PART I

Introduction

1 Debating Mobile Technologies

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Introduction

This volume is the fourth and final volume resulting from a focused programme of research and intensive group discussion of a wide range of topics related to the archaeological (and to a lesser extent, historical and anthropological/ethnographic) analysis of ancient societies in and around the Sahara, from the first millennium BC to the mid-second millennium AD.[1] While the focus of the present volume is technology, there will inevitably be discussion of crossovers and contrasts with the main conclusions from earlier volumes in the series. As explained in the Preface, the Trans-SAHARA Project evolved out of a long-term programme of fieldwork on an ancient people of the Libyan Sahara. Just as they occupied a significant nodal location in the Sahara, the Garamantes are at the centre of this volume, but the scope of debate here extends way beyond the history of a single group.[2] Connections and barriers within the Trans-Saharan region (and the interrelationship between these two aspects) form one focus. In this introduction we present an overview of crucial themes and considerations which cross-cut all or many of the contributions. Fundamentally, this book seeks to explore what defines technology, how technological knowledge spreads and how technological change has happened in Saharan societies.

Following this introductory section, Part II of the volume comprises a series of chapters that broadly relate to technological mobility and transfers. Mario Liverani argues for the importance of technological transfer running along a hyper-arid Middle-Eastern belt that extended both

[1] For other volumes in the series, see Gatto *et al.* 2019; Mattingly *et al.* 2017; Sterry and Mattingly 2020.
[2] Mattingly 2003; 2007; 2010; 2013.

west and east of the Nile. Wilson *et al.* provide a detailed case study of foggara irrigation systems, one of the technologies that appear to have moved along Liverani's belt. B. Tyr Fothergill *et al.* take a similar approach to re-evaluating the evidence for the introduction of a range of domesticated animals, but with some chronological and spatial discontinuities highlighted, suggesting that the process of transfer was more complex. Chapters by Touatia Amraoui and Sonja Magnavita have a main focus on textile working in the Maghrib and West Africa, highlighting differences of chronology and technology that are not easy to reconcile with a single model of technological dissemination.

In Part III, three case studies on metallurgy are presented, with Aurélie Cuénod's chapter also serving as an introduction to the section. The bulk of her chapter presents the results from her work on Garamantian metallurgical practices and the compositional signatures of their metals. The following pair of chapters by Jane Humphris and Caroline Robion-Brunner focus on the debate about early ironworking technology in Sudan and West Africa respectively. They reflect on aspects of scale of production and local variability in technology.

Part IV then features three chapters on glassworking technology, with an extensive introduction again in the lead-off chapter by Chloë N. Duckworth. The detailed case study at the heart of her chapter again draws on the significant material she has analysed from Garamantian sites. Peter Robertshaw offers a masterly overview of glass beads, looking at but going beyond the scientific analysis of their provenance and focusing also on their social and commercial power in African societies. The overview by Thilo Rehren and Daniela Rosenow of Egyptian glassmaking across 3,000 years of production provides a benchmark of comparative analytical data.

Part V comprises a single discussion chapter by Maria Carmela Gatto, summarising the discussion and outcomes of the handmade pottery workshop that was held as part of the Mobile Technologies work of the Trans-SAHARA Project. A concluding chapter by the editors completes the volume by returning to some of the questions outlined in this chapter, as well as considering the contribution of the volume for future agendas.

Rather than providing a generalised description of the contributions to this volume one by one, we have attempted in what follows to interweave references to them throughout our discussion of the broad themes. In the next section we set out some issues relating to connectivity within the Trans-Saharan region, before turning to definitions of technology. The technological context of the Saharan world is then introduced, before we examine some more methodological aspects. The contributions of

scientific studies are highlighted. In the second half of the chapter we introduce the other side of this volume's framing equation: how technology transfer works in a highly mobile desert world. The final section of the chapter addresses issues that complicate the narratives of technological change (adaptation and micro-invention, cross-craft interactions and interruptions).

The Connecting Sahara

> From southern Tunisia to southern Syria, the desert directly borders the sea. The relationship is not casual; it is intimate, sometimes difficult, and always demanding. So the desert is one of the faces of the Mediterranean.[3]

The very name Sahara is evocative, and conjures up a vast array of images, but it is perhaps fair to say that technology is not usually among them. Trade is certainly a prominent point of reference, epitomised by long camel trains driven by Muslim traders, carrying slaves, gold and salt. Whether the scale of trade and interaction across its vast distances allows us to see the Sahara as a barrier to contact, or a sort of connective tissue akin to Braudel's Mediterranean, has been debated numerous times over the years,[4] but it is generally agreed that the history of the Sahara itself is to a large extent a history of mobility.[5]

In this context, one of the factors that make the primarily oasis-dwelling Garamantes of the Central Sahara so significant is that they managed to build up and in the long term sustain a sedentary lifestyle on a relatively large scale, thanks largely to ingenious management and technological development of below-ground water resources,[6] coupled with involvement in far-reaching trade networks. Garamantian reliance on long-distance contacts must imply a close connection with mobile peoples, who are often less directly visible in the archaeological record.[7] For these nomadic peoples, too, technologies – particularly the use of animals – have been vital components in survival, economic gain and the structure of social life. The possibilities and constraints of changing technologies, and the interplay

[3] Braudel 1995, 24.
[4] See Lichtenberger 2016, for a recent discussion of Sahara as a desert sea. See also Lecocq 2015 and Lydon 2015.
[5] For definitions of mobility in a Saharan context, see Gatto *et al.* 2019, 19–22.
[6] See Wilson *et al.*, Chapter 3, this volume.
[7] Sterry and Mattingly 2020, chapters 1 and 2 for a detailed discussion of the mix of sedentary and pastoral elements in Garamantian society.

Table 1.1 *Summary of historical and environmental phasing in the Sahara and beyond*

Date (Millennium BC/AD)	Saharan climate and environment	Technological developments	Maghrib/ Mediterranean	Nile Valley	East Sahara	Cen
8 M BC	Start of Holocene pluvial, high stand of palaeolakes	Hunting and gathering, microlith and fine flaking technology, exploitation of wild animals and plants	Hunter gatherer societies	Hunter gatherer societies	Hunter gatherer societies	Hun s
7–6.5 M BC	Drought, reduced wadi flows, low stand of palaeolakes	Continuation of hunter gatherer technologies	Hunter gatherer societies	1st animal domestication/ transfers	Hunter gatherer societies	Hun s
6.5–4 M BC	Last pluvial phase, high stand of palaeolakes	Pastoralism – cattle and ovicaprins Pottery Ground stone tools for food processing Rock art	Pastoral phase	Pastoral phase & 1st agriculture experiments	Pastoral phase	Past
3 M BC	Start of hyper-arid phase	Donkeys Agriculture and arboriculture (Egypt) Nile irrigation Textiles Writing (Egypt)	Pastoral phase, first agricultural experiments	Pharaonic Egypt, Kerma in Sudan	First oases in Egyptian W. Desert	Fina P

2 M BC	Hyper-arid	Oasis irrigation (including shaduf well) Horses Chariots Copper metallurgy	Mainly pastoral, some agriculture?	Pharaonic Egypt, Kerma in Sudan	Spread and expansion of oases	Fina P a e
1 M BC	Hyper-arid	Agriculture Iron metallurgy Oasis irrigation (including foggara) Mudbricks Camels Writing (Libya)	Early agrarian nucleated settlements (Althiburos) Phoenician emporia Greek colonies	Pharaonic Egypt, Meroitic Sudan	Monumentalisation of oases – e.g. Siwa	Firs C r C
1 M AD	Hyper-arid	Glassworking Rotary querns Aqueducts and baths, concrete	Roman provinces (Cyrenaica, Africa, Mauretania). Vandal and Byzantine rule, then first Islamic dynasties	Roman Egypt, then Islamic	Urban status of leading oasis centres, high productive capacity	Gar h d i c Z
2 M AD	Hyper-arid	Water wheel Animal well (dalw)	Almoravid and Almohad dynasties	Islamic Egypt	Oasis civilisation continues on reduced scale	Oas c c r

between technology and the fluctuating environment, are thus crucial elements in charting how human groups developed over time in this large and complex region. By applying a broader definition of technology and moving beyond simplistic evolutionary models of technological progress, as outlined below, we can begin to unravel the complex web of long-distance interchanges and local manipulations which gave rise to, and sustained, Saharan connections over several millennia.

Geography and Historiography

To provide a succinct contextual background for much that follows, Table 1.1 summarises some of the key environmental and historical phases relating to the Saharan zone and its neighbours. The table simplifies both time and technological developments and may appear overly deterministic, but hopefully conveys some sense of the complex linkages and discontinuities between environmental factors and technological and societal developments. In the period that primarily concerns us, the first millennium BC and first millennium AD, the Sahara was already a hyper-arid desert and the localised availability of groundwater was a crucial factor for human communities.[8] The physical realities of life in a desert environment also make long-distance movement a vital component of survival. Even in areas where part of the population is known to have been sedentary, the existence of a symbiotic relationship between sedentary and nomadic pastoralist groups was necessary for the survival of the oasis.[9] The one provided food and managed the access to water, while the other bred pack animals and possessed the navigational skills paramount to conducting trade, providing the surplus of goods which allowed the growth of the oasis. In this sense, we are studying a dynamic and fluid world. The consideration of the vast geographical area described above is a vital component of this. Of course, not every individual within this area travelled a great distance, as the permanent settlements of the Garamantes imply, but the movement of goods and ideas is clearly visible in the archaeological evidence. On the other hand, the vast expanses of rocky plateaus, mountain ranges or sand seas between many settled or navigable areas of the Sahara meant that even for those with access to the appropriate technologies of donkey, mule, horse or camel exploitation, movement was

[8] For a discussion of climatic change and the onset of the current hyper arid conditions *c.*5,000 years ago, see Gatto and Zerboni 2015; Mattingly *et al.* 2017, 5–6; Sterry and Mattingly 2020, 8–12.

[9] Scheele 2017.

not free and unlimited. But just as some topographic features present barriers or obstacles to movement, some locations are preferentially suited to support human life in an extremely arid and hostile environment (through the availability there of seasonal pasture, springs, shallow groundwater, etc.). Such *refugia* were likely to become better connected to other parts of the Sahara, some becoming established oasis centres (and to remain so in the face of social and political change).[10]

The first volume in this series, *Trade in the Ancient Sahara and Beyond*, explored the complexity and shifting realities of the network of trails connecting the Sahara in the pre-Islamic period.[11] The availability of water and the topography of the terrain are key, but so is the rise or fall of sites that would have been nodes in this network. By engaging with the archaeological evidence for oasis formation, it is possible to suggest some of the main 'routes' through which goods and people might have travelled the Sahara.[12] These possible axes of communication have been traced on the map shown in Figure 1.1, but it must be noted that these are intended more as a visual aid for the reader and an illustration of the potential for connections; a chronological palimpsest rather than an exact representation of the ancient trails at any given moment. Indeed, although the inherently 'mobile' nature of the Trans-Saharan zone is becoming ever more apparent, detailed studies of what, how and when things moved are compounded by the relative lack of data points in our field: comparative, contemporary sites are rare, so in addition to the general paucity and geographical dispersion of excavated sites, there exists a daunting temporal lag between data points.

This leads us on to some important considerations: how do we trace technological transfer and interaction in the unique situation provided by the Sahara, and – in continuation of a point raised above – how may we address whether we are dealing with technology transfer, imitation (mimesis) or multiple 'inventions' of a given technique or practice?

To an extent, the answer to this question lies in how much faith we place in the ability of archaeological specialists to distinguish the meaningful connections. Behind a broad-brush division between data 'splitters' (who emphasise differences between categories) and 'clumpers' (who emphasise similarities) there lie myriad interesting positions: the polemic between the two serves to mask the complex reality of technology transfer. As made clear by Touatia Amraoui, back-and-forth technological dialogues between

[10] Purdue *et al.* 2018a; 2018b. [11] Mattingly *et al.* 2017.
[12] Explored in detail in Sterry and Mattingly 2020, with detailed listings of all available historic-era radiocarbon dates.

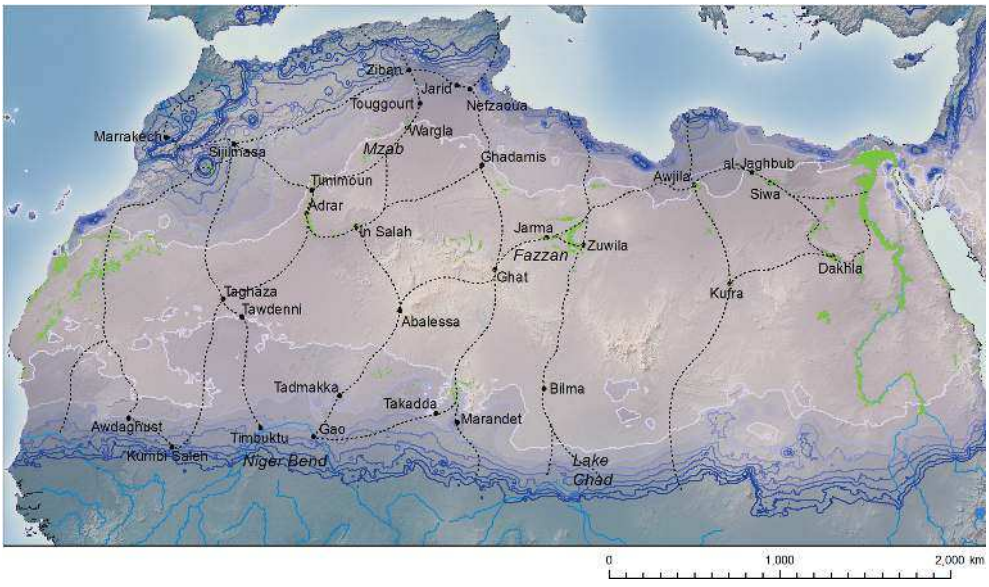

Figure 1.1 Map of key sites and axes of communication across the Sahara over time with indication of rainfall and vegetation (M. Sterry for Trans-SAHARA Project).

neighbouring areas are more difficult to trace in the archaeological record than direct 'transfer' over vast distances, but they form an equally significant window on technological practice, adoption and adaptation.[13]

The volumes in this series have demonstrated that the essential networks of communication, hardwired into social and economic connections, were already well developed within the Sahara in pre-Islamic times.[14] The establishment of oases was a particularly crucial step in that it created a network of fixed population hubs, where food and water was to be found. Although it is undeniable that certain elements of the Saharan networks became more significant in the Islamic era than they had been earlier, basic elements seem to have been laid down in the first millennium BC and the early first millennium AD. The implications of this new paradigm are considerable and studies of technology, as promoted here, will have an important role to play in developing this new agenda. But to do so effectively, we first need to be clear about the models we are using to define technology and technological transfer.

[13] Amraoui, Chapter 4, this volume.

[14] As illustrated in relation to trade: Mattingly *et al.* 2017; burial and identity markers: Gatto *et al.* 2019; oasis formation: Sterry and Mattingly 2020.