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FORUM

Material Science and the Present and Future of African Archaeology

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Introduction

Humans in Africa and elsewhere have always been deeply entangled with artificial and natural materials. This makes the study of materials recovered from archaeological sites a cornerstone of archaeological sciences. The integration of earth and engineering science approaches with archaeology and anthropology opened a new horizon in temporal and spatial explorations of the skills, knowledge, cognition, values, and beliefs of past human societies. Within their textural and compositional structures, materials contain partial histories of the cultural and natural processes that created them. This makes it possible to ask big questions about the African past—what, where, when, how, and why materials were made. The identification of constituents of materials, where the raw materials were sourced and processed into final products, and the time when the technology used to produce them was available are answerable through materials analysis (Sibilia, 1996). The reasons why certain materials and technologies were invented and the socio-cultural and economic roles of materials are central to explorations of interactions, changing values, and continuity and change across space and time. Such information is accessible through the application of engineering and earth science techniques, making it possible to reconstruct technology and how societies and materials co-shaped each other. Research to date has contributed to our understanding of the histories of specific materials and their entanglements with diverse societies—from ancient Egypt to Ethiopia, ancient Ghana and Mali, and Great Zimbabwe, to Swahili settlements on the Indian Ocean coast. However, challenges with laboratory facilities in many parts of Africa mean that materials analysis, in particular, and archaeological science in general, are poorly developed. This calls for the erasure of barriers through collaboration within Africa and between Africa and different areas of the Global South and Global North.

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What Materials in the African Past?

The African archaeological record contains diverse categories of inorganic and organic materials processed by humans for use in utilitarian, symbolic, expressive, and religious settings. However, organics such as wood require exceptional preservation conditions, which means that most long-surviving materials in the archaeological record are inorganic. These include natural materials, such as stones mechanically shaped to produce a wide array of tools, and artificial materials, such as pottery, metals, and glass produced through manipulation of heat and control of the atmosphere in furnaces, kilns, and crucibles.

Based on preserved materials, Africa has the longest archaeological record in the world, beginning

with stone tools first used by hominins circa 3 million years ago, and then continuing through the ages into contemporary times. Following the emergence of modern humans, the range of materials expanded to include the use of ochre and shells by 100,000 years ago, although the proximity to the present may account for higher survival rates of these materials. Meanwhile, at places such as Pinnacle Point, advanced stone tools were engineered using fire to heat-treat raw materials before working them to shape (Brown et al., 2009). By 10,000 years ago, pigments of ochre and adhesives were widely used to make spectacular rock paintings.

The repertoire of material objects broadened during the Holocene, though there was no linearity as technologies were often mixed and practiced side by side according to cultural contexts. Pottery was used in present-day southern Mali (Dogon Country) by 9000 BCE (Huysecom et al., 2009). In ancient Egypt, metals were used from 5000 BCE, beginning with copper, followed by bronze, and iron. In between and along the way, gold, silver, tin, mercury, and lead were used (Chirikure, 2015). Iron and copper also emerged in West Africa from 1000 BCE, before appearing in the southern third of the continent by 100 CE. Glass was produced in Egypt from 2500 BCE, but ancestral Yoruba people independently developed technologies of primary glass production in West Africa from CE 1000 onwards (Babalola et al., 2018). Although the history of these materials differed from society to society, they were deeply entangled with humans, and shaped how their societies functioned. Sometimes, such entanglements produced monumental constructions, but in others they created objects and ideas that connected the physical and metaphysical worlds and linked the earth with the heavens.

Material science techniques, therefore, make it possible to address big questions about the production, allocation, and circulation of resources and consumption of materials in the African past (Mantler & Schreiner, 2000; Shugar & Mass, 2012). For example, what was the nature and organization of metal production in some of Africa's prominent empires, such as ancient Ghana, Oyo, Great Zimbabwe, and Meroe? What was the nature of resource distribution networks within Africa before colonialism? What values were associated with different materials? By addressing these questions through material analysis (in combination with archaeological context, experiments, and ethnoarchaeology), we can learn more about the materials themselves, as well as the individuals and societies that produced, used, and discarded them.

Reconstructing African Histories Using Material Science Approaches

Studies of archaeological materials have been greatly influenced by the physical and engineering sciences (Leng, 2009; Pollard et al., 2023). The template and methodology for these studies come from the structure–property-processing-performance paradigm of materials science and engineering, also known as the material science tetrahedron (Vandiver, 2001). As a theoretical approach, the material science tetrahedron states that the characterization of materials using macroscopic, microscopic, textural, and compositional techniques yields information about their structure, properties, history of process, and performance (Chirikure, 2022). Owing to massive advancements in science and engineering, the methods for studying archaeological materials continue to see improvements in resolution and reductions in analytical costs. However, while major laboratories in the Global North are equipped with cutting-edge equipment, this is a rarity in Africa outside of South Africa (Thondhlana et al., 2022). This lack of facilities means that practical laboratory-based materials analysis does not feature in the curriculum of many African universities, and most African colleagues are not engaged with research in archaeological science. Material analyses are often limited to macroscopic observations of stylistic variables for building typologies.

In world archaeology, studying materials such as lithics, pottery, metals, and glass is now a mature field combining macroscopic, microscopic, and elemental analyses (Leng, 2009). Generally, materials analysis begins with macroscopic examination of surface features and attributes to identify groups of artifacts to be sampled for microscopic investigations. For example, pottery samples are usually prepared into thin sections for analysis with petrographic microscopes to identify the texture of minerals and other natural and artificial inclusions in the paste fabric. This helps to illuminate potters' skills and vessel-forming techniques and draw conclusions about the properties and performance of the ceramics. An example comes from Wilmsen et al. (2009) who applied mineralogical analyses to a

sample of ceramics from selected sites in Botswana dating between 900 and 1100 CE. By comparing the fabric of pots to different geologies and lithologies, they were able to demonstrate the circulation of pots over distances of 400–600 km between the Okavango Delta and Bosutswe through social networks such as marriage, trade, and other forms of exchange.

Research on African pasts has also benefitted from using elemental and microscopic techniques to study the remnants of metallurgy, such as slags, furnace remains, crucibles, and finished metal objects. Thondhlana (2013), for example, reconstructed copper smelting at Shankare, Phalaborwa, using mineralogical (microscopic) and SEM–EDS (compositional) analyses to document the skills of the smelters in gaining metal and processing it into usable objects. Meanwhile, a recent trace element and lead isotope analysis study of copper ingots used in central and southern Africa documented metal circulation networks in regions to the north and south of the Zambezi (Stephens et al., 2023). In Nigeria, Babalola et al. (2018) have applied a combination of microscopic and compositional techniques to study unique evidence of primary and secondary glass production in Ile-Ife, documenting innovation and experimentation as ancestral Yoruba people interacted with materials to produce a highly valued glass.

Material analysis is revolutionizing knowledge of the past—making it possible to better approximate the dates, places, contexts, technology, and cultural meanings embedded in material production, as well as the role of materials development in human history. But what are the new areas of material science that Africanist archaeologists should focus on, with potential maximum impact? First, there is the need across the continent to answer basic questions about production technology, circulation of materials, and the role of materials production and consumption in society. Then, the next frontier will be experimentation with ancient technologies to tackle some of the everyday challenges, such as sustainable design, in the present and future.

Will Africa Catch Up in Archaeological Science?

The number of studies applying scientific techniques to materials in African archaeology is increasing as new and advanced instrumentation becomes more available. However, most of this research takes the form of parachute science because laboratory analyses do not take place in Africa and often do not fully involve African collaborators. Colleagues from the Global North continue to exploit the rich African archaeological record but with little capacity building and skills development for African scholars and institutions (Thondhlana et al., 2022). Archaeological science represents a new frontier in extracting materials from Africa, imitating the ghost of colonial plunder but this time in the name of science. Although scholars from the Global North are increasingly co-publishing with those based in Africa, this may not be enough. The sophisticated material analysis techniques used in some of the research raise questions about the role of African colleagues—could they do this same research on their own, or does co-authorship simply create a relationship of dependency? Whatever the case, archaeological science must be wary of falling into the same patterns of exploitation that characterized the nineteenth- and early twentieth-century roots of the discipline.

Is there anything that can be done about this? Ongoing material studies, regardless of where they are being performed, are obviously very useful for reconstructing technologies, documenting interactions, and tracking group identities. However, it is necessary to redress ethical issues around data sharing, co-authorship, the reproducibility of results between different research groups, and multifarious foreign missions in Africa. Fortunately, things are fast changing: the Museum of West African Art and Archaeology in Benin City, Nigeria, is developing state-of-the-art archaeological facilities in collaboration with the British Museum, German Archaeological Institute, and the University of Oxford. This will involve equipment purchases allowing high-impact archaeological science to be performed in West Africa. Collaboration between Professors Anders Lindahl of Lund University and Innocent Pikirayi is leading to the establishment of a Ceramic Petrography Laboratory at the University of Pretoria. Given time, these sorts of substantial economic investments in research infrastructure will make it possible for high-impact archaeological science to be done in many African institutions.

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