Helaine Selin (Ed.)

Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures

Volume 1
A–K

With 1374 Figures and 107 Tables

Springer

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A C.I.P. Catalog record for this book is available from the Library of Congress

ISBN: 978-1-4020-4559-2

This publication is available also as:

Electronic publication under ISBN 978-1-4020-4425-0 and
Print and electronic bundle under ISBN 978-1-4020-4960-6

Springer is part of Springer Science+Business Media

springer.com

Printed on acid-free paper SPIN: 11609919 2109 — 5 4 3 2 1 0

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Personal Note From The Editor

Many years ago I taught African history at a secondary school in Central Africa. A few years before, some of the teachers in the country had designed a syllabus that included pre-European history, since the curriculum, left over from colonial days, did not include any mention of Africa before the Portuguese. After a year of teaching from this revised version, I asked my students what they thought was the most significant moment in African history, and virtually all of them said it was the arrival of David Livingstone.

It may well be that that was the most important moment for Africa, but it shocked me at the time that no one considered any African achievements worth mentioning. Over these years I have come to see that the dominance of the West means not only that Westerners disparage the rest of the world but also that the rest of the world sees itself as inferior to the West. This book is meant to take one step towards rectifying that, by describing the scientific achievements of those who have been overlooked or undervalued by scholars in both the West and the East.

The book is more than just a compilation of disparate articles; it is a glimpse into how people describe and perceive and order the world. I hope the reader will do some exploring. In addition to reading about Maya astronomy, one can read about Mesoamerican mathematics and medicine, as well as a general article on magic and science, because all the fields are interrelated and entwined. It might be useful to read about astronomy in Africa and in Australia, to see how similar and different these cultures are. One can travel across disciplines, following the achievements of one culture, and across cultures, comparing the same discipline. And then it would be useful to read an essay on Transmission of Knowledge, or Rationality and Method, to put the articles and their contents in a broader philosophical and social context.

My hope, and that of the advisors and contributors to the project, is that the *Encyclopaedia* will expand the horizons of scholars, teachers, and students by illustrating how extensive the accomplishments of non-Western scientists are. May our future students never believe that science is limited to a fraction of the world.

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A note about the authors' names, especially Asian ones: I made many embarrassing errors confusing peoples' surnames and given names, but I was reluctant to change authors' names to conform to the Western style, as it went against the spirit of the *Encyclopaedia*. Therefore, I have left the names as the authors wrote them.

Shafer, Harry J. and A. J. Taylor. Mimbres Mogollon Architectural Dynamics and Ceramic Style Change. *Journal of Field Archaeology* 13 (1986): 43–68.
Turnbow, Christopher. Saving the Mimbres. *Archaeology Southwest* 15.3 (2001): 2–4.

Ceramics in Africa

Olivier P. Gosselain

Pottery making is a very ancient craft in Africa, as some of the oldest pottery remains known in the world were discovered on this continent. Dating from around 10,000 BCE – i.e., one or two millennia after the inception of the Jomon pottery in Japan – they were excavated in the Aïr Region of Niger (West Africa) (Haour 2003).

Despite its age, the craft is still alive in many parts of the continent. It has of course witnessed a lot of changes through the centuries, in regard to the forms, functions and decorations of the products, but also in terms of manufacturing techniques, scale of production or the social status of the potters. The last decades have been particularly significant, due to the massive introduction of plastic and metal containers, social and economic upheavals, the development of tourism and urban lifestyle, and the geographic extension of individual movements. In most places, ancient pottery functions such as cooking, handling, and serving have been abandoned, while new categories of products such as ornamental or commemorative vases and bibelots, flower pots, tiles, braziers or incense burners are booming. Water jars, however, continue to be massively produced as they provide the cheaper, or even the only way to keep cool water in rural areas.

Social Background

A comparison of several hundred ethnographic sources[1] indicates that at last four-fifths of the African potters working today are women, confirming the usual description of pottery making in Africa as a female activity. Male potters are also at work in various regions of the continent, where they either specialize in the making of particular vessels (big water jars, elite ware, and bottles) while women make the bulk of the production, produce the whole range of vessels in contexts where women are excluded from the craft, or work together with female relatives, carrying out specific operations such as clay extraction and transport, clay preparation, firing and, above all, plastic decoration (Schildkrout and Keim 1990).

The scale of production is highly variable, ranging from part-time, isolated artisans, whose products are essentially consumed locally, to full-time specialists working in workshops, whose vessels are distributed by middlemen in a 100–200 km radius. If men tend to be proportionally more frequent in the latter category, female potters are also associated with mass production, especially in West Africa.

In many instances, pottery making is open to anyone. All one has to find is someone who is willing to serve as a teacher. This means, in practice, having a close relative, friend or neighbor who engages in pottery making and does not mind spending time with someone who may subsequently become a competitor. But restrictions are also observed throughout the continent, which pertain to age, gender, geographical origin and, above all, socio-professional affiliation. For example, in many Sahelian societies, potters belong to caste-like subgroups such as blacksmiths, bards, tanners, weavers, woodcarvers, hunters, or jewelers (Da Silva Gaspar et al. 2005; Drost 1968; Frank 1998; Gallay et al. 1997; Gosselain 2001; Haaland 1978; Sterner and David 1991, 2003; Tamari 1997). The members of these endogamous specialist groups are associated with specific activities and duties, and distinguished from the remaining population. They are regarded with a mix of awe and contempt by nonspecialists, who often consider them "dirty" and "impure", and fear being harmed by their "power." Due to recent economic changes, however, caste-like structures may become permeable to other social groups in specific places.

Manufacturing Process

There are seven main stages of the pottery manufacturing process (1) clay extraction, (2) clay processing, (3) shaping, (4) decoration, (5) drying, (6) firing, and (7) postfiring. While most of these stages are mandatory, some – such as decoration and postfiring – are optional, although widely recorded across the continent (previous surveys of pottery chaines opératoires in Africa include Devisse 1984; Drost 1967; Gosselain 2002; Krause 1997; Livingstone Smith 1999, 2001b).

[1] Information examined in this article comes from two bodies of data. Since 1990, members of the *Ceramic & Society Project* developed at the University of Brussels, and its research associates have conducted fieldwork in Senegal, Gambia, Mali, Niger, Burkina Faso, Togo, Benin, Nigeria, Cameroon, Chad, and D.R. Congo, collecting information about some 1,000 potters in nearly 100 linguistic groups. The second body of data comes from a systematic perusal of the ethnographic and ethnoarchaeological literature devoted to pottery making in sub-Saharan Africa. These sources are of varying relevance and accuracy as they range from large-scale and detailed studies to more local/regional observations, or mentions in ethnographic monographs, administrative reports, and religious publications. Altogether, more than 700 sources have been processed, which relate to some 550 linguistic groups.

Clay Extraction

Available data indicate that most African potters collect their clay within a 3-km radius from the place where they live and/or practice the craft (see Gosselain 2002: 40–41). Those who exploit sources beyond this threshold generally use animals, cars, trucks, or pirogues (canoes) to carry the clay. Also, they often make stocks that last from several weeks to the whole potting season.

Four categories of extracting techniques are observed in Africa: surface collection, pit extraction, underground gallery, and underwater extraction.

In surface collection, the raw material is extracted on, or just below the surface, either on the ground (plain, fields, dried ponds, or riverbeds), a hill, or the wall of a slope or an embankment. After having eliminated the superficial organic and mineral layer, the potter extracts clay without really digging underground. The operation may be described as "peeling" a clay bed.

Pit extraction consists of digging the ground vertically or diagonally until an appropriate layer is reached. Most pits are some 1 or 2 m deep, and 2 or 3 m in diameter. But they may be as large as quarries, reaching some 15 m deep as in southeastern Nigeria (Nicklin 1979: 349). Variations are observed in the way potters exploit and manage these structures. For instance, some use them until the clay layer is completely exhausted, while others abandon the pit until a specific depth is reached, or as soon as it shows risks of collapsing.

Raw materials may also be extracted from galleries. This type of structure generally starts with the excavation of a vertical shaft. When the access shaft reaches the clay bed, the structure is extended horizontally (Livingstone Smith 2001b; Nwafor 1980; Schneider 1993). Galleries, like pits, are generally abandoned at the end of the potting season, but some may be used several years in a row. In the latter case, only the access shaft is re-excavated each year.

Finally, the rather uncommon technique of underwater extraction has been observed among the Tikar of Cameroon and Punu of Gabon (Gosselain 2002: 52–53). Here, artisans build two small dams in a river, bale out the water and dig the clay before the upstream dam gives way.

Usually, it is while performing other activities, and especially activities which force them to dig the ground (e.g., tending fields, building houses, and digging wells) or to frequent places such as riverbeds or swamps, that potters, members of their family, or any of their acquaintances may "discover" a new source and get the process leading to its possible exploitation under way.

A first requirement is that the clay must have the "right" physical properties; i.e., plasticity, texture, color, and even its taste and odor fit with the personal requirements of the potter (see also Barbour 1989; Brown 1989; Frank 1998; Trowell 1941: 61; Woods 1984: 305). If newly discovered clay is judged suitable, a second requirement is that it must be located nearby the potter's main occupational areas and/or working place. Since pottery making is usually subordinated to other activities, such as farming and domestic tasks, potters tend to restrict their investment in time and energy or, at least, to avoid scheduling conflicts between their different activities. Sources located nearby living or working sites, fields, rivers frequented for fishing, roads, or tracks, are therefore more likely than others to be selected and subjected to long-term exploitation. In fact, about 90% of the hundreds of sources that we visited in sub-Saharan Africa were situated nearby or within sites used primarily for other activities. Such a situation has an obvious impact on clay exploitation strategies. More importantly, it shows that clay extraction sites are not distributed randomly or according to a specific logic, but are an integral part of the overall territory frequented by both potters and nonpotters.

Finally, the selection and exploitation of clay sources are also surrounded by a series of rituals and taboos (Barley 1994; Berns 1993; Drost 1964; Gosselain 1999; Herbert 1993; Pinçon 1993). For instance, certain persons are systematically kept aside from the extraction site or the places were the potters store and manipulate the clay: men if the craft is practiced by women, women in other contexts, uninitiated people, members of other social groups than the potters, little girls or boys, pregnant women, menstruating women, twins, warriors, etc. Likewise, artisans must avoid doing particular things on the eve of extraction, during the trip to gather clay or at the site: e.g., having sexual intercourse, talking, singing, swearing, urinating, manipulating certain objects, eating particular food, etc. Rituals and sacrifices (i.e., food offering) may also be performed at the extraction site, a practice still widely recorded in Muslim societies.

Clay Processing

As in most places around the world, African potters never use the clay in its raw state but prepare it in one way or another. While processing practices are usually very simple, they may also involve complex combinations of techniques. These may be grouped into four main categories: pretreatments, removal of nonplastics, addition of nonplastics, and homogenization.

Pretreatments usually involve leaving the raw materials to dry, soak or sour for some hours, some days, some weeks, or even some months. Soaking is usually done in a pit, an old jar or a plastic container, and used when clay is extracted in a dry state. Its aim is to allow the material to regain its plasticity. If clay is

already wet, the aim may be to give it a better workability through increasing the amount and distribution of water between particles and pores. A long soaking time may also help in increasing plasticity through pH alteration and the subsequent flocculation of clay particles, but such souring process seems quite rare among African potters.

When the clay is appropriately dried or soaked, a series of techniques may be used to remove undesirable nonplastics. The most common way is hand sorting, as potters always remove coarse impurities such as pebbles, roots, or leaves at some point during the process. But there are several other ways of controlling clay composition and texture. For example, potters may pound the clay with a stone or a wooden hammer on a stone, or they may simply pound it in a wooden mortar, grind it with lower and upper grinding stones, or grind it on a rock. Finally, nonplastics may be removed by sieving with baskets, pierced calabashes, or imported nylon meshes. Potters may also remove the coarser fraction of nonplastics by shaking the crushed raw materials in a calabash or by winnowing it with a winnowing basket or a calabash. A last technique, levigation, is quite rare in Africa. Here, the material is mixed with water until it reaches a colloidal state, the larger particles are retrieved at the bottom of the container, and the water is allowed to evaporate (David 1983; Gallay and Sauvain-Dugerdil 1981).

Generally called tempering, the addition of plastic or nonplastic elements to the clay may be done with a great variety of materials: another clay (or several clays), dust, organic rich earth (soil), mud, termite heap clay, sand, gravel, rocks (calcareous rocks, gneiss, schist, and asbestos), iron stone, grog (crushed, grounded, and/or sieved potsherds; Fig. 1 – by far the most common material), fired earth, ash, straw, cereal husks, grass, stems, bark, dung (horse, cow, goat, or donkey), shells, calcareous solution (grounded and sieved calcareous rock mixed with a large amount of water; Sall 2001), or bark decoction.

The last processing step generally consists in a thorough homogenization of the paste. This operation is mandatory in clay processing and has a determinant impact on clay workability. It may be done in different ways: kneading with the hands, trampling with the foot, or pounding with various kinds of tools and supports (the most current of which are mortars and pestles, lower and upper grinding stones, and handles of diverse farming tools). If one considers the different combinations of these four categories of treatments, as well as the diversity of behaviors, postures, and tools, there are probably hundreds of ways of preparing the clay.

Potters usually explain that they act the way they do because of "tradition" (i.e., the way they have been taught), but also because vessels made with a clay prepared differently would not survive the drying or firing stages, or would break during utilization. Such conceptions explain why some potters use different processing techniques according to the intended function of vessels, or according to vessel parts. Among the Koma-Gimbe of Cameroon, for example, potters simply pound the clay when making small vessels, but add sand when making large beer brewing jars. They explain that jars would crack when drying if

Ceramics in Africa. Fig. 1 Pounding sherds in wooden mortars for making grog. Note that tools and postures are identical to those used in the realm of food preparation (photo by Olivier Gosselain).

they did not do so (Livingstone Smith 2001b). Others examples of the use of different processing recipes have been collected elsewhere in Africa (Gallay and Sauvain-Dugerdil 1981; Herbich and Dietler 1991; Nicholson 1929; Tobert 1984; Trowell 1941). Most commonly, however, potters use the same preparation technique, whatever the intended function of the vessel.

Another factor that explains the local use of particular processing techniques is the existence of ties to techniques used in other realms of activity, such as food processing and agricultural practices. For instance, staple foods and clay may be prepared with the same tools and gestures, and according to the same recipes. In the Bariba village of Tourou (Benin), for example, potters pound the clay in a wooden mortar and separate the fine and coarse fraction by shaking the material in a calabash. Then, they pound the coarse fraction a second time, and let it soak in a jar placed in the sun. When the liquid is sufficiently thick, it is sieved through a pierced tin can and mixed with the fine fraction of the raw material. Potters explain that this mixture acts as "cement" and that the best millet porridge is obtained in a similar way. Similarly, the clay desalinization technique observed among certain Jola Kasa potters of Casamance echoes, the practices for agricultural land preparation in mangrove swamp zones (Sall 2001).

Symbolic or religious concerns may also influence clay-processing strategies. For example, some Boko potters of Benin take great care in extracting all rootlets from the raw material. This is because rootlets are used to prepare a medication that prevents potters from "swelling" when fashioning vessels. Some West African potters often recycle archaeological sherds into grog, as they consider this material to possess particular qualities because "ancestors knew how to make stronger pots," or because "what has lain underground is stronger than what lies on the ground" (Da Silva Gaspar et al. 2005; Livingstone Smith 2001b). Another example comes from Tukulor potters of Senegal who stop putting dung in the clay when they settle in Soninke communities since the latter consider dung impure (Gelbert 2001).

Shaping

In most instances, shaping techniques may be divided into two specific operations that differentiate both in their purpose and the set of tools and gestures used to carry them: (1) roughing out and (2) preforming. During roughing out, potters transform a lump of clay and/or joint pieces of clay together in order to constitute a hollow volume – the rough shape – whose form, often cylindrical, has not yet reached that of the finished product. During preforming, potters give the hollow volume its final geometric characteristics through scraping and smoothing operations, with the help of a series of tools.

Wheel throwing – not considered here – is only documented in North Africa, where it has been practiced for centuries by male potters. South of the Sahara, only passing references are made to the use of wheel throwing by a few male potters in the Lower Congo area. The technique would have been introduced by Portuguese in the late seventeenth century (Vincentelli 2003: 44), but given the lack of precision, it is not clear whether it is still practiced as such by Kongo potters or has been modified.

Roughing Out

Techniques used in sub-Saharan Africa belongs to seven main categories (1) pounding in a concave form, (2) drawing of a ring-shaped lump, (3) superimposition and drawing of large rings, (4) molding (on concave or convex molds), (5) pinching, (6) drawing of a lump, and (7) coiling. As the last three techniques are widely documented outside Africa, only the first three will be considered here.

The pounding technique – also called "tamper and concave anvil technique" – consists of placing a lump or a pancake of clay on a mat-covered depression or a concave anvil made in wood, clay or stone, and beating it with the fist, a wooden pestle or, more generally, a stone or a clay tamper (Fig. 2). Continuing with rhythmic beating, the potter rapidly obtains a concave form that he/she turns continuously on the anvil or the depression while beating the clay. This technique is used throughout the Sahel, from Mali to Egypt (Drost 1967; Gosselain 2001; Huysecom 1992; Sterner and David 2003).

In the drawing of a ring-shaped lump, the potter fashion a ring of 20–60 cm in diameter with one or several slab(s) of clay, and pulls its wall up with the help of the fingers (Krause 1985; Lawton 1967; Livingstone Smith 1999, 2001b; Roy 1989). In most cases, the lower part of the vessel is fashioned later with coils or a pancake of clay, after the upper part has been preformed and is sufficiently dry to be put upside down. In a variant observed in western Cameroon, the bottom part is made before the upper one (Nyst 1996).

The superimposition and drawing of large rings is similar to the previous technique, except that the initial volume is made with two to eight crown-shaped rings of clay which are superimposed and carefully joined together. So far, the technique has only been recorded in the southeastern part of Central Africa, among several Bantu-speaking groups (Lorenz and Plesner 1989; de Maret and Bulckens 1978; Woods 1984).

The seven techniques mentioned above are seldom used as such by African potters. The shaping of medium to large vessels usually involves the combination of the last two of these techniques, with the consequence that a detailed comparison of actual shaping processes allows one to identify more than 50 variants across the continent.

Ceramics in Africa. Fig. 2 Shaping a vessel with the pounding technique, on a concave wooden anvil with a clay tamper (photo by Olivier Gosselain).

Compared to clay extraction and processing, the most striking aspect about the roughing out process is that it is based mainly on movements. While techniques such as molding and pounding require special tools and devices, it is especially the artisan's hands and fingers that are in action during the major part of the shaping process. The movements employed are also distinctive because of their relatively specialized character: few ties exist to other activities and only body postures (for example, working while standing bent over, seated with legs spread, or with one leg folded in front) find an echo in domains other than pottery making.

This preponderance of specialized gestures has been identified as a crucial factor for explaining the usual stability of shaping technique through time and space and its possible coincidence with major social boundaries such as language, socio-professional groupings, or political units (Gosselain 2000, 2002; Wallaert 1999). Their mastery involves a close interaction between two individuals and a training period that may span over several years, so that motor habits would be more resistant to change than other stages of the manufacturing process. Recent studies have showed, however, that borrowing processes also affect the shaping stage (Gelbert 2001; Sterner and David 2003). Another way of explaining stability in shaping techniques is that they are widely viewed by potters as an inheritance and a material correlate of social boundaries. Stability could thus be deliberately sought, as among the Songhay blacksmiths of Niger who acquired the molding technique from their Bella neighbors (considered as former slaves), but have chosen to pass on the pounding technique to their daughters, the later being regarded as the "true Songhay technique."

Preforming

This stage, which is carried out as a continuation of roughing out, consists of giving the just constituted hollow volume its final geometric characteristics. To this end, potters perform scraping and smoothing operations, with the help of a series of tools, which allow them to distort the wall of the vessel gradually to the desired curvature by applying pressure.

In order to round the body and make it bulge, potters scrape the outside and inside walls and modulate the pressure exercised on the tool, while supporting the wall with the other hand. Tools used for scraping the inside wall are generally round or spherical: rounded off pottery sherds, pieces of calabash, pods, large seeds, nuts, shells, or spoons. Moved horizontally or obliquely, they do not generate much displacement of clay since internal scraping aims essentially at modifying the shape of the body. Scraping and smoothing operations made on the outside wall, on the other hand, allow the potter to mask irregularities and to heighten the vessel through the displacement of a rather large amount of clay. Such operations are typically carried with flat and oblong tools such as flat sticks, spatulas, bones, blades, pods, shells, or corncobs.

Forming the neck may be done with different methods, either as a continuation of preforming the body or after having added one or several coil(s). A first method consists of bending the upper part of the wall through horizontal smoothing of the inside wall. In this case, the potter exercises increasing pressure on the smoothing tool, while supporting the wall with the other hand, until the appropriate curvature is reached. Another method consists of smoothing the outside wall of the vessel horizontally with a tool whose curvature

Ceramics in Africa. Fig. 3 Forming the neck and the lip of a vessel with the fingers. A constant pressure is exerted on the wall while the vessel is rotated slowly with the other hand (photo by Olivier Gosselain).

corresponds to that of the neck. Rounded off sherds or calabash pieces are typically used to that aim. A later method consists of pinching the rim between fingers (directly or with the help of a leaf, a rag, or a piece of leather) and rotating the vessel slowly with the other hand, while exerting a constant pressure on the rim and progressively tipping up the hand toward the exterior (Fig. 3).

Finally, lips may be formed through constant pressure between fingers – or with the help of any supple material – as in the neck-forming method described above. Depending on the position of fingers, the pressure exerted and the materials used, resulting lips may acquire a rounded or sharp profile, or bear a groove. The rim may also be shaped through smoothing with a flat or slightly concave tool such as a spatula, a stick, a bone, or the nervure (principal vein) of a large leaf. Here also, the potter usually rotates the vessel while exerting a constant pressure on the tool, placed perpendicularly on the rim. Instead of rotating the vessel, the tool may be displaced itself on the rim, especially when shaping the lip of large and heavy vessels. A last method consists of adding one or several coil(s) above the rim or on its side, and smoothing it with fingers or a supple material.

The very personal character of the preforming operations described above must be stressed. Minute variations in profiles – the shape of the neck, lip, handle, or base – are also likened to "signatures," which can be recognized as readily by eye as by touch (Gosselain 2002: 113, 115).

Another striking characteristic of the preforming stage is its permeability to innovation and outside influences. From simple widespread forms, artisans seem to be able easily to meet new requests (flowerpots, moneyboxes, stills, and incense holders) or to modernize the aspect of their products (Argenti 1999). This explains the current appearance of a new generation of flat-bottomed pots fitted with handles, faithful copies of the aluminum pans produced in urban environments. The realization of such products may allow a few individuals to position themselves as experts and agents of modernity.

Decoration

Plastic decorations – i.e., made when the clay is still wet – belong to four large categories (1) grooving, (2) incising, (3) impressing, and (4) appliqué.

Grooving consists of tracing lines or figures on the surface of the vessel with the fingers or various tools whose end(s) is/are rounded or sharp: sticks, stalks, thorns, ends of calabash scrapers, sharp stones, bones, shells, nails, bicycle spokes, bracelets (drawn on the surface), bundles of stalks or thorns held between finger or driven into a clay ball (Fig. 4), hair combs, and indented pieces of calabash, wood, plastic, or metal.

Incising is similar to grooving, except that the tools used have a sharp cutting edge so that clay surfaces are actually incised. Such tools include knives, spearheads, and scraps of metal.

Impressing is done with distinct tools and methods. The simplest is to press any kind of device or material (fingers, natural objects, sticks, combs or carefully designed wooden or iron stamps, as those used in the Inland Niger Delta; Gallay et al. 1998), in order to make a single impression that may be subsequently repeated on the surface. Another method consists of pressing while simultaneously rocking convex devices such as blades or indented combs and bracelets, so as to obtain zigzag-like rows of impressions. "Rouletting" is

Ceramics in Africa. Fig. 4 Decorating a vessel with a comb-like device (photo by Olivier Gosselain).

a third impressing method, done either with natural objects such as corn cobs, shells, fish vertebrae and various plant parts, or, more generally, with tools made by carving wood or twisting, knotting, braiding, coiling, or wrapping fiber strips or cords (see examples in Gosselain 2000; Soper 1985). Such tools and materials are rolled on the vessel's surface to impress regular patterns.

Appliqué comprises all types of clay elements added onto the surface: e.g., coils, buttons, spikes, and human or animal figures.

Besides plastic decoration, vessels may also be ornamented with painting and/or specific surface treatments. The most usual treatment consists of applying a slip made from iron-rich clays, crushed beforehand on a stone or in a mortar, and subsequently sieved and diluted in water. The application is made on a dried surface, directly with the hand or with a rag. In many instances, slipped surfaces are then carefully polished with round stones or strings of seeds (mostly from baobabs) or cowries. The resulting effect, after firing, is a dark red and shiny surface. Polishing may also be done on unslipped surfaces or with graphite, as among several South African populations (Bell and Calder 1998; Lawton 1967).

Painting occurs either before or after firing, the first being widespread on the continent, the second especially observed in South Africa or on modern ornamental vessels aimed at tourist or city markets. Prefiring painting is done with various mineral pigments diluted in water and occasionally mixed with gum Arabic, salt or sugar, all elements that are said to "strengthen" the adherence. The application is made with a feather, a millet ear, a stalk, or a stick with a crushed or rag-wrapped end. In southwestern Niger, Bella and Zarma potters use a blade for drawing thin lines and motifs (Fig. 5). Postfiring paintings are made with industrial paints and inks.

Regardless of the techniques, tools, and materials used, a striking feature of decoration is the casual way in which most potters talk about it. Decoration would be a matter of "simple embellishment," "like a hairstyle or clothes," the main function of which is to "attract the customer's eye." In some cases, even the esthetic function of decoration is questioned, as when potters explain that roulette impressions are simply a matter of modifying wall texture to prevent wares from being slippery (Bredwa-Mensah 1996; Priddy 1971).

This does not mean that artisans work with no references or precise rules. On the one hand, pottery decoration is generally only one realization among others in a much broader decorative system. For example, the existence of numerous parallels has been found between vessel ornamentation and tattooing or scarification (Barley 1994; David et al. 1988; Ritz 1989), and parallels also exist with architecture, certain technical devices such as cast iron ovens, or other containers (baskets, gourds, and aluminum pots). On the other hand, while decoration is obviously very susceptible to innovation (e.g., the current generalized use of letters of the alphabet in the painted decorations of West Africa), change is seen to particularly affect the components of decorations rather than their organization or "grammars." Some think that it would be at this second level that the symbolic function of decoration comes into play and that collective identities would express themselves (David et al. 1988).

Drying

A comparison of data indicates that there are no "rules" as regards drying modes and duration. For instance, some potters deem it necessary to place the wares in the

Ceramics in Africa. Fig. 5 Applying a mineral paint with the help of a blade (photo by Olivier Gosselain).

sun during the early stage of drying, while others take great care to shelter them during the first hours, the first days, or even the whole drying process. Similarly, some may wait several weeks or several months before firing the vessels, while others do it after 2 or 3 days. While drying periods are often shorter in the Sahel than in tropical areas, differences in practice appear to proceed essentially from personal conceptions and ways of scheduling manufacturing operations, rather than climatic variations or the chemical and physical characteristics of raw materials. Thus, potters who make vessels on demand or frequent weekly markets generally resort to short drying periods. If necessary, wares cracked from too fast a drying are simply repaired with fresh clay.

Such flexibility in drying procedures is due, in part, to the accommodating nature of the raw materials used in Africa. But it may be reinforced through the use of prefiring techniques that allow the gradual evaporation of residual water through preheating. For instance, pots may be placed around or above a cooking earth (Gosselain 2002: 145–146; Priddy 1971; Woods 1984), on glowing embers (Kanimba and Bellomo 1990; Mercader et al. 2000) or a rack-like structure below which a fire is kept going, as among several Kongo groups from Central Africa (de Maret 1974; Mpika 1986).

Firing

Although the emphasis will be put here on fuels and structures, several other aspects of firing may be taken into consideration, including the scheduling of firing events, the location of firing structures, the way vessels and fuel are positioned within the structure, the overall firing schedule (duration, refueling, way of assessing the degree of firing of the wares), or the identity of people taking part in the operation.

Fuel

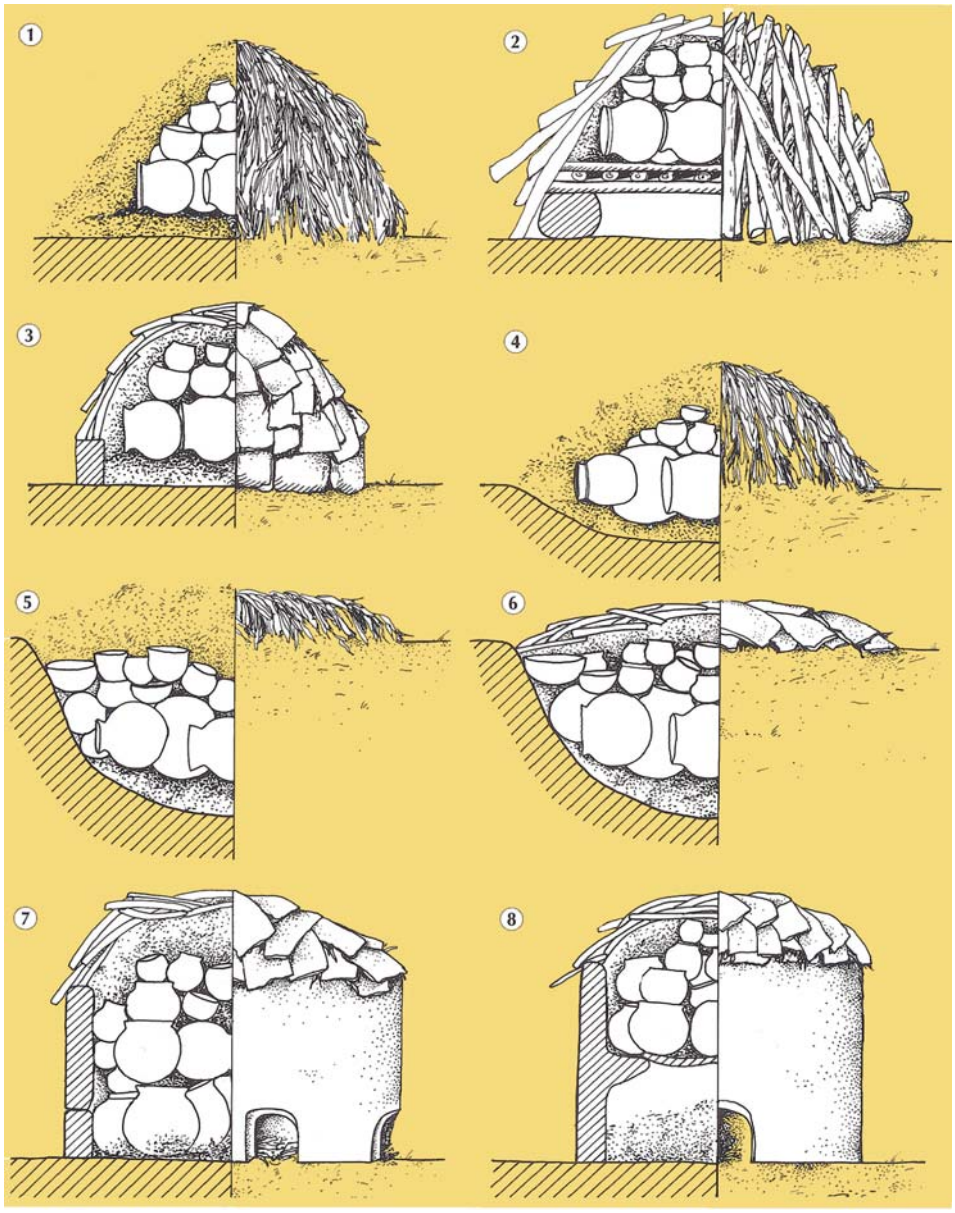
As summarized by Livingstone Smith (2001a: 993), almost everything that can be burned is used for firing pottery in Africa. Used independently or combined in various proportions, the materials may be grouped into three categories corresponding roughly to those made by the artisans themselves when asked about the nature of "appropriate" and "inappropriate" materials (1) manure – cows, donkeys, camels, or horses; (2) "light" fuels – dry grass or cereal stalks, cereal chaff, palm fronds, leaves, twigs, barks, or roots; and (3) "heavy" fuels – branches and logs from dozens of tree species.

Neither the firing structure nor the firing conditions possibly sought by potters seem to impose restrictions on the selection of fuel materials. With the notable exception of manure, whose combustion is slower, all the fuels used throughout Africa allow potters to obtain similar firing schedules and temperatures.

Structure

Eight firing structures are documented in Africa (see details in Drost 1967; Gosselain 2002: 153–162) (1) bonfire, (2) elevated bonfire, (3) bonfire with isolation, (4) depression, (5) pit, (6) pit with isolation, (7) oven, and (8) updraft kiln (Fig. 6).

The bonfire – also called "open firing" – is one of the simplest and most widespread technique in Africa. Pots are placed on a bed of fuel, at ground level, and covered with another layer of fuel. Those structures vary tremendously in dimension (50–250 cm in height and 50–700 cm in diameter), firing duration (from



Ceramics in Africa. Fig. 6 Firing structures used in Africa (1) bonfire, (2) elevated bonfire, (3) bonfire with isolation, (4) depression, (5) pit, (6) pit with isolation, (7) oven, and (8) updraft kiln (drawing by Yvette Paquay).

20 min to several hours), as well as the number of vessels fired at once (from 1 to 500). This number depends both on the stock of wares available at the moment of firing and on the personal conceptions of the potters. For example, some Gbaya potters from Cameroon deem it impossible to fire more that one to three vessels at once. They thus multiply firing sessions or construct several bonfires side by side.

Elevated bonfires have only been recorded so far in the Great Lakes region, among the Twa of Burundi and Rwanda and the Konjo of Uganda (Célis and Nzikobanyanka 1984). The technique consists of placing the vessels on an elevated bed of fuel constituted of a rack-like layer of branches placed on four or five big stones.

Bonfires with isolation differ from simple bonfires in that a layer of fireproof materials – sherds, old basins, and sheets metal – is placed either between the vessels and the upper layer of fuel or upon the whole structure. In the first case, the aim is to avoid color variations due

to contacts between fuel and the surface of vessels; in the second, it is to protect the structure from the wind and keep the fuel in place.

Depressions are shallow excavations made in the ground (between 20 and 40 cm depth) in which vessels stand higher than ground level after having been placed on the bed of fuel. Their shape is circular, oval, or rectangular, with diameters (or sides) between 100 and 500 cm. As for the bonfire technique, important variations are observed in the number of wares fired at once and the duration of the firing. Variations also exist in the way vessels are positioned within the structure. For instance, while most potters place them horizontally or vertically, some place them upside down on the bed of fuel, in order to obtain a dark and shiny internal surface (Zaghawa of Sudan (Tobert 1984) or Hausa and Kanuri of Niger).

What differentiates pits from depressions is the fact that vessels stand below the ground surface after having been placed on a bed of fuel. Thus, their depth always exceeds 50 cm and may reach as much as 100–150 cm, for a diameter between 50 and 400 cm. Another difference pertains to the duration of the firing, often observed to be several hours long. In a variant observed among Bamileke fe'fe' from western Cameroon (Gosselain 2002) and Kongo Manyanga from Kongo (Mpika 1986), the wares are placed on a rack-like wooden structure standing above the pit and carefully tipped in the hole in the course of firing.

Pits with isolation resemble bonfires with isolation in that a layer of fireproof materials is placed either on the vessels or on the upper layer of fuel. This technique is often used in southern Africa (Lawton 1967; Krause 1985), but also in the Sahel area, from Senegal to Sudan. Here, firing is usually a whole night long, even though the fire actually burns for a few hours.

Ovens correspond to wall-enclosed firing structures within which fuel and vessels are put together. Such structures have only been documented in West Africa. Their walls are made of mud, with a height between 50 and 180 cm, and a diameter between 100 and 400 cm. One or several holes is/are made at the base of the wall, through which fuel is put in during firing. From 20 to 200 vessels are fired at once, which are piled and subsequently covered with fuel and/or a layer of sherds. Burning stalks or grasses are then put in the hole(s), either at the beginning or throughout the whole firing. A simpler oven technique, observed among some Yoruba of Nigeria (Fatunsin 1992: 39–40) and Bariba of Benin, consists of using a bottomless jar placed on mud bricks upon a small fire. Such technique is only used for firing small vessels.

Updraft kilns are even more rare than ovens, as they would be used in Nigeria only, among Nupe of Bida (Nicholson 1934; Vernon-Jackson 1960) and Yoruba of Abeokuta (Fatunsin 1992). The firing structure is also enclosed in a mud wall, but fuel is put in a distinct chamber and separated from the vessel with sherds or a perforated clay plate.

As stated above, measurements performed in the field show that the variety of fuels and structure used results, paradoxically, with a considerable homogeneity of firing conditions. Whether it is a question of temperature rise, temperatures reached, or the duration of exposure at temperature thresholds, each variant makes it possible to achieve the same global results (Livingstone Smith 2001a). This homogeneity in firing conditions is echoed by the way in which potters judge the degree of pottery firing; most of them interrupt the process or stop refueling when the wall of the pots becomes incandescent.

As regards relationships to other activities, certain similarities exist with cooking techniques (Gosselain 2002: 165). However, an activity such as metallurgy, a priori much closer, maintains no link with pottery making, even in societies where blacksmiths and female potters belong to the same endogamous subgroup. The fact that these two activities are practiced by different actors seems to present an obstacle to transfer. At the same time, firing is surrounded by a series of prescriptions and prohibitions, but these are less numerous than at other levels of the operating chain and do not seem to have much influence on the artisan's technical behavior. They mainly concern avoiding the situation in which badly intentioned people or those in impure states jeopardize the operation solely by their presence.

This worry stems from the generally public and collective character of the firing stage. In most regions of Africa, artisans habitually associate with relatives, friends, or neighbors for firing their wares. These associations have several advantages; they not only allow artisans to invest less effort in gathering fuel, organizing wares, or sharing in firing surveillance, but they also allow artisans to conform to a restrictive firing calendar (for example, weekly markets) when placements reserved for the operation are few in number.

Postfiring

In many regions of Africa, vessels receive a last treatment after firing, either when retrieved red hot from the fire or after having cooled off. These postfiring treatments, that aim at improving the physical characteristics and appearance of vessels, may be grouped into five categories (1) organic coating, (2) resin application, (3) smearing, (4) smoking, and (5) water sprinkling or soaking.

Organic coating is by far the most common treatment. It consists of coating the surface with an organic mixture made from the bark, fruits, leaves, branches, or root parts of several dozens of tree species, the most common of which are *Bridelia*

ferruginea, *Bridelia micrantha*, *Parkia biglobosa*, *Parkia filicoidea*, *Diospyros mespiliformis*, *Ximenia americana*, *Pterocarpus angolensis*, and several species of *Acacia* and *Syzygium* (see details in Drost 1967: 174–182; Gosselain 2002: 184–190). After having been crushed, the part used is soaked in water for several minutes, several hours, or several days. It may be boiled (decoction), put into hot water (infusion), or kept at ambient temperature (maceration). As for the application, it is done by plunging the hot vessels in the mixture, sprinkling them with it, or smearing the surface with the help of a series of brush-like tools. Alternatively, cooled off vessels may be coated with the help of a rag. Besides having a decorative purpose, organic coatings are said to strengthen and waterproof the vessels.

Resin application is solely aimed at waterproofing the vessels. Here, the inside surface is coated with resin extracted from several tree species – e.g., *Canarium schweinfurthii*, *Copaifera demeusei* or *mildbraedii*, various *Acacia* species, *Euphorbia candelabrum*, *Dodonea viscosa*, and *Guizotia abyssinica* – either by melting it directly in the vessel or separately. In both cases, the vessel is rotated rapidly so as to ensure a homogeneous surface coating.

Other organic materials may also be smeared on the surface or cooked in the vessel in order to strengthen or waterproof them: leaves of *Ricinus communis* or *Sida rhombifolia*, oil or sap from *Raphia vinifera* or *Elaeis guineensis*, fruits, fibers, roots, cereal husks, milk, porridge, or cow dung (see examples and details in Gosselain 2002: 191–192).

Smoking aims at covering the vessel surface with wood tar in order to give it a black shiny aspect and, according to some potters, improve their strength and imperviousness. To that aim, vessels retrieved red hot from the fire are usually buried in organic materials such as grass, maize spaths, cereal husk or chaff, animal manure, fruit pods, bark or wood shavings (see examples in Gosselain 2002: 192–193). Another technique, observed in the Great Lakes region, consists of maintaining vessels above a fire made of grass, plantain leaves, or reeds (Trowell 1941).

Lastly, vessels may be plunged in, or sprinkled with, fresh water or boiling water (see examples in Gosselain 2002: 193). Here again, the aim would be to waterproof and strengthen the wares.

As with clay preparation or firing techniques, artisans generally have a very clear-cut opinion about the ingredients that it is advisable to select and the way to prepare them. These opinions are extremely divergent. In sub-Saharan Africa, about 50 plants are currently used for making organic coatings, as we have seen above, but few potters know about more than one and each potter believes there is no alternative to his or her choice. Similarly, those who prepare their coating in decoction or maceration form and apply them hot or cold consider it inconceivable to proceed otherwise. In reality, all choices are perfectly justified from the point of view of technical and esthetic aims. An analysis of the various fruits and barks used in certain zones of sub-Saharan Africa indeed reveals the presence of one same category of tannins, the procyanidins, which have excellent coloring and waterproofing properties (Dialo et al. 1995).

In general, the most striking aspect of the postfiring stage has to do with its numerous relationships to other spheres of activity. Thus, most of the plant types that artisans select are used for diet, leather dyes, fabrics or baskets, wall and pavement waterproofing and, above all, pharmacopoeia. This last domain is particularly interesting as the illnesses and injuries treated with the help of the same preparations that potters use are characterized especially by discharges (Gosselain 1999, 2002: 197–198, 210–211): various wounds, diarrhea, gonorrhea, hemorrhage, menorrhagia, ulcers, etc. Use of these preparations also appears during birth and circumcision rites. What we find at work, here, is simply the materialization of an extremely widespread association between pottery making and human beings (Barley 1994; David et al. 1988; Gosselain 2002: 205–208; Ritz 1989). And since treating a pot or treating a body are related activities from a symbolic point of view, a strong channeling of behaviors can occur when selecting ingredients or preparation modes.

This fact illustrates perfectly why a *chaîne opératoire* cannot be reduced to mere actions on matter. As stressed by Lemonier (1991) and several other scholars, techniques do not solely aim at transforming materials or acting upon the material world. They also respond to a series of social, political, economical, and symbolic concerns, whose components may be found at any level of the manufacturing process as we have seen throughout this article.

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Ceramics in China

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China was one of the earliest countries that possessed pottery, and was also the country that invented porcelain. She has a unique and sustained history of technique development of 10,000 years. The entire development can be summarized by five milestones and three technological breakthroughs. The outstanding achievements in this development constituted an indispensable contribution to Chinese culture (Table 1 and Map1).

Five Milestones

The First Milestone: Appearance of Pottery in the Early Neolithic Age

According to archeological information, after the discovery of potteries of the Yangshao culture, the following were discovered:

- Those of the Hemudu culture in Yuyao, Zhejiang Province about 7,000 years ago
- Those of the Cishan culture and the Peiligang culture about 8,000 years ago
- Those of the Pengtoushan culture in Li County, Hunan Province and the Jiahu culture in Wuyang County, Henan Province about 9,000 years ago
- Those at the Yuchanyan site in Dao County, Hunan Province, the Xianrendong site in Wannian County, Jiangxi Province, and the Nanzhuangtou site in Xushui County, Hebei Province about 10,000 years ago