	878	62	9	3	0	0
10	5	1	0·6	+	Sp	34	521	644	744	70	1	0	0	0
11	19	2	0·8	+	Sm	21	672	728	799	130	4	0	0	0
12	56	2·2	1	+	—	40	644	799	926	24	13	8	3	0
13	29	2·5	1	+	—	54	600	743	848	42	9	2	0	0
14	—	—	—	+	Sp	15	—	800	—	114	3	0	0	0
15	—	—	—	+	Sp	20	—	703	—	64	1	0	0	0
16	19	2	1·5	+	Sp	25 (27)	480	560	663	23	0	0	0	0
17	20	1·5	1	+	So	25	580	645	690	44	0	0	0	0
18		1	1	+	Sp	41	65	575	813	18	2	1	0	0
19	22	1·5	1	+	Sp	24	400	661	904	37	4	1	0	0
20	25	1·6	1	+	Sp	25	604	737	892	28	6	1	0	0
21	20	2	1·5	+	Sp	25	620	727	779	33	5	0	0	0
22	21	1·5	1	+	Sp	30	576	727	870	39	4	1	0	0
23	4	0·5	0·5	+	Sp	14	646	735	865	52	2	0	0	0
24	3	0·8	0·7	+	Sp	18	508	676	867	18	4	1	0	0
25	—	1	0·8	+	Sm, Sp	34	542	667	736	20	2	0	0	0
26	100	7·5	1·8	+	Sp	119	678	738	783	17	18	0	0	0
27	5	1	0·6	+	Sp	80	648	728	793	11	6	0	0	0
Bonfire, heavy fuel														
28	1	0·6	0·6	+	Sp	13	604	642	672	52	0	0	0	0
29	4	0·6	0·5	+	Sp	20	610	662	745	35	1	0	0	0
30	3	0·6	0·5	+	Sp	18	632	709	757	53	5	0	0	0
31	—	1	1	+	Sp	42 (45)	820	869	906	19	21	11	1	0
32	4	1	0·5	+	Sp	33	404	678	857	31	5	2	0	0
33	3	0·5	0·5	+	Sp	25 (28)	681	743	871	30	3	1	0	0
34	—	1	1	+	Sp	45 (50)	514	710	901	17	8	4	1	0
35	3	1	0·6	+	Sp	15	408	763	929	54	1	1	1	0
36	11	1	0·6	+	Sp	24	578	681	832	33	4	1	0	0
37	4	0·6	0·5	+	Sp	45	—	825	—	46	25	15	0	0
38	10	1	0·8	+	Sp	58	—	875	—	26	21	14	0	0
39	—	0·5	1	+	Sp	32	681	801	961	26	7	3	1	0
40	—	0·7	0·6	+	Sp	24 (27)	748	853	919	35	10	6	2	0
41	1	0·5	0·6	+	Sm, Sp	37	587	655	698	21	0	0	0	0
42	—	0·8	0·5	+	Sp	25	755	833	926	44	9	3	1	0
43	20	1·6	0·9	+ (sp.)	So	81	605	710	825	20	6	1	0	0
44	20	1·7	0·9	+ (sp.)	So	104	627	790	996	28	6	3	1	0
Bonfire, dung fuel														
45	—	0·5	0·5	—	—	49	—	670		24	0	0	0	0
46	8	—	—	+	Sm?	19	—	770		64	8	0	0	0
47	40	—	—	+	no	80	—	940		16	40	32	15	0
48	300	—	—	—	no	85	—	715		42	8	0	0	0
49	5	—	—	+	—	18	—	890		89	9	5	0	0
50	3	—	—	+	—	23	—	830		49	12	5	0	0
51	—	—	0·8	—	—	150	808	919	1011	8	79	55	16	4
Depression, light fuel														
52	9	1·5	0·8	+	Sp	25	663	788	829	54	7	2	0	0
53	—	2	0·8	+	Sp	45	450	589	709	42	0	0	0	0
54	32	2·5	0·8	+	Sp	44	820	920	1006	22	17	14	7	0
55	29	2·5	0·9	+	Sp	60	591	758	854	15	11	2	0	0
56	13	2	0·5	+	Special	19	540	681	825	125	5	0	0	0
Depression, heavy fuel														
57	27	—	—	+	Sp	79	—	880	—	14	56	30	0	0

Note: Sm: smoking; Sp: sprinkling; So: soaking.

Table 1. Continued.

No.	Schedule No. of pots	Diameter	Height	Interupt.	Post-firing (Sm, Sp, So)	Duration (min.)	Max. temperature (°C) Min	Mean	Max	Heating rate Average (°C)	Soaking time Average (min.) >700	>800	>900	>1000
Depression with heavy insulation, dung fuel														
58	200	3	1	—	—	275	800	847	863	4	88	40	0	0
Bonfire with light insulation light fuel														
59	100	2	1·5	—	—	100	605	763	859	31	10	2	0	0
Bonfire with light insulation heavy fuel														
60	17	2·3	0·9	+	Sm, Sp, So	44	717	773	864	27	13	3	0	0
61	45	2·4	0·9	+	Sm, Sp, So	36	651	753	898	19	7	1	0	0
62	13	2·3	0·8	+	Sm, Sp, So	44	602	689	785	31	3	0	0	0
Bonfire with light insulation, dung fuel														
63	—	—	—	—	—	80	650	746	926	20	14	4	2	0
64	7	1·5	0·6	—	—	135	505	568	630	19	0	0	0	0
Bonfire with heavy insulation, dung fuel														
65	500	4·5	1·5	—	—	1155	707	829	904	2	117	60	6	0
66	500	5	1·5	—	—	188	857	915	956	7	76	51	14	0
Pit, light fuel														
67	50	3	1·4	—	—	550	685	866	972	3	100	51	13	0
Pit, dung fuel														
68	40	3	1·1	—	—	360 (+)	550	625	700	4	0	0	0	0
69	—	—	—	—	—	150 (+)		856		12	64	34	0	0
70	8	1	0·6	—	—	58	786	831	913	22	28	10	3	0
71	32	1·6	0·6	—	—	453	604	838	987	2	64	38	11	0
Pit with heavy isolation, dung fuel														
72	5	2·3	1·1	—	—	360	580	743	870	6	10	4	0	0
Simple kiln, light fuel														
73	15	2·3	1	—	—	39	642	759	918	38	6	2	0	0
74	9	1·5	1	—	—	46	604	734	868	31	9	2	0	0
75	45	2·1	1·1	—	—	81	812	957	1074	15	33	22	12	4
Kiln, light fuel														
76	627	4·5	3·4	—	—	192	—	690	—	4	0	0	0	0
77	625	4·5	3·4	—	—	183 (200)	850	853	855	5	62	44	0	0
78	—	—	—	+		55	—	905	—	18	32	20	5	0
79	—	—	—	Special	Special	240	—	660	—	3	0	0	0	0
Kiln, heavy fuel														
80	55	1·2	1·6	—	—	81	669	804	879	19	9	3	0	0

Note: Sm: smoking; Sp: sprinkling; So: soaking.

the vessels are usually left to cool down in the structure.

Scale

The number of pots fired at the same time ranges from one to over 600, while the dimensions of the structure ranges from 0·5 to 7·5 m in diameter. Here, I will only consider the number of vessels fired at the same time. Besides the fact that it seems difficult to devise an accurate index of the number of pots per volume, a rapid overview of data shows that the dimensions of the structure tend to increase with the number of pots fired. I will consider three types of procedures: small scale firings (with less than five vessels), medium scale firings (between six and 60 vessels) and large scale firings (over 60 vessels).

Firing Procedures: a Thermometric Characterization

I first will review the thermometric data in a general way, without taking the procedure into account. The idea is to check whether the various expressions of time and temperature display any meaningful clusters. Secondly, I will examine the specific relationships between the firing procedures characterized by the parameters I referred to above (structure, fuel, schedule and scale), and their thermal profiles. I will then examine the thermal characteristics of "open" and "closed" or "kiln" firings as characterized in the literature. The idea is to see how several socially meaningful factors may have an influence on the thermal profile of a firing and hence, may be considered separately or together as a convenient way of explaining firing conditions.

General overview of the data

Temperature records are consistent with the theoretical concepts pertaining to the evolution of temperature through time during a firing. Average maximum temperatures are not correlated to the duration of the firing (Figure 1). On the other hand, the heating rate and soaking time display a good correlation to the duration of the process. Short firings allow for higher heating rates and/or short soaking times above 700°C,

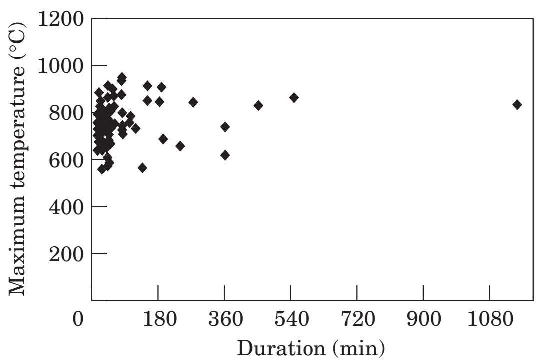

Figure 1. Temperatures versus time.

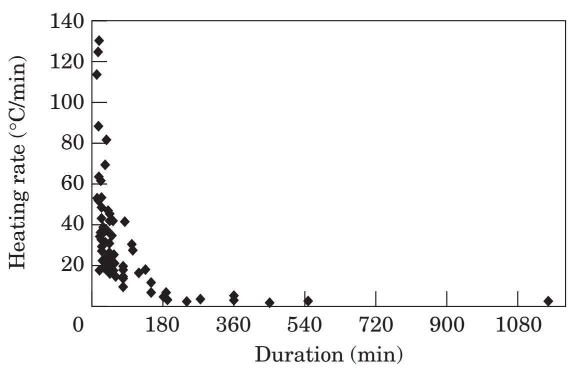

Figure 2. Heating rates versus time.

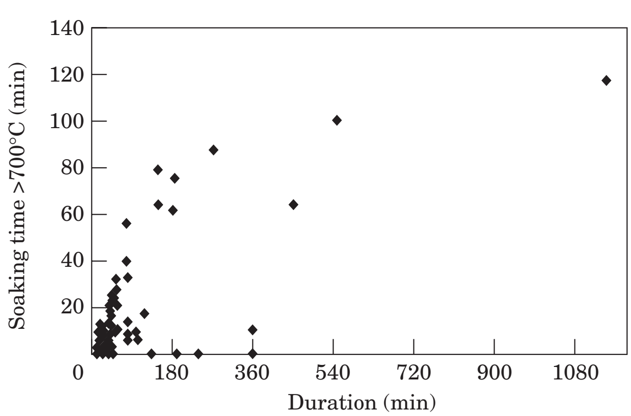

Figure 3. Soaking times <700°C versus time.

while long firings allow for slower heating rates and/or longer soaking times above 700°C (Figures 2 & 3). Despite this trend, it is also apparent that a relatively long firing may have a very short soaking time above 700°C.

A closer examination shows that two types of firing could be distinguished according to their soaking time above 700°C (Figure 4 & 5). The first group includes nine firings (Table 1: firings number 51, 57, 58, 65, 66, 67, 69, 71 and 77) characterized by particularly long soaking times (over 1 h), very low heating rates

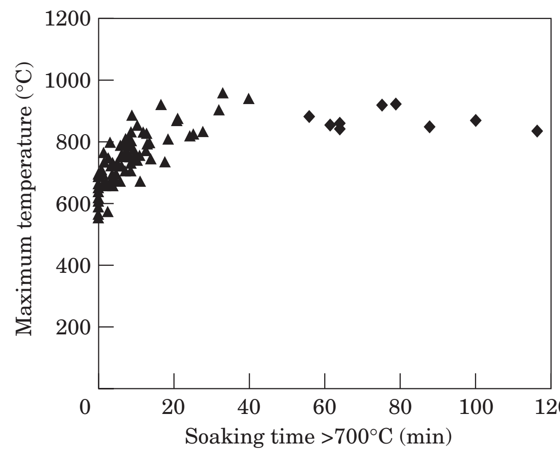

Figure 4. Maximum temperatures versus soaking times <700°C (group 1 and 2). ◆, first group; ▲, second group.

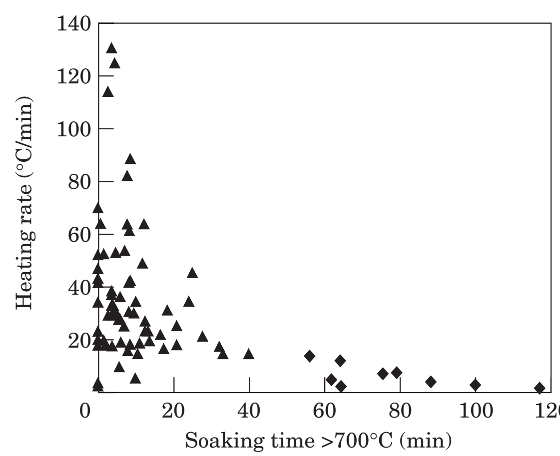

Figure 5. Heating rates versus soaking times <700°C (group 1 and 2). ◆, first group; ▲, second group.

(below 10°C/min) and high maximum temperatures (averaging over 800°C). The second group, composed of 71 firings, is characterized by lower soaking times (mostly below 10 min above 700°C), fast heating rates (mostly between 20 and 40°C/min) and lower maximum temperatures (mostly from 700–800°C).

At this stage it already seems clear that there is not a great diversity of distinct thermal profile. It remains to be seen, however, if the two groups are related to specific firing procedures (structure, fuel, etc.) and to confirm the fact that different firing procedures—as characterized in Table 1—may induce similar thermal profiles.

Relationship between firing procedures and thermal profiles

Structure. Looking at the duration of the firings, it appears that three groups could be distinguished. The first includes bonfires, depressions, bonfires with light insulation and simple kilns (updraughts kilns without a firebox), that all display average duration well below an hour. The second group includes bonfires, depressions and pits with heavy insulation, as well as pit firings, with average duration from 4 to 6 h. Kilns, with an average duration of two hours, represent an ambiguous third group by themselves. Despite this rough distinction, all categories overlap with at least one other category when taking into account the whole range of values.

The average maximum temperature appears to be a very poor parameter for distinguishing the various categories of structure. Most values are comprised between 600 and 900°C with a large overlap of the data between 700 and 800°C.

The situation is different with the heating rate. Here, the most striking feature is not so much the three groups one could differentiate on the basis of average values (around 40°C.min, around 20°C/min and below 10°C/min), than the two groups apparent when considering the range of heating rates: bonfires and depression against all the other types of structures. This distinction is not absolute though, despite the fact that none of the closed or insulated structure displays any values of heating rate above 40°C/min, the lowermost values of bonfires and depressions are below 20°C/min.

Most structures display average soaking times above 700°C below 20 min. Bonfires and depressions with heavy insulation as well as pits are the only structures displaying average values around or above 60 min. Such a distinction does not make much sense though, and it is clear, when considering the whole range of values for each category that the overlap of data is too important to allow for the differentiation of the various structures on the basis of their soaking times. For instance, most categories may produce no soaking time above 700°C.

Fuel. Generally speaking, the fuel seems to be poorly correlated to the thermal profile of the firing. Although dung fuel seems to be associated with longer firings than light and heavy fuel, the type of fuel does not display a good correlation to the duration of the process. The three types of fuel may be associated with firings from several minutes up to several hours.

Maximum temperatures are indistinct for the three categories. The values for light, heavy and dung fuel range from 600 to 900°C, averaging between 750 and 800°C.

The situation is fairly similar when examining the heating rate. the slight decrease of the average values from light fuel to dung fuel makes sense with the idea of faster to slower burning fuel; but the overlap of data between the three categories makes it difficult to attribute a particular heating rate to a specific fuel. The soaking time above 700°C does not allow to differentiate the three categories either. Despite the fact that dung displays a higher average soaking time than light and heavy fuel—making sense with the idea that a slower burning fuel allows for a build-up in temperature—the overlap of data is considerable between 0 and 60 min above 700°C.

Schedule. Considering the minimum, average and maximum duration of the two types of schedule it appears that, despite some overlap of the data, they have relatively distinct characteristics. As I said above interrupted firings tend to fall below 1 h, with an average time of 39 min, while slow cooling firings tend to exceed one h with an average time of 4 h (239 min). Despite distinct average duration, the data for both categories overlap, however, lowermost values of slow cooling processes are equal to the average duration of interrupted processes.

Maximum temperatures are, yet again, clearly indistinct. Both categories of schedule have average maximum temperatures around 800°C, with a large overlap of data between 600 and 900°C. The heating rate, as could be expected from a parameter with a time dimension, allows to differentiate the two types of procedures to a certain degree. The average heating rate is clearly distinct: below 20°C/min for slow cooling processes, over 40°C/min for interrupted firings. The overlap of data is similar to that of the duration, lowermost values of heating rate for interrupted processes are equal to the average heating rate of slow cooling processes. Also, the uppermost value for slow cooling processes is equal to the average heating rate of interrupted processes.

The pattern is similar when considering the soaking times above 700°C. Average values are very different, 9 min above 700°C for interrupted firings, against 37 min above the same threshold for slow cooling processes. Again the data overlap as both type of procedures may produce no soaking times above 700°C, and the uppermost value of interrupted firings is superior to the average value of slow cooling processes.

Scale. Looking at the average values of each parameter, the thermal profile of procedures characterized by their scale, fits, for what its worth, with the assumption that the scale of a firing is of influence on its thermal performances. There seems to be an overall increase of the duration of the process from small to large-scale procedures (from 1 to 6 h), although small and medium scale firings have similar average values. Unfortunately, the overlap of data between the three categories is, yet again, too important to allow the differentiation of these procedures with this parameter.

Maximum temperatures for the three procedures overlap between 700 and 800°C. The average heating rate does not allow to clearly differentiate the three categories of firing either. Despite a slight decrease of the average values from small to large scale firings, a trend that is not confirmed when looking at the extreme values, the overlap of data between the three categories is considerable from 10 to 30°C per min.

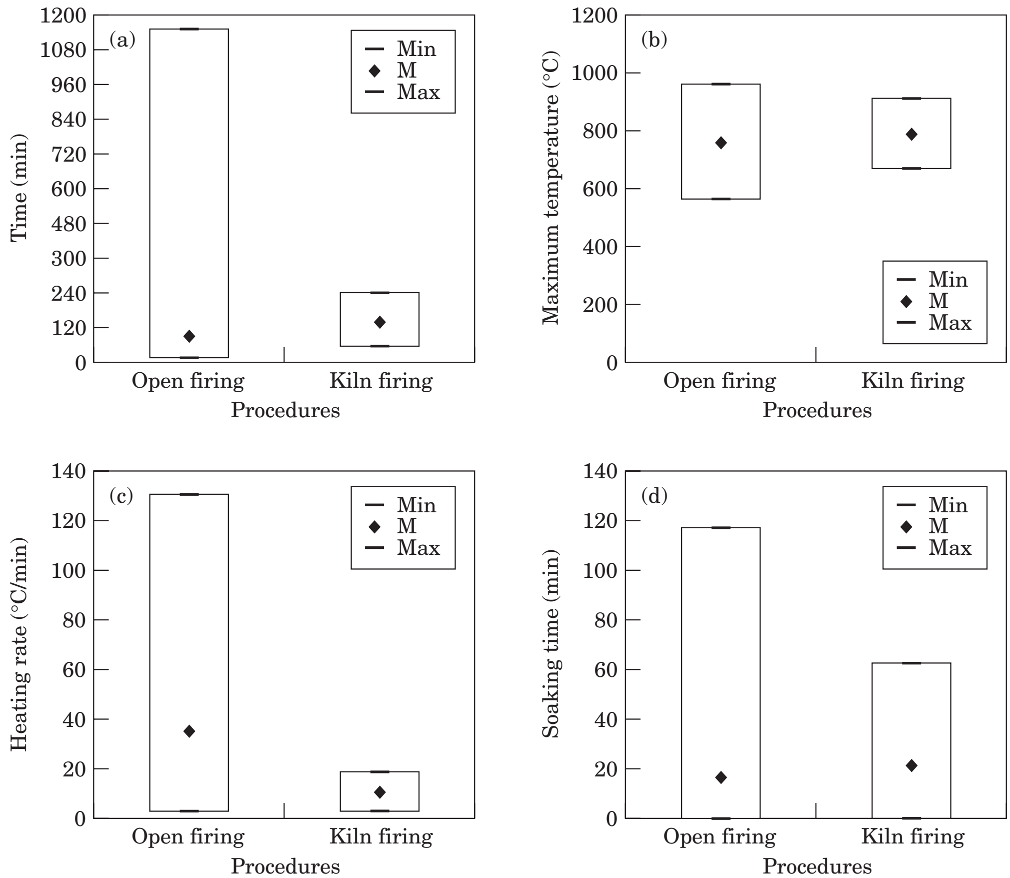

Figure 6. Thermal profile of "open" and "kiln" firings.

Average soaking times—like the duration—increase with the scale of the firing, from below 10 min for small scale to almost 60 min for large scale firings. It is worth noting that small scale firings do not allow for soaking times superior 30 min above 700°C. Unfortunately, the overlap of the data for each categories is too great to make the soaking time above 700°C a distinctive feature for the scale of the firing.

"Open firing" versus "kiln firing". Given what proceeds, it is already clear that the simplistic opposition between the thermal characteristics of "open" and "kiln" firing does not hold. The duration of both types of "procedures" is extremely variable (Figure 6(a)). "Open firing" last from several minutes to over 19 h, while "kiln firings" last from 1 to 4 h, which means that although the scope of their variability is very different, there is a considerable overlap of their effects in that respect. As a matter of fact, the average duration is similar for both types of procedures.

Average maximum temperatures fall between 550 and 950°C for open firings and between 650 and 900°C for kilns (Figure 6(b)). So, if open firing may produce lower maximum temperatures than kilns, they do not necessarily do so. The average value is similar for both categories and the upper range of maximum temperature is higher for open firings than for kilns.

The heating rate provides a better way of distinguishing these two types of procedures, as open firing range from a few degrees per minutes to over 120°C/min, while the range of heating rates for kiln firings is below 20°C/min (Figure 6(c)). Unfortunately, although the average values are quite different, it appears that kiln firing are not the only one to allow for very low heating rates, the lower range of heating rates for open firings being inferior to that of kiln firings.

The average values of soaking time above 700°C are fairly similar for both categories—around 20 min (Figure 6(d)). It is worth noting that the upper range of open firings is around 2 h, against 1 h for kilns, while both categories may also produce no soaking times above 700°C.

Discussion and Conclusion

After examining the technical and thermometric characteristics of 80 firing procedures recorded around the world, one is forced to admit that the dramatic diversity and complexity of firing technologies has been very much underestimated by archaeologists and material scientists alike.

Although one might devise other ways to examine the thermometric data, I think that there is enough material here to address the three ideas I had in mind when starting this paper, namely:

(1) reassess the notions of firing technologies (firing procedures) and firing temperatures (thermal profiles);
(2) assess the validity of Gosselain's hypotheses concerning the usefulness of the heating rate and soaking time to differentiate firing traditions (Gosselain, 1992);
(3) and check for new ways of apprehending the meaning of technical diversity at this stage of the *chaîne opératoire*.

Although some aspects of the reassessment of firing procedures and firing temperatures may come as no surprise considering the detailed literature on the subject, several reflections may be drawn from the above data.

Firstly, firing technologies may be characterized by a number of socially significant facets and can not be reduced to "open" and "kiln" categories without a considerable loss of technical and cultural information. There has been a tendency to equate firing structures to firing techniques and to consider some of these "techniques" as variants of major technologies. Although I do not deny the existence of variants, there are many independent and recurrent aspects of the process that should not be seen as variants. Pits and bonfires with heavy insulation, for instance, are often presented either as variants of bonfires, or as an intermediate stage between bonfires and kilns. Although pits and bonfires with heavy insulation share some similarities with other types of structures, they can not be considered as variants of "kilns": they are built and used by people who belong to different technical and cultural traditions.

Secondly, it is now perfectly clear that the structure is by no means the major parameter of firing technologies. Among the various parameters of social and technical significance, there are a number of aspects likely to influence the thermal characteristics of a firing. Considering only some of them—structures, fuels, schedules and scales—allow for the identification of a number of distinct "simplified" firing traditions.

To verify Gosselain's hypothesis and solve our main problem—the reconstruction of firing technologies from archaeological sherds—we must characterize the thermal profile of these "simplified" firing traditions. In other words, we must establish the relationship between firing conditions in terms of temperature, and particular firing technologies. To do so, we need to consider two aspects: the characteristics displayed by the thermometric data in general and the relationships between the various procedures and their associated thermal profiles.

An overview of the thermometric data, without taking technical specificity into consideration, is consistent with the theoretical principles of a firing. Maximum temperatures display little correlation to time. The heating rate displays an exponential relation to time (as longer firing time induces slow heating rates when similar maximum temperatures are reached), while there is an saturating exponential relationship between soaking times above 700°C and duration of the process (as longer firings induce more time over certain temperature thresholds).

Focusing on the soaking time above 700°C, it seems that two groups display distinct thermal profiles. The first group is characterized by particularly long soaking times, very low heating rates and high maximum temperatures. The second group is characterizd by shorter soaking times, fast heating rates and variable maximum temperatures. Both groups include contrasted firing traditions. At this stage, however, it is clear that the various firing procedures observed in the field do not produce a great number of distinct thermal profiles. If that were the case, one would expect more ruptures in the distribution of heating rates and soaking time versus time.

This general assessment is confirmed when examining the relationship between the various firing procedures and their associated thermal profiles. Be it from the point of view of "open" and "kiln" firings, or from the point of view of the various structures, fuels, schedules and scales, none of the technical categories envisioned above induce specific thermal characteristics. In other words, it is impossible to relate a particular set of thermal characteristics (duration, maximum temperature, heating rate and soaking time) to a specific firing procedure. This is also true when devising more complex categories combining for instance structures and fuels. Firings number 73 and 75, for example, are undertaken with similar structures and fuel—simple kilns with light fuel—by a *moba* speaking women of Togo and a *moore* speaking man of Burkina Faso respectively (Table 1, Figure 7). While the thermal characteristics of firing number 73 are very similar to that of a bonfire (see for instance firing number 43, a bonfire with heavy fuel), firing number 75 displays a longer duration with higher maximum temperatures, a lower heating rate and longer soaking time. Clearly, very different characteristics may be achieved within the same structure and similar fuel. When pointing that fact to a male potter, he explained to me that the structure was not the only thing of importance in a firing. Male potters, he said, started their firing slowly to "make a strong fire", while women were careless and unable to achieve "strong fires" like men did—needless to say that no women were present when that explanation was given to me. Without taking part in this debate, one will notice that a toucouleur-speaking woman of Senegal also achieves a "strong fire" in a simple bonfire with dung.

The thermal variability of firing procedures observed in the field is not so surprising though. Besides the fact that a degree of natural variability should be expected as "real life" firings are not laboratory experiments, there are several ways for the potter to act, consciously

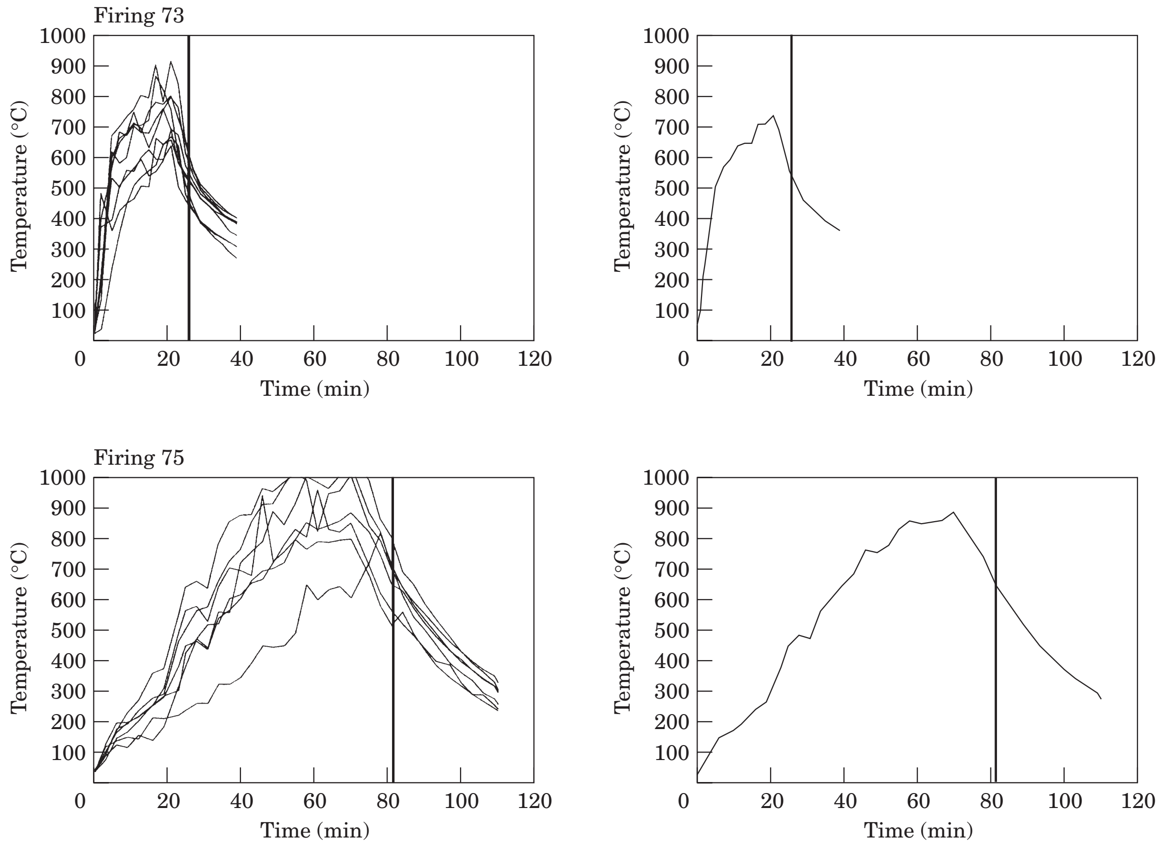

Figure 7. Thermometric data for firing number 73 and 75.

or unconsciously, on the time/temperature profile. For instance, a low heating rate may be induced by a structure allowing a control over the fuelling rate (i.e. kiln) or by the use of a slow burning fuel (i.e. dung or millet husks). But some potters using a bonfire and light fuel combination control the heating rate by wetting the straw prior to firing the structure. A long soaking time may result either from a regular refuelling or from the use of a slow burning fuel in a "closed structure". It is worth noting that potters are very often unaware of the advantages and disadvantages of their firing techniques. Most of the time they simply apply a recipe, a tradition, without having the faintest idea of other ways to fire a pot.

Since different firing procedures or "techniques" may result in similar thermal profiles, temperature estimates cannot be used to identify and compare past firing technologies. According to the thermometric data I have assembled here, a pottery sample displaying evidence of high temperature firing (i.e. a high degree of vitrification) may have been fired according to a great number of different processes: in a simple kiln, a pit, or a bonfire with heavy isolation, with different kinds of fuel and according to various schedules. Maximum temperature, be they "actual" or "equivalent", are therefore meaningless indexes of technical variations. There is no typical range of maximum firing temperatures for open firings in the same way that there is no typical range of maximum firing temperatures for kiln firings. A sherd fired at a maximum temperatures around 700 to 800°C, with a heating rate of 20°C/min, and 20 min soaking time above 700°C may have been fired according to many different procedures.

What can we do, thus, if all we can say is that a pot sherd is either "soft" or "hard"? The distinction between non-vitrified and vitrified pottery is no problem, but we lack data on the relationship between the techno-functional aims of potters and their finished products. We know that potters may control the effects of their firing and that, while a lot of potters are unable to explain the effect of their processes in detail, some are aware that the "strength" of the fire is of importance to obtain "strong" pots. If vitrification was only temperature dependant, one could think that in large areas of Africa today, vitrification will only be an occasional by-product rather than a requisite of the firing process. It does not seem to be the case in other contexts though. In the Mediterranean world, for instance, there are large assemblages of consistently vitrified pottery (Maniatis & Tite, 1981). As most researchers working in the field now accept the influence of the socio-economic environment of the potter on many aspects of pottery manufacture, it might be useful for future studies to focus on the physical characteristics of pottery with respect to their context of production.

Finally, if the detailed characterization of firing procedures and their thermal profiles have failed as far as archaeologists are concerned, it has shown the usefulness of controllable ethnographic data in pottery studies. Archaeology and anthropology are actual sciences and we can not rely on assumptions or simple laboratory experiments for the reconstruction and interpretation of technical behaviours. I hope that this paper will have made that point clear for firing temperatures.

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References

Andrews, K. (1997). From ceramic finishes to modes of production: Iron Age finewares from central France. In (C. G. Cumberpatch & P. W. Blinkhorn, Eds) *Not so Much a Pot, More a Way of Life*. Oxford: Oxbow Books, pp. 57–76.

Balansky, A. K., Feinman, C. M. & Nicholas, L. M. (1997). Pottery kilns of ancient Ejutla, Oaxaca, Mexico. *Journal of Field Archaeology* **24,** 139–160.

Blinman, E. & Swink, C. (1997). Technology and organisation of Anasazi trench kilns. In (P. M. Rice, Ed.) *Ceramics and Civilisation. Vol. VII. The Prehistory and History of Ceramic Kilns*. Colombus: The American Ceramic Society, pp. 85–102.

Degoy, L. (1997). *Enquêtes ethnoarchéologiques au Rajasthan. Etude de la production céramique*. Unpublished manuscript. Tervuren: Documents du Projet Céramiques et Sociétés no. 5.

Echallier, J.-C. (1984). Elements de technologie céramique et d'analyse des terres cuites archéologiques. *Document d'Archéologie Méridionale Série "Méthodes et Techniques"* **3**.

Gelbert, A. (1995). *Etude ethnoarchéologique des phénomènes d'emprunts céramiques dans les haute et moyenne vallées du fleuve Sénégal (Sénégal). Rapport de la première mission de Janvier à Avril 1995*. Unpublished manuscript. Université de Paris X—Nanterre, Département d'Ethnologie et de Sociologie comparative.

Gibson, A. M. & Woods, A. J. (1990). *Pottery for the Archaeologist*. Columbia: Columbia University Press.

Gosselain, O. P. (1992). The bonfire of the enquiries. Pottery firing temperatures: what for? *Journal of Archaeological Science* **19,** 243–259.

Gosselain, O. P. (1995). *Identités Techniques. Le Travail de la Poterie au Cameroun Méridional*. Ph.D. dissertation. University of Brussels, Belgium.

Gosselain, O. P. & Livingstone Smith, A. (1997). The "Ceramic and Society Project": an ethnographic and experimental approach to technological style. In (A. Lindhal & O. Stilborg, Eds) *The Aim of Laboratory Analysis in Archaeology*. Stockholm: KVHAA Konferenser **34**, pp. 147–160.

Gosselain, O. P., Livingstone Smith, A., Wallaert, H., Ewe, G. W. & Vander Linden, M. (1996). Preliminary results of fieldwork done by the "Ceramic and Society Project" in Cameroon, December 1995–March 1996. *Nyame Akuma* **46,** 11–17.

Heimann, R. B. (1982). Firing technologies and their possible assessment by modern analytical methods. In (J. S. Olin & J. D. Franklin, Eds) *Archaeological Ceramics*. Washington, DC: Smithsonian Institution, pp. 89–96.

Heimann, R. B. (1989). Assessing the technology of ancient pottery: the use of phase diagrams. *Archeomaterials* **3,** 124–148.

Herbert, E. W. (1993). *Iron, Gender, and Power. Rituals of Transformation in African Societies*. Bloomington: Indiana University Press.

Hodges, H. W. M. (1963). The examination of ceramic materials in thin section. In (E. Pyddok, Ed.) *The Scientist and Archaeology*. London: Phoenix House, pp. 101–110.

Kingery, W. D. (1997). The operational principles of ceramic kilns. In (P. M. Rice, Ed.) *Ceramics and Civilisation. Vol. VII. The Prehistory and History of Ceramic Kilns*. Colombus: The American Ceramic Society, pp. 11–19.

Krauze, R. A. (1985). *The Clay Sleeps. An Ethnoarchaeological Study of Three African Potters*. The University of Alabama Press.

Lauer, P. K. (1974). *Pottery Traditions in the d'Entrecasteaux Islands of Papua*. University of Queensland Occasional Papers in Anthropology **3**.

Livingstone Smith, A. (1997). The reconstruction of firing procedures: problems and perspectives. Paper presented at conference: 'Ceramic Technology and Production', 20–22 November 1997, British Museum.

Maniatis, Y. & Tite, M. S. (1981). Technological examination of Neolithic-Bronze Age pottery from central and south-east Europe and from the Near-East. *Journal of Archaeological Science* **8,** 59–76.

Matson, F. R. (1971). A study of temperatures used in firing ancient Mesopotamian pottery. In (R. Brill, Ed.) *Science and Archaeology*. Cambridge: MIT Press, pp. 65–79.

Mpika, L. (1986). *La Céramique Traditionnelle des Kongo de la Région de Boko, XVIIIe–XXe Siècle*. Mémoire de D.E.S. Université Marien Ngouabi.

Nicholson, P. (1993). The firing of pottery. In (D. Arnold & J. Bourriau, Eds) *An Introduction to Ancient Egyptian Pottery*. Mainz am Rhein: Deutsches Archäologisches Institut Abteilung Kairo, Sonderschrift **17**, pp. 103–121.

Nicholson, P. R. & Patterson, H. L. (1989). Ceramic technology in Upper Egypt: a study of pottery firing. *World Archaeology* **21,** 71–86.

Perinet, G. & Courtois, L. (1983). Evaluation des températures de cuisson de céramiques et de vaisselles blanches néolithiques de Syrie. *Bulletin de la Société Préhistorique Française* **80,** 157–160.

Pinçon, B. (1984). *La céramique Teke de la région de Zanaga (XIXe–XXe siècle)*. Mémoire de D.E.S. Université Marien Ngouabi.

Pool, C. A. (1997). Prehispanic kilns at Matacapan, Veracruz, Mexico. In (P. M. Rice, Ed.) *Ceramics and Civilisation. Vol. VII. The Prehistory and History of Ceramic Kilns*. Colombus: The American Ceramic Society, pp. 149–171.
Pool, C. A. (2000). Why a kiln? Firing technology in the Sierra de los Tuxtlas, Veracruz (Mexico). *Archaeometry* **42,** 61–76.
Rye, O. S. (1981). *Pottery Technology*. Washington, DC: Taraxacum.
Sall, M. (1996). *La Poterie en Pays Serere (Senegal). Etude Ethnographique des Procédés de Façonnage et des Modes de Distribution Céramique au Mbadane, Dieghem et au Sine*. Unpublished manuscript, Documents du Projet Céramiques et Sociétés no 4, Tervuren, Belgium.
Senasson, D. (1992–93). *Approche Ethno-archéometrique des Céramiques Actuelles de la région de Mubuga (Burundi)*. Mémoire de maîtrise. Université de Paris VI Pierre et Marie Curie, France
Shepard, A. O. (1936). Technology of Pecos pottery. In (A. V. Kidder & A. O. Shepard, Eds) *The Pottery of Pecos, Vol. 2*. Andover: Papers of the Phillips Academy, South-western Expedition **7**, pp. 389–587.
Shepard, A. O. (1956). *Ceramics for the Archaeologist*. Washington, DC: Carnegie Institution of Washington.
Shepard, A. O. (1977). Beginnings of ceramic industrialisation: an example from Oaxaca Valley. In (A. O. Shepard, H. B. Gottlieb, E. W. Andrews & H. E. D. Pollock, Eds) *Notes from a Ceramic Laboratory*. Washington: Carnegie Institution of Washington, pp. 1–23.
Tite, M. S. (1969). Determination of the firing temperature of ancient ceramics by measurement of thermal expansion: a reassessment. *Archaeometry* **11,** 131–143.
Tite, M. S. (1995). Firing temperature determination: how and why? In (A. Lindhal & O. Stilborg, Eds) *The Aim of Laboratory Analysis in Archaeology*. Stocklholm: KVHAA Konferenser **34**, pp. 37–42.
Tobert, N. (1984*a*). Ethnoarchaeology of pottery firing in Darfur, Sudan: implications for ceramic technology studies. *Oxford Journal of Archaeology* **3,** 141–156.
Tobert, N. (1984*b*). Potters from El-Fasher: one technique practised by two ethnic groups. In (J. Picton, Ed.) *Earthenware in Asia and Africa*. London: Percival David Foundation, pp. 219–237.
Woods, A. J. (1984). Methods of pottery manufacture in the Kavango region Namibia: two case studies. In (J. Picton, Ed.) *Earthenware in Asia and Africa*. London: Percival David Foundation, pp. 303–325.
Wotzka, H.-P. (1991). Keramikbrand in offenen feur: vergleichende analyse pyrometrischer daten aus dem Töpferdorf Ikenge (Aquatorregion, Zaïre). In (H. Lüdtke & R. Vossen, Eds) *Töpfereiforschung-archäologisch, ethnologisch, volkskundlich*. Bonn: Rudolf Habelt, pp. 289–318.

Appendix

				Probes	
1 Agotohui	Cameroon	OTO.07	Ceramic & Society	8	Wood, straw
2 Bakipa	Cameroon	BAK.07	Ceramic & Society	5	Wood, straw
3 Balgou Lesdi	Cameroon	BAL.01	Ceramic & Society	10	Wood, straw
4 Boulko	Cameroon	BUL.01	Ceramic & Society	4	Wood, straw
5 Carrefour Po	Cameroon	POL.01	Ceramic & Society	6	Wood, straw
6 Djagou	Cameroon	DJA.01-03	Ceramic & Society	5	Wood, straw
7 Djongue	Cameroon	JON.01-03	Ceramic & Society	4	Wood, straw
8 Katchala Vo	Cameroon	KAT.10	Ceramic & Society	10	Wood, straw
9 Kpaladai	Cameroon	KPA.01-0	Ceramic & Society	8	Wood, straw
10 Librou	Cameroon	LIB.01-04	Ceramic & Society	4	Wood, straw
11 Nigba	Cameroon	NBA.01	Ceramic & Society	4	Wood, straw
12 Pate Petel	Cameroon	PET.01	Ceramic & Society	4	Wood, straw
13 Toukte	Cameroon	OTE.01-0	Ceramic & Society	5	Wood, straw
14 Mubuga	Burundi	—	Senasson 1992–93	1	Wood, straw
15 Mubuga	Burundi	—	Senasson 1992–93	1	Wood, straw
16 Biamo	Cameroon	BIA.01	Gosselain 1995	3	Palm fronds
17 Goufan I	Cameroon	OUF.01	Gosselain 1995	5	Palm fronds
18 Ndikinimeki	Cameroon	DIK.01	Gosselain 1995	8	Palm fronds
19 Kiki	Cameroon	KIK.01(1)	Gosselain 1995	7	Palm fronds
20 Kiki	Cameroon	KIK.02-03	Gosselain 1995	8	Palm fronds
21 Kiki	Cameroon	KIK.01(2)	Gosselain 1995	9	Palm fronds, straw
22 Kiki	Cameroon	KIK.04	Gosselain 1995	7	Palm fronds, straw
23 Mbem	Cameroon	MEM.01-0	Gosselain 1995	8	Palm fronds, palm leaves
24 Ndimi	Cameroon	DIM.01	Gosselain 1995	3	Palm fronds
25 Mangai	Cameroon	GAI.01	Gosselain 1995	4	Palm fronds, wood, palm leaves
26 Sindou	Birkina Fa	SIN.00	Ceramic & Society	7	Wood, straw, rice husks
27 Kelenke	Cameroon	KEL.01	Gosselain 1995	3	Palm fronds, wood
28 Andikol	Cameroon	ADN.01	Gosselain 1995	3	Wood
29 Akouen	Cameroon	AKU.01	Gosselain 1995	3	Wood
30 Akouen	Cameroon	AKU.02-0	Gosselain 1995	4	Wood
31 MBay	Cameroon	BAY.01-0	Gosselain 1995	7	Wood
32 MBay	Cameroon	BAY.03	Gosselain 1995	6	Wood
33 Sarkimbaka	Cameroon	KAK.01-0	Gosselain 1995	8	Wood
34 Likound	Cameroon	LIK.01	Gosselain 1995	9	Wood
35 Emana	Cameroon	MAN.01	Gosselain 1995	5	Wood
36 Mambioko	Cameroon	MBI.01	Gosselain 1995	6	Wood
37 —	Congo	—	Mpika 1986	2	Wood
38 —	Congo	—	Pinçon 1984	1	Wood

Appendix—*continued*

				Probes	
39 Atta	Cameroon	ATT.03-0	Gosselain 1995	7	Wood, charcoal, palm nuts
40 Ngoro	Cameroon	GOR.01	Gosselain 1995	8	Wood, leaves
41 Manbaria	Cameroon	BAR.02	Gosselain 1995	4	Bark
42 Mouzi	Cameroon	UZI.01	Gosselain 1995	3	Bark, wood
43 Edioungou 2	Senegal	DIO(2).00	Sall 1997	6	Wood
44 Edioungou 1	Senegal	DIO(1).00	Sall 1997	6	Wood
45 Halili	Namibia	—	Woods 1984	1	Dung
46 San Ildefons	USA	—	Shepard 1957	1	Dung
47 Zia	USA	—	Shepard 1957	1	Dung, wood
48 Chinautia	Guatemala	—	Shepard 1957	1	Dung, grass
49 Cochiti I	USA	—	Shepard 1957	1	Dung, wood
50 Cochiti II	USA	—	Shepard 1957	1	Dung, wood
51 Mouderi	Senegal	—	Gelbert 1995	6	Dung, straw, wood
52 Bogué	Cameroon	BOG.05	Ceramic & Society	8	Wood, straw
53 Guédé	Cameroon	GUE.01	Ceramic & Society	10	Wood, straw
54 Karlai	Cameroon	KAR.01-0	Ceramic & Society	4	Wood, straw
55 Koubi	Cameroon	KOB.01	Ceramic & Society	10	Wood, straw
56 Babwantou	Cameroon	BAB.01	Gosselain 1995	10	Corn stalks, palm fronds
57 Ikenge	Zaire	Brand 4	Wotzka 1991	1	Wood, barks, palm fronds
58 Bolasar	India	OLA.00	Degoy 1997	9	Dung, straw
59 Dariavad	India	DAR.00	Degoy 1996	8	Wood, straw, feuille
60 Boromo	Burkina Fa	MOT.02-0	Ceramic & Society	8	Wood
61 Nanou 1	Burkina Fa	NON.01-0	Ceramic & Society	8	Wood
62 Nanou 2	Burkina Fa	NON.07	—	9	Wood
63 Sinthiou Gar	Senegal	—	Gelbert 1995	6	Dung, straw, wood
64 —	South Africa	—	Krause 1985	2	Dung
65 Badkha	India	KHA.00	Degoy 1997	10	Dung, millet husks, straw
66 Pachpadra	India	PAD.00	Degoy 1997	10	Wood, dung, straw
67 Diatang 2	Senegal	DYG.00	Sall 1997	6	Wood, straw, leaves
68 —	South Africa	—	Krauze 1985	2	Wood, barks, grass et dung
69 Kadedere	Namibia	—	Woods 1984	1	Dung, grass, reed
70 Beka	Cameroon	BEK.01	Ceramic & Society	6	Dung, straw
71 Komargou	Burkina Fa	ARG.01	Ceramic & Society	9	Dung, straw
72 Sissis	Senegal	SIS.01	Sall 1996	6	Dung, wood, millet husks
73 Nanergou	Togo	NAN.02	Ceramic & Society	8	Millet stems
74 Sibortoti	Togo	SIB.01	Ceramic & Society	9	Millet stems
75 Zagtouli	Burkina Fa	ZAG.01	Ceramic & Society	7	Millet stems
76 Deir el-Ghar	Egypt	Firing 2	Nicholson & Paterson 1	2	Millet stems (bales of sorghum)
77 Deir el-Ghar	Egypt	Firing 1	Nicholson & Paterson 1	2	Millet stems (bales of sorghum)
78 Atzompa	Mexico	—	Shepard 1977	1	—
79 Coyotepec	Mexico	—	Shepard 1977	1	—
80 Basni	India	BAS.00	Degoy 1997	8	Sawdust, kerozene