A Tale of Two Taphonomies

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A Tale of Two Taphonomies: Assessing the Contribution of Taphonomic Analysis to our Understanding of Neolithic Sudanese Burial Sites using both the Standard Anglophone and Francophone Definitions

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Abstract

The Kadruka concession represents an area of study grouping together a large number of funerary (as well as habitat) sites located in Upper Nubia in modern day Sudan. Five of these sites (KDK1, KDK2, KDK18, KDK21 and KDK23) served as the basis for a doctoral thesis that provided a new perspective on the identity and practices of these populations. These results are part of a larger and ongoing project, which aims to expand our understanding of the Kadruka area, how the different sites relate to one another and to the surrounding region more broadly. Initially excavated and studied by J. Reinold and C. Simon from the 1980s to the early 2000s, the vast documentation made available by this work served as an important means to perform a taphonomic analysis on this collection of burials a posteriori. Traditionally, the term taphonomy possesses two different meanings within its use in archaeology. On the one hand there is the widely used English language definition and on the other there is its meaning and scope in French. Both uses contribute significantly to an improved understanding of the diversity of methods of disposal of the dead, of deposition practices for grave-goods and of the way in which a cemetery may have functioned within a specific environment.

Keywords: Neolithic, funerary archaeology, bioarchaeology, taphonomy, Kadruka, Nubia, Sudan.

Résumé

Une histoire de deux taphonomies. Évaluer l'apport de l'analyse taphonomique dans la compréhension des sites funéraires néolithiques soudanais en employant, à la fois, la définition standard anglophone et francophone

La concession de Kadruka représente une zone qui regroupe un grand nombre de sites funéraires (ainsi que des sites d'habitats), situés en Haute-Nubie au Soudan. Cinq de ces sites (KDK1, KDK2, KDK18, KDK21 and KDK23) ont servi comme base de travail pour une thèse de doctorat qui a apporté un nouveau regard sur l'identité et les pratiques de ces populations. Ces résultats font partie d'un projet plus vaste, en cours, qui vise l'approfondissement de notre compréhension de la région de Kadruka en tentant d'élucider la manière par laquelle les différents sites sont liés les uns aux autres et plus globalement, comment ils s'insèrent dans la région environnante. Initialement fouillée et étudiée par J. Reinold et C. Simon des années 1980 au début des années 2000, la concession bénéficie également d'une documentation vaste. Cette base importante a pu être exploité pour mener à bien, mais aussi a posteriori, une analyse taphonomique sur cette collection conséquente de sépultures. Traditionnellement, le terme « taphonomie » possède deux définitions différentes dans son utilisation en archéologie. D'un côté, il y a la définition bien connue de la tradition anglophone et de l'autre il y a son sens et sa portée en français. Les deux usages contribuent de manière significative et complémentaire à une meilleure compréhension de la diversité des pratiques funéraires (gestion des morts, agencement des tombes et dépôt du mobilier d'accompagnement), ainsi qu'une vision de la manière par laquelle une nécropole a pu fonctionné au sein d'un environnement spécifique.

Mots-clés: Néolithique, archéologie funéraire, bioarchéologie, taphonomie, Kadruka, Nubie, Soudan.

Resumo

Uma história de duas tafonomias: Avaliar a contribuição da análise tafonómica para a compreensão de sítios funerários neolíticos sudaneses empregando em simultâneo as definições standard anglófona e francófona

A concessão de Kadruka integra uma zona agrupando um grande número de sítios funerários (assim como sítios de habitats), situados na Alta Núbia, no Sudão. Cinco destes sítios (KDK1, KDK2, KDK18, KDK21 e KDK23) serviram de base de trabalho para uma tese de doutoramento que trouxe um novo olhar sobre a identidade e as práticas destas populações. Estes resultados fazem parte de um projecto mais vasto em curso, que visa aprofundar a nossa compreensão da região de Kadruka, tentando elucidar a forma como os diferentes sítios estão ligados entre si e de uma forma mais global, como se inserem na área circundante. Inicialmente escavada e estudada por J. Reinold e C. Simon desde os anos 1980 até o início dos anos 2000, a concessão beneficia igualmente de uma vasta documentação. Esta base importante pôde ser utilizada para levar a bom termo, mas também a posteriori, uma análise tafonómica sobre esta importante colecção de sepulturas. Tradicionalmente, o termo «tafonomia» tem duas definições diferentes do ponto de vista da sua utilização em arqueologia. Por um lado, há a conhecida definição da tradição anglófona e, por outro, há o seu sentido e alcance em francês. Os dois usos contribuem de forma significativa e complementar para uma melhor compreensão da diversidade das práticas funerárias (gestão dos mortos, disposição das sepulturas e depósito do mobiliário de acompanhamento) bem como para a visão de como funcionou uma necrópole no quadro de um ambiente específico.

Palavras-chave: Neolítico, arqueologia funerária,bioarqueologia, tafonomia, Kadruka, Núbia, Sudão.

A Tale of Two Taphonomies

Assessing the Contribution of Taphonomic Analysis to our Understanding of Neolithic Sudanese Burial Sites using both the Standard Anglophone and Francophone Definitions

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Dataset related to this article: "Kadruka: A Tale of Two Taphonomies," https://nakala.fr/collection/10.34847/nkl.dce0p66b
These data consist of 6 images and 2 maps related to the archaeological site of Kadruka, Upper Nubia, Sudan, which are also reproduced in this article.
See also: http://sfdas.com/fouilles-et-prospections/fouilles-programmees-de-la-sfdas/article/kadrouka?lang=en [archive].

Introduction to the region and subject of study

Funerary sites represent a crucial source of information on the biology of ancient populations, by virtue of the fact that they present a unique opportunity to analyze the remains of buried individuals directly. They also make it possible to consider a population, as a whole, as well as (under certain conditions) to access a sort of reflection of the living population and structure of a community. Funerary practices (or what can be reconstructed of them) constitute, for the bio-archaeologist (in the anglophone tradition) or archaeo-anthropologist, in the French tradition,1 a glimpse into ideology and ancient mindsets, as well as an indication of the relationships between biology, culture and the environment.

If the main goal of the dissertation (Maines 2019), from which this article is drawn, was an analysis of biological elements and funerary features in order to reconstruct practice and function of the burial mounds of the Sudanese Neolithic, the present work seeks above all to elucidate the means by which a comprehensive approach to burial and human remains analysis provides access to different sources

1. In the anglophone tradition this is defined as a person practicing "bioarchaeology" or "the study of human remains from archaeological contexts" (Larsen 2014) with an emphasis on the importance of the contextual nature of this practice. Synonyms include: archaeo-anthropology, osteoarchaeology (Buikstra & Beck 2006). In the French tradition, the term "archéo-anthropologue", that is, archaeo-anthropologist is more common, and the parameters of their responsibilities are often more precisely defined. Indeed an archaeo-anthropologist is responsible for the study of the biological identity of human remains discovered in archaeological contexts, but also for the study of all elements and traces of activity that speak to the installation and evolution of the burial in which the human remains were retrieved (Signoli 2008; Boulestin & Duday 2005; Crubézy et al. 2000).

of information, which are all equally important for reading funeral data and for the reconstruction of human activity within a specific environment. Furthermore, as a study that engages with relatively forsaken archaeological and anthropological collections, it represents a unique opportunity to engage with questions of heritage, not simply in terms of the physical remains or vestiges, but also in terms of the data we—as practicing members of these disciplines—leave behind us. Indeed, as archaeologists we necessarily destroy the physical manifestations of what we study, at least in their original context. We therefore have a responsibility to document each of our gestures thoroughly and to imagine ways of allowing others to engage with the primary artifact. In the case of burials, it is entirely possible to study parts of this artifact *a posteriori*, but the original ensemble is destroyed upon excavation. Thus, the importance of measured drawings and photographs is readily apparent. This present study was an opportunity to examine the conclusions that can be drawn from engaging with what is left behind for the archaeologist and anthropologist studying a burial that they have not excavated. Finally, the Kadruka collection—which groups data from a large number of funerary as well as habitat sites, of which five will be examined in this paper (KDK1, KDK2, KDK18, KDK21 and KDK23)—also represented a unique opportunity to confront and blend traditions, theoretical models and methodological practices surrounding the concept of "taphonomy," examined and detailed below.

Located in Upper Nubia, in the Northern State of modern-day Sudan, the Kadruka concession forms a vast "multi-site" zone of study, stretching 25 kilometers along the right bank of the Nile, south of the 3rd cataract, in an area known as the "Northern Dongola Reach" (fig. 1). It groups several different geographical areas: the "Kerma basin" (a floodplain) to the west, the desert to the east and the Wadi el-Khowi in the center. It corresponds to an ancient pathway of the Nile (a detail of this entity can be found in fig. 11) that has now disappeared but was an active branch of the river during the Neolithic period, between approximately 7000 and 4500 BC. The Kadruka concession represents a key element for our understanding of the functioning of sites located along the banks of the Nile, specifically with the aim of reconstructing burial timelines (from the installation of each grave, to their evolution, and finally degradation/alteration within a specific context) in an attempt to better understand funerary practices.

From a geographical point of view, Nubia is generally defined as corresponding to the portion of the Nile valley between the 1st and the 6th cataract (Gatto 2011a, 22; 2014, 45). It is traditionally understood as having functioned as a corridor linking Egypt and sub-Saharan Africa (Adams 1977). Current research encourages us to broaden and loosen this definition to define a much larger area, more permeable to external cultural influx and population movement (Gatto 2002; 2011a & b; 2014). Nubia must then be considered as a whole: it includes a multitude of cultures and populations and blends the desert regions of the east and west of the Nile Valley, as well as other areas of exchange and interaction between Nubian populations and

Figure 1: Geographical context of study
Illustration: Emma Maines.
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others, whose identity vary depending on the considered period. Nubia would thus have acted as a sort of gateway or fluid zone, both from the perspective of cultural exchange and population movement, not only along a north-south but also east-west axis. We can therefore consider that the cultural entities present in northern Sudan responsible for burial mounds, like the Kadruka sites, may have played a role in this transfer thanks to their central geographical location (Wengrow et al. 2014, 102, 107). Furthermore, Sudan occupies a rather singular geographical position: it has access to the Red Sea and is located near the heart of the African continent. This territory remains at the confluence of many cultural areas and a mosaic of populations.

The most striking environmental trait of Nubia is the Nile, a powerful river that traverses East Africa along a north-south axis and whose presence is essential for the understanding of several crucial elements of this study. Indeed, the Nile has been an important route of trade since prehistoric times (Wengrow 2001, 95–97; 2003; 2006, 26–29, 44–59; 2014, 96; Edwards 2004, 49–59, 67; 2007, 216–217; Gatto 2011b). The Nile valley is even proposed as a central axis for Africa's population, given its role in the exchanges between the Mediterranean and sub-Saharan worlds and the opening that it presents on one side towards the Middle East and on the other to Ethiopia and the Horn of Africa (Crubézy 2010, 26), via the Blue Nile. The Nile works as a motor of permutations and cultural mixing; it has also had a direct impact on the cemeteries we study, as well as the evolution of these sites.

While it is evident that the Neolithic represents—in Nubia, as elsewhere—a period of transition and change in lifestyle, the catalysts for this process are still open to debate. Before addressing the three main axes of this discussion (the role of climate, production methods and populations), it is necessary to specify the chronology of Sudan for this period. The Upper Nubian Neolithic is generally divided into three parts: the Early Neolithic (6000–5500 BC), the Middle Neolithic (5000–4000 BC) and the Late Neolithic (4000–3500 BC). In Central Sudan, the chronological divisions are staggered. The Mesolithic period spans between 8000 and 5000 BC, while it is dated between 8000 and 6000 BC in Upper Nubia. It is divided between an early period and a late period, beginning around 6000–5500 BC. The Early Neolithic, for the region of Central Sudan begins in 5000 and ends in 4000 BC. A direct passage to a late Neolithic culture is proposed, a period which ends around 3000 BC. In Upper Nubia, the Late Neolithic period remains very poorly understood (Salvatori & Usai 2008, 155). The pre-Kerma and Kerma periods that follow are better known and show the peak of some of the key cultural evolutions that appear to already be underway in the Neolithic, with a further transition to proto-urban and proto-state forms.

For Sudan, there are many similarities between the cultures of the Mesolithic and Neolithic: a concentration of sites along bodies of water, lifeways integrating a form of nomadism and the fabrication and use of ceramic (Garcea 2006; Edwards 2004, 28). As stimuli and characteristics of the Neolithic in Upper Nubia, we can retain three main axes: climate, production methods and population.

Some researchers favor climate change as the trigger for lifestyle changes in the second half of the 6th and throughout the 5th millennium. Thus, an increasing mobility of the populations of hunter-gatherers during the second part of the 6th millennium is linked to climate change, responsible for the drying out of lakes (today paleo-lakes) and lake areas in the West Nile (Williams & Adamson 1980; Usai 2006; Salvatori et al. 2016, 125). M. Honegger's important work in the "Northern Dongola Reach" region also points to a gradual shift of the location of sites over time and relates this to an aridification process underway in the region. Before 5000 BC, the sites are located outside the alluvial/floodplain, and therefore sheltered from recurrent flooding caused by the Nile. After 5000 BC, the climate becomes increasingly arid, and the sites are found within the plain.

This very clear interpretation suggests a direct link between populations, practice and the environment, but other researchers warn against what they consider to be too strong a climatic determinism (Crubézy 2010, 29; Edwards 2004, 40). D. Wengrow, for example, advises that the climate hypothesis has come to fill for too long the absence of other models for social change. He proposes that the north-south axis of trade, which is fundamental for later periods, must be taken into consideration for prehistoric phases. This hypothesis does not call into question the importance of the climate, but rather suggests other complementary influences of the practical and identity evolutions that we recognize for the Neolithic and the following periods (Edwards 2004, 40; Wengrow et al. 2014, 98, 102).

This change in lifestyle and practice in Neolithic Sudan, may also have been the result of material culture innovations, in particular within the field of technology, brought on both by the arrival of new populations (immigration with importation), as well as through an indigenous process (Sadig 2013, 30; Salvatori & Usai 2008, 147–156). In this interpretation, the Upper Nubian Neolithic should be understood as having been instigated by three major factors: a technological, economic and demographic shift, which may have occurred in some instances in a complementary or interactive manner. According to some, ceramics would have played a leading role. This technology allows food to be boiled, which improves the overall health of populations, but especially of young children during the weaning period (Handwerker 1983; Edwards 2004, 35). This improvement would have led to population expansion, resulting in a change in the lifestyle and organization of human groups (Halaand 1995). However, an emphasis on the role of ceramics in this cultural and practical shift represented by the Neolithic, must be confronted with the significant presence and already well assimilated use of ceramics in this region during the Mesolithic (Salvatori et al. 2014; Garcea 2006).

The arrival of domestic animals from the Near East is also proposed as a catalyst, by the modifications it would have encouraged in terms of subsistence by causing a shift towards a way of life of production and provision (Edwards 2004, 38). Indeed, agro-pastoralism is an essential element of the Neolithic period of Upper Nubia and its surroundings. It is a food economy that is based on practices that are already well established: hunting, fishing, and gathering (Leclerc & Tarrête 1988; Blaise 2009). The 5th millennium in Upper Nubia saw an important arrival of domesticated, as well as an indigenous effort to tame animal and plants species (Wengrow et al. 2014). While the large fauna (elephants, hippos, buffaloes, giraffes and others) is primarily attested to at this period in the southern regions of the Sahara, remains are also found on the sites of Upper Nubia (Arkell 1953, 12; Pöllath 2008, 72–73; Crubézy 2010, 29). The arrival of domesticated sheep from Egypt is documented as early as 6000 BC in the Nile Valley (Blench and Macdonald 1999; Hassan 2002; Shillington 2005; Barker 2009; Linseele et al. 2010). An indigenous domestication of bovids is also proposed between 6000 and 5500 BC, according to data from excavations and archaeological surveys (Salvatori & Usai 2008, 152; Crubézy 2010, 29). Though the origin of these cattle is still a subject of controversy and, for the moment, neither archaeological data nor genetic information provide entirely satisfactory answers (Brass 2018).

Other studies also demonstrate that centers of domestication (of bovids and some plant species) did exist in the Western Desert (in Egypt) and in the Eastern Sahara. They suggest that these regions may have also supplied the Nile valley (Warfe 2003). Cattle will occupy a significant (and growing) role in Neolithic funeral rites, which then appear to culminate during the later Kerma period (Salvatori & Usai 2008, 154; Dubosson 2011; Chaix, Dubosson & Honegger 2012). Animal husbandry was therefore fully integrated into the Middle Neolithic economic and food systems operating in Upper Nubia, whether of the species may be considered to be of African origin or from elsewhere.

The arrival of wheat and barley from the Near East is also hypothesized, though native grains were already in the repertoire of Mesolithic hunter-gatherers (Barker 2009). The Badari culture provides the first direct evidence of prehistoric agriculture in Lower Nubia. The emergence of this culture is proposed as early as 5000 BC. (Watterson 1998, 31), and can be considered to be fully integrated into local economies around 4400–4000 BC. (Shaw 2000, 479). Phytoliths from tombs, as well as studies of dental calculus of the deceased buried on the El Ghaba and R12 sites from Sudan demonstrate the presence and consumption of wild and domesticated plant species. Indeed, while the analysis of phytoliths from El Ghaba mainly highlights the exploitation of native plants in a savannah-type environment, the analysis of the specimens from R12 allowed the identification of cereals (wheat and barley), for which authors suggest a provenance from the North of the Nile valley. The analyses of dental calculus revealed evidence of consumption of these two species (wild and domesticated) from both necropolises. In addition, it was possible to date one of the phytoliths from a tomb from R12 and the latter provided a date of 5311–5066 cal. BC (Usai 2016; Madella et al. 2014). This result pushes back the presence of domesticated cereals for Upper Nubia, for which the only other known date is from a KDK1 barley sample (Reinold 2000), dating between 4500 and 4000 cal. BC. This data places the presence of domesticated cereals in Sudan at dates at least 500 years earlier than previous estimates, including the Egyptian sites of Fayum and Merimde (also dated around 4500 cal. BC). This would confirm an earlier expansion of agriculture from the Near East to the south-west (Madella et al. 2014, 5–6). Researchers also highlight a similarity between the Nile river valley environment around the 3rd cataract and that of the Near East. Indeed, both environments can be considered favorable to methods of cultivation by flooding (Macklin et al. 2013; Hassan 1997c) and also suggest that these populations were familiar enough with the occasional exploitation of native wild species to have encouraged a rapid adoption of new methods of cultivation and introduction of new species (Madella et al. 2014, 5–6).

While one must admit that desert and semi-desert environments do not favor the adoption of agriculture (Garcea 2006), this is not necessarily the case in the network of settlements in the Nile Valley. If the hypothesis of large-scale agricultural operations should probably be abandoned, that of seasonal or *ad hoc* agriculture would appear, at this stage, to be more in agreement with the archaeological data. If, for the groups of the Middle Neolithic, one cannot affirm a prevalence of agriculture, one can neither ignore the evidence of an agricultural culture, undoubtedly light in terms of the terrain invested, and which would have relied on wild, as well as domestic species. Some authors suggest that the importance of agriculture may still be underestimated. It seems essential to reflect on the strategies put in place by these societies in the face of the arrival of new populations and the modalities of their integration (Holdaway & Philipps 2017). It should also be noted that, in general, plant remains are not well preserved, which could partly explain the paucity of information on this subject. The Kadruka ensemble provides a variety of archaeological and anthropological evidence for agriculture, including objects associated with the cultivation of plants, such as the sickle; palynological remains of cultivated species, if not domesticated; as well such as dental wear, and calculus.

Finally, it is necessary to consider the different potential modalities by which this kind of evolutive process takes place, as well as how the assimilation of a new lifeway alters or not the exploitation and occupation of a territory. One hypothesis is that the Neolithic populations came from the North with a previously well-established set of practices, their culture and way of life, and that they inserted themselves into their new environment and the local population(s) as a wave would, progressively and in a continuous manner (Salvatori et al. 2016, 132). Differences between these populations have already been signaled, whether economically, technologically or biologically (Salvatori et al. 2016, 95; Crèvecoeur 2012, 27–28; Irish 2005). On a biological level, the results remain insufficient to specify the chronology or the process of mixing or replacement. The most recent studies highlight a rupture between the Paleolithic and Neolithic populations (Irish & Turner 1990; Turner & Markowitz 1990; Irish 1993; 1998a, b & d; 1999; Franciscus 1995; Holliday 1995; Groves & Thorne 1999; Irish 2005, 14; 2008; Irish & DeGroote 2016), as well as a great diversity of Mesolithic and Neolithic (Crèvecœur 2012), despite a similarity of material cultures and production techniques (Trigger 1976; Phillipson 1994; Williams 1997). Other studies maintain that the biological data demonstrate above all a relative homogeneity and continuity of populations, despite a dearth in data, specifically, for example for comparisons between late Mesolithic populations in the South and well-established Neolithic populations in the North (Greene et al. 1967; Greene 1972; Trigger 1976; Carlson & Van Gerven 1977; 1979; Small 1981; Wendorf et al. 1984; Phillipson, 1994; Williams 1997; Barich, 1997; Hassan 1997a & b; Wetterstrom 1997; Wendorf & Schild 2001; Irish 2001; Salvatori & Usai 2008). A study that compares pre-, proto- and historical populations of Lower and Upper Nubia based on craniofacial morphology (Godde 2009) highlights the continuity and a close affinity between the Egyptian and Nubian populations. Thus, seemingly supporting the scenario of significant population migration(s) from North to South. However, this study also underscores the impact of a similar environment in complicating the interpretation of the results. If different populations evolve within an identical environment, what part should be attributed to genetics, epigenetics and the environment in a homogeneous phenotypic expression (Godde 2009, 401)? We must also consider the modalities of migration. We may not be, in all cases, facing large-scale movements. Indeed, small geographical distances between the different groups, at all periods, may have allowed for an exchange of variable genes, in a relatively constant manner over time.

In summary, this Neolithic transition is therefore both the result of an external influx, as well as an indigenous process. A great variability is visible within the Neolithic in the regions of Upper and Lower Nubia, as well as in central Sudan, and this diversity is linked both to climatic, technical, practical and cultural changes, as well as to differential evolutions according to region and chronological phase (Edwards 2004, 42). Furthermore, this process of regionalization gains in magnitude in the periods following the fifth millennium (Edwards 2004, 42; Sadig 2013, 27–28). The aim is, therefore, not to provide a definitive answer as to which element (or combination of elements) triggered this process of neolithization, which was already strongly established during the period corresponding to the use of the Kadruka cemeteries, but rather to examine the important insights that the Kadruka ensemble provides regarding cultural and biological aspects of the identity of Neolithic Nubian societies.

To date, the preferred hypothesis is that of Middle Neolithic semi-nomadic pastoralist populations who would have moved along the banks of the Nile river and its tributaries within the floodplain. These were undoubtedly groups of varying size, with a more or less complex social organization depending on the group and with varying degrees of residential mobility (Salvatori & Usai 2008, 154). The emergence or accentuation of a social hierarchy during the Neolithic period is proposed in connection with the criteria mentioned above. A hypothesis was put forward by J. Reinold, that the later sites of the Kadruka ensemble present a selection among the dead and group together an elite from within a larger population (Reinold 2000, 46; 2001, 2, 6). Increasing social hierarchy during the Middle Neolithic is understood to be the primary catalyst behind these changes in practice and was interpreted based on significant concentrations of grave goods within a fraction of burials, within cemeteries where the buried population already represents a selection among the overall population (Reinold 2000). However, real evidence of a reorganization of society, around an elite, concentrating power and wealth, is still lacking. An evolving analysis of wealth, expressions of power and their variability within the different sites studied is necessary and ongoing (Reinold 2000; Honegger 2006; 2014a & b; Salvatori & Usai 2008). The dissertation work (Maines 2019) from which this article results represents an attempt to answer, at least in part, the question of population and practice: who were the different populations using these cemeteries? Who had access and did this access differ over time? And, how similar or divergent were these populations in terms of biology and practice?

Engaging with archives and previously excavated material: development of a methodological framework

The "Northern Dongola reach" is noteworthy in terms of the density of funerary sites that has been surveyed and recorded for this area, specifically for the Neolithic period. The Kadruka concession represents an exceptional case within an already remarkable region, with a total of 17 funerary sites identified. Initially explored between 1986 and 2009, Jacques Reinold (former director of the SFDAS, French Section of the Department of Antiquities of Sudan), gathered a preliminary inventory of the sites, as well as excavated several cemeteries (nearly exhaustively in the case of KDK1 and 18, and at least partially for KDK2 and 21). Despite the more than 700 graves excavated since the 1980s, and numerous publications, analysis of funerary practice and population identity remain rare within his work (Reinold 1987; 1991; 1993; 1994; 1996; 2000; 2001; 2004a & b; Simon 1997).

For most sites detailed and anatomically legible site plans and measured drawings, as well as precise and informative field notes exist. The biological studies carried out by C. Simon for KDK1 and 18 represent valuable information and a good basis for comparison. Regrettably, mass plans are missing for certain cemeteries: KDK18 and KDK21 have partial mass plans, for which it was possible to reconstruct an estimation of the complete plan using individual measured drawings and coordinates; the mass plan is entirely missing for KDK2. Labelled burial photographs are also missing in many cases and information relating to stratigraphy is sparse.

Figure 2: Summary of the available data for each burial mound

	KDK1	KDK2	KDK18	KDK21	KDK23
Total number of tombs estimated for each burial mound	± fully excavated	1000 +	± fully excavated	~ 300	~ 300
Total number of tombs excavated for each burial mound	124	116	165	288	103
Total number of tombs studied for each burial mound	109	/	162	277	103
Representativity of studied tombs (in %)	87.9	/	98.2	96.2	100
Total number of individuals studied from a biological perspective	111	43	147	234	108
Total number of individuals added by funerary analysis	5	0	21	65	0
Representativity of individuals compared to number excavated burials (in %)	89.5	37.1	89.1	84.5	100
Representativity of individuals compared to the estimated total number of burials for each site (in %)	89.5	4.3	89.1	77.3	36.0

Emma Maines, 2020.

Since 2014, and under the insignia of the SFDAS and the QSAP (Qatar-Sudan Archaeological Project), the Kadruka concession has been at the heart of a new project that aims to excavate the KDK23 burial site in an exhaustive manner, as well as protect and inventory other fragile sites, notably habitat sites.[2] A bio-

2. Co-directed by Olivier Langlois (CNRS, UMR 7264), Philippe Chambon et Pascal Sellier (CNRS, UMR 7206).

archaeological study of five Neolithic cemeteries all dated to the Middle Neolithic, (KDK23 and four others excavated formerly by J. Reinold: KDK1, KDK2, KDK18 and KDK21) including not only the study of human remains, but also a wide range of documents and excavation archives were the subject of a previously cited and recently completed doctoral thesis (Maines 2019). From a biological point of view, the corpus includes a total of 643 individuals for whom it was possible to carry out a study directly on the osteological or dental remains. From an archaeological point of view, it was possible to study 664 structures, including 656 tombs, the distinction of which was based on the re-examination of plans and other field documents (fig. 2). In the context of re-examining archaeological archives in the hopes of improving our understanding of these collections, it is critical to assess the available data and be transparent about its representativity and potential for the aims of the study.

The importance of vocabulary, or taphonomy *vs.* "taphonomie"

In order to correctly and fully grasp the implications of scientific interpretation it is essential to have a clear understanding of the vocabulary used for study and the definition of some basic principles. Perhaps the most intrinsic of these terms would be the notion of a "burial." By this term we understand the place where the body or the remains of a deceased is deposited. Though burial may not represent a compulsory act following death, the intentionality of the gesture is to its definition. Indeed, both grave and burial imply an intentionality that the term "deposit," for example, does not (Knüsel & Robb 2016, 3; Lauwers & Zémour 2016, 15–16).

Several types exist; a so-called "primary burial" supposes that the body decomposes within the site of this initial and sole deposit (Leclerc 1990; Duday et al. 1990). A "secondary burial" involves moving the remains in a pre-programmed manner, after waiting a more or less important lapse of time following the start of the decomposition process (Duday et al. 1990). Finally, a "reduction" refers to an intentional regrouping of human remains, reducing their initial volume, though remaining within the space where the decomposition of the corpse took place (Blaizot 1997). This may be opposed with bones that are found in the backfill of a burial and were disturbed from their original burial context and for whom the context in which they are discovered reflects no intention of deposit. A primary burial implies a single funeral, while a secondary burial can include double or multiple funerals. An "individual burial" houses a single individual, while a "collective burial" refers to a repository wherein several burials are grouped together, though they are inserted in the tomb at different times. A "multiple burial" is a primary burial that includes the simultaneous and unique deposit of several subjects (Duday & Guillon 2006, 150–152; Boulestin & Duday 2005, 27).

We should also clarify what is meant by funerary practices and timelines. Funerary practices are broadly defined as a series of regulated gestures and postures which represent an operative sequence, and which are associated with a set of specific timelines around death and the deposit of the body. It is through the recognition of these gestures that we access a reconstruction of the layout of the tomb at its origin and a vision, at least partial, of the sequence of funeral rites and of a "program" defined for these practices, the prescribed gestures and chronology of which, are integral and essential parts (Pereira 2013, Lauwers & Zémour 2016).

The definition and analysis of "funerary timelines" are more complex. While these timelines necessarily begin with death, the sequence that follows can be more or less complex and it is often difficult to identify the end of the process. Because death can be followed by the preparation and/or exhibition of a corpse, or a more or less swiftly held burial following death, the funeral does not necessarily end with the burial (Pereira 2013, 2–3; Boulestin & Duday 2005, 21; Boulestin 2012). If a division can be clearly drawn between the corpse, the transformations it endures and its eventual conversion into merely skeletal remains, the question that remains is that of memory and the eventual disappearance of the deceased from an individual or collective memory and negotiating how this timeline fits into the overarching sequence and into the definition of an end to a funerary timeline (Pereira 2013, 2–4; Leclerc 1990, 17).

To the notions of burial or grave and the intentionality and scope of different gestures we should add those of "cemetery" or "necropolis," used to refer to places where the deceased are grouped together and within which burials may be organized according to a notion of space and function or other criteria. These are places of life and worship, waste management, space, human relations within the user population and whose duration of use can vary enormously, or even be multiple. In order to be able to determine what is remarkable about a burial or a set of burials, one must have access to an appreciation of the standard. And for that, it is necessary to be able to distinguish between the obligatory funerary acts and those which reflect a true personal or individual choice and to appreciate their respective chronology. The norm in this context, then corresponds to all the acts that are performed by the living, motivated by an obligation to respect these gestures during the funerary period (Bocquentin et al. 2010, 159). Finally, the goal in funerary archeology is to consider each set of human remains or burial individually in order to better understand the whole (Bocquentin et al. 2010, 160).

A key term used for the analysis of each of these notions or elements remains problematic. "Taphonomie" in French (i.e. "taphonomy[3]"), in the context of French funerary archaeology, is a technical term often used to designate a type of analysis performed on human remains and their context and which belongs to the overarching discipline of "archaeothanatology." This discipline is also commonly referred to as "archéologie de la mort" (which translates to: archaeology of death) or "anthropologie de terrain" (field anthropology) or again "archéologie funéraire" (funerary archaeology). These names all serve to underscore the importance of

3. Our text in no way strives to provide a historic appraisal of the development or use of the term outside of funerary archaeology and readers are encouraged to refer to Knüsel and Robb (2016), for example, for a historical approach to and analysis of "taphonomy."

anthropological analysis *in* the field. Most importantly "archaeothanatology" is understood as grouping and blending the study of biological and cultural aspects of ancient populations (Boulestin & Duday 2005). In the French tradition, the gestures we referred to above are directly related to the application of taphonomic analysis, that is to say: to the deceased and their surroundings, and all possible traces of their preparation, exhibition and burial which remain, as well as any intervention or re-intervention (natural or anthropogenic) that are visible through the position of the osteological or material remains (Duday 1990; Duday et al. 1990; Boulestin & Duday 2005). All of these elements reveal both information relating to the identity of the individual, and funerary practice. Through a taphonomic analysis, the evolution of the decomposition of the corpse, including the space of decomposition, as well as notions of burial timelines can be re-imagined and re-constructed. Specifically, every initial volume present at the moment of burial (the body, any possible container or envelopment, material goods, grave architecture, *etc.*) is taken into consideration in order to assess the extent of any possible movements within the tomb which may have caused a particular displacement of the remains within the grave or altered the burial during the course of its timeline until discovery (Duday 1990; 2009; Duday & Sellier 1990; Duday et al. 1990; Duday & Guillon 2006; Boddington et al. 1989; Maureille & Sellier 1996; Sellier 1990; 1992).

In the English-speaking tradition of funerary archaeology or bioarchaeology, the notion of taphonomy is more frequently linked to an observation of visible changes to the bones, be it micro or macro, and occurring directly before or after burial. The definition includes a study of the color, surface details and shape of the bone, in order to elucidate a variety of perimortem events and post-mortem processes that may have taken place, and which may have left legible traces on the bone (Buikstra & Ubelaker 1994, 95–106). In his 2005 publication, R. Sprague defined this practice as the study of the changes taking place on the bone since its burial, and which may relate to the processes of preparation or preservation of the corpse, as well as erosion in the natural environment (Sprague 2005, 175). This practice also exists within the French tradition but tends to be classified under laboratory observations, is often divorced from the understanding of burial reconstruction, is not referred to as "taphonomic" and is correlated to conservation and limitations imposed by degradations suffered in an archaeological context to the biological analysis.

It is interesting that as a term that began to be used in archaeozoology (Knüsel & Robb 2016, 655), the understanding of its implications has remained so divergent, despite the complementariness of both scopes of definition. Indeed, one might summarize the rift as one that applies to where the analysis takes place: in the field, following the French tradition, or in the laboratory, following the English-speaking tradition (*ibid.*, 657). There is little attention paid in the French tradition to the useful implications of taphonomic analysis, as it is defined by English speakers, for understanding burial context and evolution. Translations of French methodology and theoretical frameworks do exist (Duday & Guillon 2006; Knüsel 2014; Knüsel

& Robb 2016). In particular, C. Knüsel has contributed significantly to bridging the gap by rendering available, to English-speaking researchers, recent publications that engage specifically with French technical vocabulary and the difficulties of effective translations, as well as with specific methodological frameworks. Nonetheless, it is primarily among those who have already been exposed to the French definition and use that we observe this practice of analyzing the precise positioning of certain elements of the skeleton, grave goods or burial architecture in order to reconstitute the original set up of a burial (Roksandic 2002; Duday, 2009; Knüsel 2014, 27; Nillson, Stutz & Larsson 2016; Knüsel & Robb 2016).

Toward a better understanding of identity, practice and environment through taphonomic analysis

The taphonomic study of the Kadruka ensembles was carried out with several primary objectives. The first was to obtain a better understanding of the chronology and precise sequencing of the funerary process for each burial. The second ambition was to improve understanding of the variability of the funerary norm and to be able to compare these "gestures" and practices with one other (Duday et al. 1990), whether it be intra or inter-site. Finally, we wanted to gain access to a vision of the environment within which decomposition was taking place during the Neolithic in order to better grasp the interaction between these populations and their environment.

It is worth underscoring that in order to reconstruct the funerary sequence, it is always preferable for the archaeo-anthropologist to carry out a series of *in situ* observation of the elements that make it possible to reconstitute the original state of the burial. The reconstitution of the original position of the corpse and of the arrangement at the origin of the tomb is therefore carried out by observing all the different connections of the body and the state of their conservation, while taking into account the standard order of decomposition of the skeletal joints (labile vs. persistent), as well as the differential dislocation probabilities according to the surrounding environment (Sellier & Bendezu-Sarmiento 2013, 33–34). This was of course not possible for many of the remains included in the analysis of the Kadruka collection and obliged a reflection around how best to consider the results, their reliability, representativity and significance.

Before considering these results, some notions of anatomy and human decomposition should be outlined. As we have mentioned, a burial is above all a set of volumes: the volume of the corpse, the container, the objects deposited, and the grave dug to receive the deposit, as a whole. For the final reconstruction we must come to understand the interaction between all of all the aforementioned variables components, as well as their evolution during and following decomposition. This timeline begins with the corpse, the most unstable part of this composite formula. Without human intervention, putrefaction begins between 24 and 36 hours after death. From there follows a formation of gas, followed by destruction of organic matter, from which liquefaction of parts of the corpse results. The organs are the first elements to break down, followed by the epidermis and muscles, later ligaments and tendons, and finally keratin (hair and nails) (Duday 1987; Haglund 1993; Haglund & Sorg 1997; Roksandic 2002). It is also important to emphasize that the amplitude of the possible movements, for the different regions of the human body is very unequal (for example the fairly easy rotation of the femur, the humerus or the head, compared to the relative rigidity of the entire pelvis or lower spine) (Duday 1987; Williams et al. 1995). Finally, the joints of which the human skeleton is composed of can be grouped into two types: labile or persistent. "Labile" joints include those of the skull and mandible, cervical vertebrae, ribs and sternum, scapula and thorax, the bones of the hands and wrists (carpal bones, metacarpals and phalanges), hips, patellae, and the bones of the feet (metatarsals and phalanges). "Persistent" joints include the atlanto-occipital connection, the lumbo-sacral joint, and all of the lumbar vertebrae, as well as the sacro-iliac junction, the knees, ankles, and posterior portion of the tarsal bones (Duday 1987; Roksandic 2002).

An "in ground" burial refers to the digging of a pit in the natural substrate with a direct deposit of the deceased within this space, directly on the ground, followed by the immediate backfilling of said space, leaving no primary void unfilled (Duday 1990, 194). It is the disappearance of the soft tissues of the corpse which leave behind what we will refer to as secondary empty spaces. In fact, during the process of decomposition the formation of gas and liquefaction can lead to movement of the skeletal elements despite there being no primary volume previously present within the tomb. In this kind of context, we can speak of two types of decomposition according to the texture and fluidity of the sediment: a decomposition in a "sealed" space with progressive filling of the original volume of the cadaver or in a "semi-sealed" space with delayed filling of the original volume of the cadaver. In the first case, even the most labile joints retain their anatomical relationships with one another, because the spaces freed by the disappearance of the soft parts of the corpse undergo progressive filling and assure that the positions are retained. This scenario also ensures a detailed and reliable reading of the deceased's original positioning within their burial space. However, it should be emphasized that an interpretation of the conservation of articular relationships as meaningful from a taphonomic perspective only applies if their original position was unstable (Duday 1990, 194). In the second case, the secondary spaces left by the disappearance of the soft parts of the cadaver are filled in following a more unstable and inconstant timeline. Movements are therefore possible but are restricted to the initial volume of the corpse (Duday 1990, 195).

It is necessary to underscore the frequent difficulty of analysis in this context. It is, for example, almost impossible to distinguish between the burial of an individual directly in the ground and that of an individual covered with a shroud or a thin covering and then buried. Indeed, these fine, flexible and biodegradable coverings pose a particular set of challenges when interpreting taphonomic processes occurring in a burial setting, due to the variability of their thickness, rigidity, and impact on positions of limbs and decomposition processes, as well as the degree to which they allow sediment to filter in. Particular attention has been paid to this kind of element in French archaeological endeavors and reflection, and represents important advances in the understanding of the significance of *minutiae* in taphonomic analysis (Bizot & Signoli 2009).

However, if an empty space is retained long enough and some of the ligaments are already destroyed by this time, then bones may emerge from the original volume of the cadaver. This is particularly the case for burials wherein a wooden structure exists, or wherein the deceased is covered with animal skin or branches. It is also possible that the two scenarios exist within one and the same burial (Duday 1990, 195). The movements of anatomical segments outside of the initial volume of the cadaver should not necessarily be interpreted as evidence of empty spaces existing at the moment of deposit. They can also be produced when an item of perishable material, deposited at the time of burial, disappears (the displacement of the bones then becomes a testimony to its existence). This is the case, for example, when one observes a tilting back of the skull, with disjunction of the tempero-mandibular joint or dislocation of the cervical vertebrae, following the decomposition of an apparatus placed beneath the head, such as a cushion or a tablet (Duday 1990, 196). Attention should also be drawn to the peculiarity of the contracted or flexed position of the deceased, especially in the case of burials typical of Neolithic populations in Sudan. In these cases, a delayed filling of the secondary volumes left by the corpse can generate what is called a "closure of the inter-segmental angles" resulting from a displacement generated by gravity or pressure exerted by the surrounding sediments or deposits. This effect necessarily occurs when the flesh and muscles have disappeared, but the ligaments are still present (Duday 1990, 195).

A major obstacle to our work is that a majority of methods applied in funerary archeology were primarily developed in a temperate environment (Duday 1990; Duday et al. 1990) and the geographic and chronological context presented by the Kadruka ensemble does not present decomposition conditions that correspond to such temperate environments. In fact, in these cases, particular attention must be paid to the potential impact of a decomposition timeline diverging from the proposed model and it is necessary to re-evaluate the notions taken for granted around decomposition and what this implies for the reconstitution of any latent structure.

Indeed, if today the Eastern Sahara is one of the most sterile and hyper-arid deserts of the planet, during the Holocene a series of important hydrographic networks, as well as lakes dotted this same landscape. This wet phase was followed by an irreversible aridification which was visible as early as 3000 BC in northern Nubia (Kuper & Kröpelin 2006; Kuper et al. 2007). We can therefore imagine that during the period during which our five sites were operating, processes of transition to an aridification of the climate were already underway and would have had consequences on the evolution of corpses in their burial context and therefore necessarily present issues for our taphonomic interpretations.

Multiple studies have shown that in arid environments, the remains exhibit an accelerated rate of desiccation compared to temperate environments. In addition, a recent study demonstrated that while one might imagine that in an arid context, the surface remains would dry out sooner than the buried remains, the specimens exposed on the surface lost much more tissue, which led to earlier mummification, but with a smaller overall mass (Munkres 2009, 84). Ambient temperature has the greatest impact on the rate of decomposition (Mann et al. 1990). This is because heat accelerates the process of self-destruction by increasing the efficiency of catalytic enzymes in the body. Therefore, the rate of decay is also increased (Perper 2006). But temperature influences many other variables that affect decaying human remains. For example, under these conditions, plants, animals and insects are more active and exist in greater numbers. It can therefore be accepted that decomposition occurs at an accelerated rate in warmer climates (Mann et al. 1990; Perper 2006), but it can also be compensated by processes of mummification. In addition to the importance of temperature, the activity of insects, scavengers, the importance of clothing or elements covering the deceased, the pH of the sediment, the depth of the burial, trauma suffered, the size of the deceased, prior exposition to sunlight or precipitation also has a significant impact on the decomposition process. The universality of the decomposition models and the chronological divisions proposed must be reviewed in consideration of this data (Cockle & Belle 2015, 136e2). Furthermore, while we can generally expect to see rapid disappearance of soft tissue, longer preservation of certain organs or organic material components is possible (Mann et al. 1990; Perper 2006; Cockle & Belle 2015, Munkres 2009, 73). For example, desiccation tends to occur on the extremities more quickly and can therefore influence the preservation of joints considered elsewhere as labile, such as the hands and feet.

How important this emerging aridity was for the decomposition processes within the five Kadruka ensembles remains to be elucidated. Fortunately, some taphonomic indications make it possible to detect a possible desiccation or mummification (in these cases, natural, without ruling out the hypothesis that it was an intentional process). Indeed, mummification, whether natural or anthropogenic, ensures a connection between all the elements of the skeleton, in particular of the labile joints (Pereira 2013, 2–5). It can lead to a reduction in body volumes in the event of a burial following prior mummification. In addition, in the case of a relaunch of the putrefaction processes, it can also modify the order of joint dislocation resulting in what is referred to as a "paradoxical order of dislocation" (Maureille & Sellier 1996; Sellier & Bendezu-Sarmiento 2013, 33–34). In our analysis, we therefore take these realities into account and we will discuss the possible consequences for our taphonomic understanding of the burials and the clues at our disposal to argue for possible cases of partial mummification.

Another obstacle to the study of the Kadruka ensemble was that *in situ* observation of a majority of burials was not possible (excepting KDK23). J. Reinold's archives for KDK1, 18 and 21, provided a very satisfactory quality of information for taphonomic analysis (no burial plans were retrieved for KDK2). This work made it possible to establish a notion of a norm for these sets, through the identification of a set of taphonomic phenomena (defined below), as well as to identify cases of re-intervention, burial reduction and secondary deposits. Keeping in mind the limitation of *a posteriori* observation of taphonomic phenomena, the goal was to establish a set of criteria for observation, in this case a set of overarching categories that might group together different taphonomic processes; these include: evidence of hyper-flexed positioning, retention of empty spaces or evidence of movement, retention of elements in unstable equilibrium or constraints exerted on the individual in the form of pressure applied to the cadaver or structuring elements shaping the positioning of the deceased. An advantage to this work was the ongoing research at KDK23, which allowed for a better grasp of taphonomic phenomena, through a perspective informed by *in situ* observations, and which might apply to the other sites, or help to underscore examples of divergence. Unfortunately, and obviously, *lacunae* persist when working on photos and site plans for taphonomic analysis of burials, and as the examples included in this article will illustrate, some interpretations remain necessarily hypothetical, but the hope is that these examples also demonstrate the wealth of information that can be garnered, especially from an overarching perspective. Indeed, this work represents a first for reflection around decomposition processes in this climate/environment and the contributions to our understanding of practice in ancient populations using these methods.

The goal is therefore to move from the individual to a global vision, and to establish what may be considered as the standard funerary practice, if there is one, and which treatments appear to be exceptional cases. The hope is that by highlighting the variability or standardization of practices, and by recognizing repeated gestures, we acquire a cultural and social perspective. Ideally, we want to gain access to a vision of the cemetery as a constructed space, and better understand the actions that led to each particular composition. The cemetery therefore exists as a lived-in place, bringing together people who have or have not known each other in life, and our task is to further develop our understanding of their relationships and identities, in connection with the cultural and social expression of death and funerary practice.

Finally, the analysis of the formation and evolution of the burial mounds allows us to better understand the interaction between these populations and their environment. Because taphonomic interpretation is also influenced by the environment in which decomposition takes place, insofar as it can be favorable to the disappearance or the conservation of certain elements, it was vital to gain a geomorphological assessment of the mounds. Furthermore, during the occupation of the Kadruka sites, the climate may have been, at least occasionally, conducive to the desiccation of bodies and at other times not.

Diversity as the rule, within an inconsistent and variable environment

What emerged from the analysis of the Kadruka funerary data was a range of possible expression, creating at once the impression of continuity and variability of practice, within which both cultural and environmental factors were necessarily at play. This taphonomic analysis of the funeral program allowed for the identification of a standard, as well as variations stemming from this baseline, in one direction or the other, toward more or less extreme expressions of the norm for the Kadruka ensembles. This understanding of the specific sets of choices available to and made by these populations then allowed for the identification of the potential environmental influences on the burials.

The elements that form the prerequisite components of this funeral program represent broad categories that are continuous, and which are not impermeable to one another. This program is part of what we will call a "continuum of variability" (fig. 3).

This variability is expressed by:

- a) variable duration between death and burial (testified by particular positions or the conservation of unstable elements)
- b) variations in the dimensions of the pit
- c) variations in positioning (lateral, dorsal, or ventral; hyper-flexed or ample)

This "continuum of variability" is important but presents no real discontinuity. There are many conditions and small details that represent margins of freedom that the gravediggers may have exercised and which produce similar results.

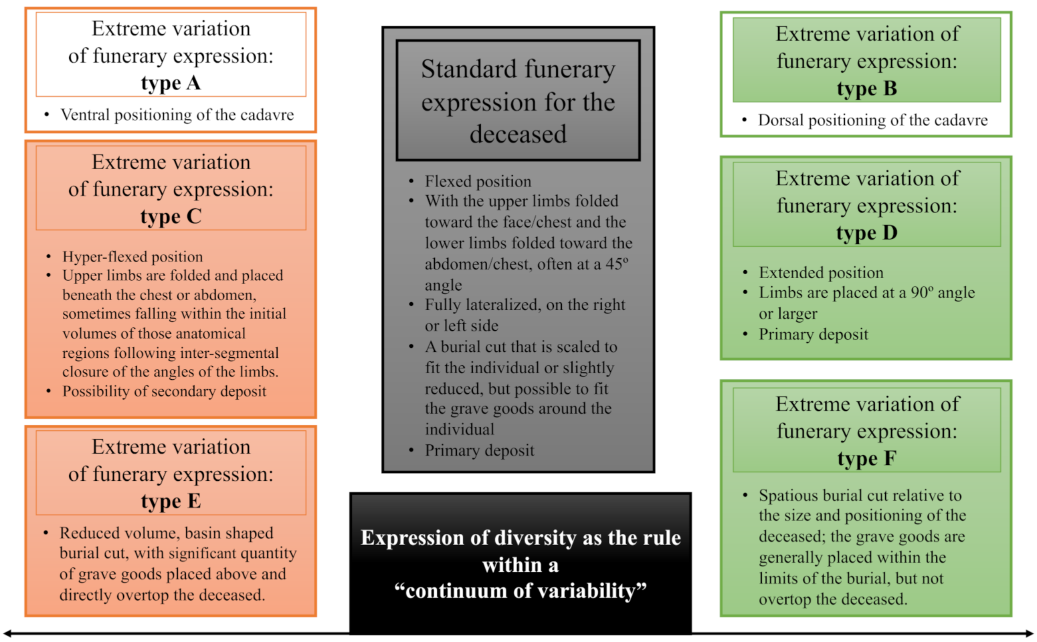

Figure 3: Visual representation of the "continuum of variability" represented within funerary expression for the Kadruka ensemble
Illustration: Emma Maines, 2020.
https://doi.org/10.34847/nkl.4dbdz5k5.

The standard burial timeline appears to follow death relatively quickly, and the vast majority of burials are primary deposits (fig. 4). The overarching taphonomic analysis took into consideration the four major categories of phenomena, mentioned above, and was only applied to adult burials. Given the *a posteriori* nature of this analysis, burials of immature individuals, whose skeletal elements are, generally speaking, more mobile, were not taken into consideration. Moreover, the site drawings of juveniles were not as anatomically precise as their adult counterparts, which would have further complicated their analysis. The cut off for inclusion was therefore established at approximately 15 years of age. Furthermore, only legible burials were considered.

It should be noted that the total number of burials taken into consideration for these analyses are variable and sometimes diverge from the totals that figure in the summary of available data (fig. 2). This is because additional individuals were identified for most of the sites, for which no plans were found, and were interpreted as probable reductions or back-fill. These cases were not inventoried by J. Reinold and his team. In addition, there are more primary burials than individual ones, because double burials may also be primary. Thus, the taphonomic analysis also unites elements of the biological study and applies observations within the laboratory to the funerary analysis.

Figure 4: Résumé of the different totals for each inhumation and burial structure type per site

Categorisation of INHUMATION type										
		Probable								
Site	Primary	Secondary	Reduction	Backfill	Total	Other	% Primary	% Secondary	% Reduction	% Backfill
KDK1	80	1	3	35	119	4	67.2	0.8	2.5	35.0
KDK18	114	/	14	40	168	4	67.9	/	8.3	40.0
KDK21	257	2	3	35	297	8	86.5	0.7	1.0	35.0
KDK23	98	1	7	5	111	13	88.3	0.9	6.3	5.0

Categorisation of STRUCTURE type								
Site	Individual / single	Double	Disturbed burial (probable)l	Total	Other	% Individual / single	% Double	% Disturbed
KDK1	98	1	17	116	4	84.5	0.9	14.7
KDK18	118	2	44	164	4	72.0	1.2	26.8
KDK21	249	2	23	274	4	90.9	0.7	8.4
KDK23	95	1	14	110	113	86.4	0.9	12.7

Emma Maines, 2020.

What emerges from the data are very similar percentages of individual burials between KDK1 and KDK23 (fig. 4). KDK18 stands out as the site with the most variability in terms of the types of burial structures being implanted, with a higher percentage of double burials, and especially of disturbed burials. KDK21 stands out as the site on which there are the fewest re-interventions, which begs the question of a more effective marking system or a different system of operating on site?

Very similar percentages of individuals presenting hyper-flexed anatomical regions are present between sites. There is, however, significantly more evidence of the retention of empty spaces and/or movement within burials at KDK18, followed by similar percentages for these phenomena at KDK1 and KDK21. KDK18 is also the site that presents the most retention of skeletal elements in unstable equilibrium, as well as a taphonomic analysis that points to significant constraining forces within the burials for the site (fig. 5). Though the *a posteriori* nature of these observations limits the detailed hypotheses that can be posited about the factors and circumstances that provoked these phenomena and their convergences or divergences, we can imagine that KDK18 set up their burials with different devices, structures or features. We can also suggest a more systematic covering or wrapping of the deceased within the burials at KDK18. For the two sites with the highest rate of post-burial re-intervention, be it with retention of a previously buried individual in a reduced format, or with the inclusion of human remains in the backfill, one can imagine a previous system of burial marking that disappeared before subsequent use, or it may speak to a desired and deliberate association of individuals and/or re-use of burial spaces.

Figure 5: Overview of taphonomic analysis per established category and for each ensemble

Taphonomic analysis									
Site	Hyper-flexed	Represen-tativity (%)	Empty spaces / movements	Represen-tativity (%)	Retention of unstable equilibrium	Represen-tativity (%)	Constraints	Represen-tativity (%)	Total number of adult tombs studied
KDK1	13	19.1	14	20.6	16	23.5	7	10.3	68
KDK18	10	16.7	32	53.3	20	33.3	14	23.3	60
KDK21	22	17.2	29	22.7	11	8.6	12	9.4	128
KDK23	5	8.6	9	15.5	14	24.1	6	10.3	58

Emma Maines, 2020.

What emerges from these analyses is a more complex and dynamic vision of burial mound use. Despite being partial, the data allows for the advancement of new, and the informed defense of prior, hypotheses. Funerary practices, at least what is translated of them through taphonomic analysis, appear to be stable in an overarching manner, but with inter-site variability related to specific elements.

The standard pit is generally scaled to the individual, if not slightly reduced, with the possibility of placing the grave goods around the deceased, as well as on top of. The two possible extremes for the size of the burial pit are either very small or very large. The standardized position is flexed, to one side or the other, but fully lateralized, with the lower limbs flexed and slightly bent towards the torso and the upper limbs bent and folded towards the face. It is from this position that there are more or less extreme variations. At the two extremes are individuals whose positions are either ample or hyper-flexed. Ample positioning implies limbs flexed at or greater than 90 degrees. The hyper-flexed position has been identified following the definition of "inter-segmental angle closure" (defined above). Another component of the variability of expression in positioning is to what extent the subject is actually lateralized, and the deviation concerns shifts toward placement on their back or stomach (two possible extremes). Although all of the components operate within the same system, the extremes, as well as the possible variations between them, are not correlated. Thus, an individual in a hyper-flexed position may be buried in a very large pit, just as an individual buried in a dorsal position may be deposited in a small grave, and so on.

The burial structure 42 of KDK18 (an older adult male) is illustrative of both the maintenance of unstable elements in equilibrium and of the decomposition environment (fig. 6). The study of this burial also underscores issues of an *a posteriori* taphonomic interpretation based on archival documents. For this structure, there existed a series of documents: a sketch of only skeletal material, a plan of the burial as an ensemble, and a photograph. It was only through examination and interpretation of all three of the separate documents that it was possible to develop a reliable interpretation for this burial as each represents a source containing different information relative to the burial's contents and set up.

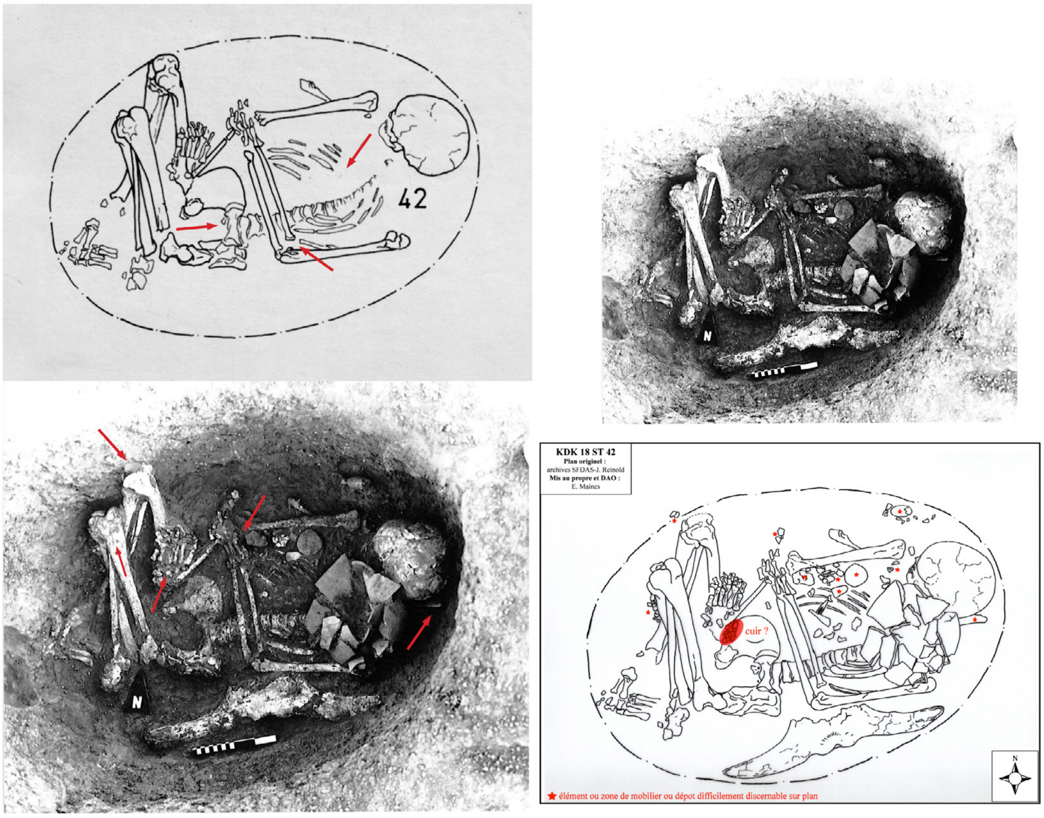

Figure 6: Case study of a useful example of skeletal elements retaining unstable equilibrium, of the importance of the context of decomposition, as well as the limitations of taphonomic analysis *a posteriori* based on different mediums
KDK18, St. 42; photograph and drawings taken from SFDAS/J. Reinold archives. https://doi.org/10.34847/nkl.103e7o30.

The burial sketch provides essential information about the osteological material because the grave goods do not appear. The individual is laid primarily on their back, which has resulted in an opening and flattening of the rib cage, which may also suggest that the individual was covered or wrapped. Objects deposited atop the individual have fallen into the freed secondary volumes. It is difficult to interpret the maintenance of skeletal elements in unstable equilibrium (such as the right hand, head and knees in elevated positions) without knowing the location of the burial structure and set up, possibly composed of perishable materials. The plan of the burial as an ensemble provides us with valuable information about the orientation of the deceased (from East to West), with a gaze (towards the North-West) and the identification of the structure, set up and boundaries of the grave.

This individual was provided a small burial, which may in part explain why the accompanying grave goods were mostly placed on top of the deceased. This placement might also have resulted in some of the displacement of certain skeletal elements, making the maintenance of others all the more remarkable. For reasons that escape us, the gravediggers dug a small sized burial relative to the size of the individual. The reduced size of the burial pit does not appear to have exerted constraint on the placement of the upper limbs, nor on the thorax, but did, however, influence the placement of the head, neck, and lower limbs. Volumes and the verticalizations can be difficult to read with only photographs and plans as the mediums of interpretation. In this case, however, the photograph allowed for confirmation of the verticalization of the lower limbs, as well as of the right hand and the conservation of elements in unstable equilibrium. This may be related to the decomposition environment, which may have favored natural, at least partial and temporary mummification, or it may have resulted from the use of devices such as a covering or structure in perishable material.

The burial structure 1 of KDK21, containing the remains of a young adult of undetermined biological sex, demonstrates a useful example of the extreme degree of hyper-flexion visible on the lower limbs of this individual, seemingly unrelated to the size of the burial and a clear linear effect that also appears to be discrete from the burial cut itself (fig. 7). Once again, this individual is laid primarily on their back, which has resulted in an opening and flattening of the rib cage and may imply the use of a covering or wrapping of the cadaver.

In this case, however, the ceramic vessel deposited atop the individual has not clearly fallen into the secondary volume left behind by the thoracic and abdominal volumes. We can posit that some form of malleable constraining force (shroud, hide, or ligatures) must have controlled and restricted movement of the lower limbs. The left upper limb and both lower limbs appear to be resting on one side of the burial cut, but with this medium alone it is impossible to ascertain verticalization or maintenance of these elements in unstable equilibrium. The linear effect would appear to be independent of the burial cut and reinforces the interpretation of evidence of empty spaces and disappeared structuring elements. It is possible that the right shoulder maintained unstable equilibrium against whatever structural element

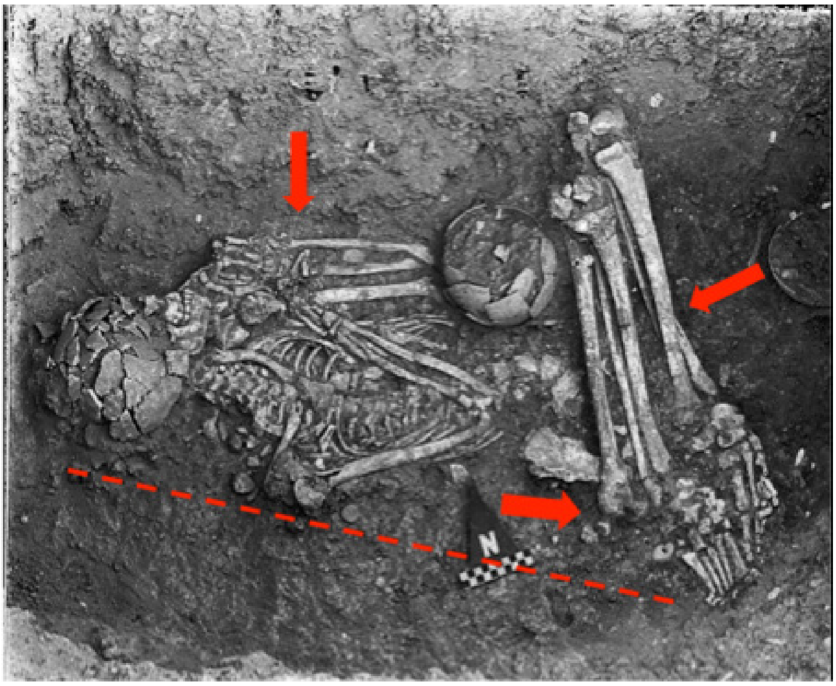

Figure 7: Case study of a useful example of hyper-flexed, linear effect, open spaces and movement, as well as grave good placement overtop the deceased
KDK21, St. 1; photograph taken from SFDAS/J. Reinold archives.
https://doi.org/10.34847/nkl.aa7am387.

created the linear effect, but once again the *a posteriori* nature of our observations makes it impossible to confirm this hypothesis.

In terms of the surrounding environment, we also found traces on many of the bones that suggest old mold or the presence of water. In addition, an alteration on a large number of bones was visible and suggests recurrent cycles of humidification followed by a drying phase. Examples were found at KDK18, 1 and 23 (fig. 8 and 9) and the identification of such evidence for KDK2 or KDK21 remains very complicated due to the sampling of osteological material practiced by the excavators.

In the first case, the traces observed are black, dull and featureless spots (fig. 8), while in other cases the bone takes on an altered appearance, usually with the presence of longitudinal cracks, leafing or exfoliation of its surface (fig. 9). The black spots could indicate the presence of old mold and/or water in the graves. Molds may have developed either after exposure of the deceased or because of empty spaces within the tomb (Fernándo-Jalvo & Andrews 2016, 165). In these cases, the mold is present long enough for its trace or stain to remain after the mold itself has disappeared. However, the coloring process, the color itself, the type of mold and the circumstances that would favor its persistence are still far from being fully understood (Pokines & Symes 2013, 84). Here it will suffice to specify that mold traces have already been associated with a black coloration on bones studied (Fernándo-Jalvo & Andrews 2016, 155). It may be that these black traces visible on certain bones from the Kadruka sites indicate a period of exposure (insufficient for desiccation, during a period favorable to the formation of mold) or rather the presence of empty

Figure 8: Example of dark, dull features found among the remains of different Kadruka sites
Photograph: Emma Maines.
https://doi.org/10.34847/nkl.03b6704g.

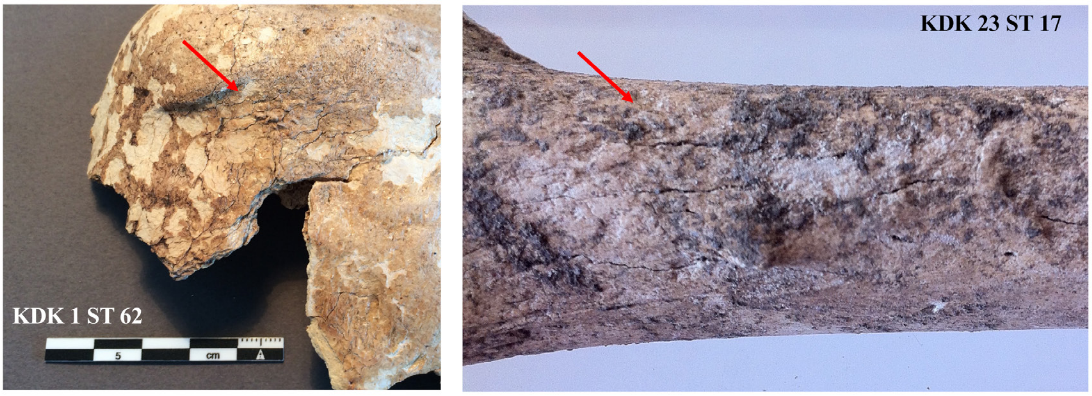

Figure 9: Two examples of weathering found among the remains of different Kadruka sites
Photographs: Emma Maines.
https://doi.org/10.34847/nkl.1c79y81k.

spaces within the tomb that would allow for the appearance of such growth (Pokines et al. 2016, 77).

These traces may also correspond to manganese deposits which are characterized by amorphous and discontinuous spots, of a black and matt color. Manganese is present in many minerals and is generally one of the most abundant minerals found in sediment (Emsley 2001; Dupras & Schultz 2013, 325). Depending on its condition, it binds with other components and causes different colorations on the elements with which it comes into contact. A black coloration is caused by manganese dioxide (MnO2) (Cukrowska et al. 2005; Shahack-Gross et al. 1997; Dupras & Schultz 2013, 325; Applegate 2008, 4). Although exposure to water usually causes a lightening of the color of bone, if the water is recently oxygenated, this can promote the formation of manganese dioxide. Oxygenation of water can result from the presence of aquatic plants or from the dissolution of atmospheric oxygen in water, sometimes facilitated by winds disturbing the surface of the water or by water movement caused by a current, a waterfall or even a flood (Withgott & Brennan 2005). Floodwaters are, however, very quickly deprived of oxygen, especially when they are stagnant (Herrera 2013). The presence of this kind of deposit on the bones is generally related to an environment characterized by a humid, moderately alkaline and oxidized sediment, which may include the presence of bacteria (Dupras & Schultz 2013, 325; López-González 2006).

Longitudinal cracks and exfoliation or lamination of the bone surface, often referred to as "weathering," are interpreted in the literature as evidence of repeated cycles of dry, then wet conditions or periods of freezing followed by thawing (Buikstra & Ubelaker 1994, 99; Applegate 2008, 5–6). For the Kadruka ensembles it seems unlikely that the Neolithic of Upper Nubia presents a climate conducive to periods of frost. We can therefore imagine periods of drought alternating with wetter periods in relation to the flooding of the Nile. This is a separate phenomenon from the erosion of the sites, which occurred later and linked to the strong sand winds known in the region, but which did not reach the buried skeletons.

Many remains also present significant taphonomic changes to the bone (fig. 10) related to post-mortem alterations associated with the surrounding environment. In this case, we are referring to a dissolved aspect, often with a gallery-like organization or amorphous appearance. In other contexts, in Sudan, this alteration is noted as occurring most often on the side of the bones which were facing the ground and is a reminder of the erosion effect observed with certain scavenging or necrophagous insects (Huchet 2014, 201–202, X).

These "osteolytic alterations" may be caused by subterranean termites, examples of which have been identified for populations buried on the Island of Sai and at Sedeinga in Sudan (B. Maureille and A. Chen, in Huchet 2014, X). The lighter color around the galleries and erosion sites, as well as the absence of scarring or remodeling, supports the appearance of these lesions on dry, as opposed to living bone (Huchet 2014). Furthermore, as a species in general, termites are attracted to and thrive in humidity.

Figure 10: Example of potential termite activity found among the remains of different Kadruka sites
Photographs: Emma Maines.
https://doi.org/10.34847/nkl.c1b93116.

Finally, this information, which may appear contradictory (desiccation vs. humidity), must be replaced in the context of an environment structured by the Nile, within an alluvial plain in which the arms of the river form braided channels (fig. 11). The important hydrographic network, still attested to during the Lower Holocene, is affected by a final aridification phase from 3000 BC onward (Kuper & Kröpelin 2006; Kuper et al. 2007; Honegger 2010, 81). The five Kadruka burial mounds are therefore active sites during a period of transition, with ongoing aridification, but also wetter periods, as they spanned different portions of the Middle Neolithic.

The excavation of KDK23, which included a geophysical prospection campaign in 2016, as well as topographical and geomorphological analysis by Morgan de Dapper (Ghent University) and Lucie Cez (University of Paris 1, UMR 7041, ArScAn) has confirmed prior hypotheses advanced about the formation of the funeral mounds that are typical of this region of Upper Nubia, as well as shed new light on the specificities of these processes. The geophysical prospection, led by J. Thiesson and L. Bodet, (Pierre and Marie Curie University, UMR 7619 METIS) produced a multi-depth mapping of the electromagnetic conductivity in a large area around KDK23. The geophysical prospection was sought out in order to attempt to follow the path of the paleo-channel, whose existence is known for decades now and was confirmed with the excavation of a test trench. All these efforts contributed to confirming the presence of subterranean remains of a paleo-channel that likely structured the surrounding environment.

Indeed, the initial results of L. Cez's analyses confirm that KDK23 was shaped and altered by river dynamics. She proposes that in this context, islands are created and circumscribed by the channels of the river which incise the landscape in depth, and which regularly deposit sediment in height and in an increasing manner with their passage. During periods of flooding, the mounds which are formed by these successive deposits can also be destroyed or at least partially destroyed. Within such

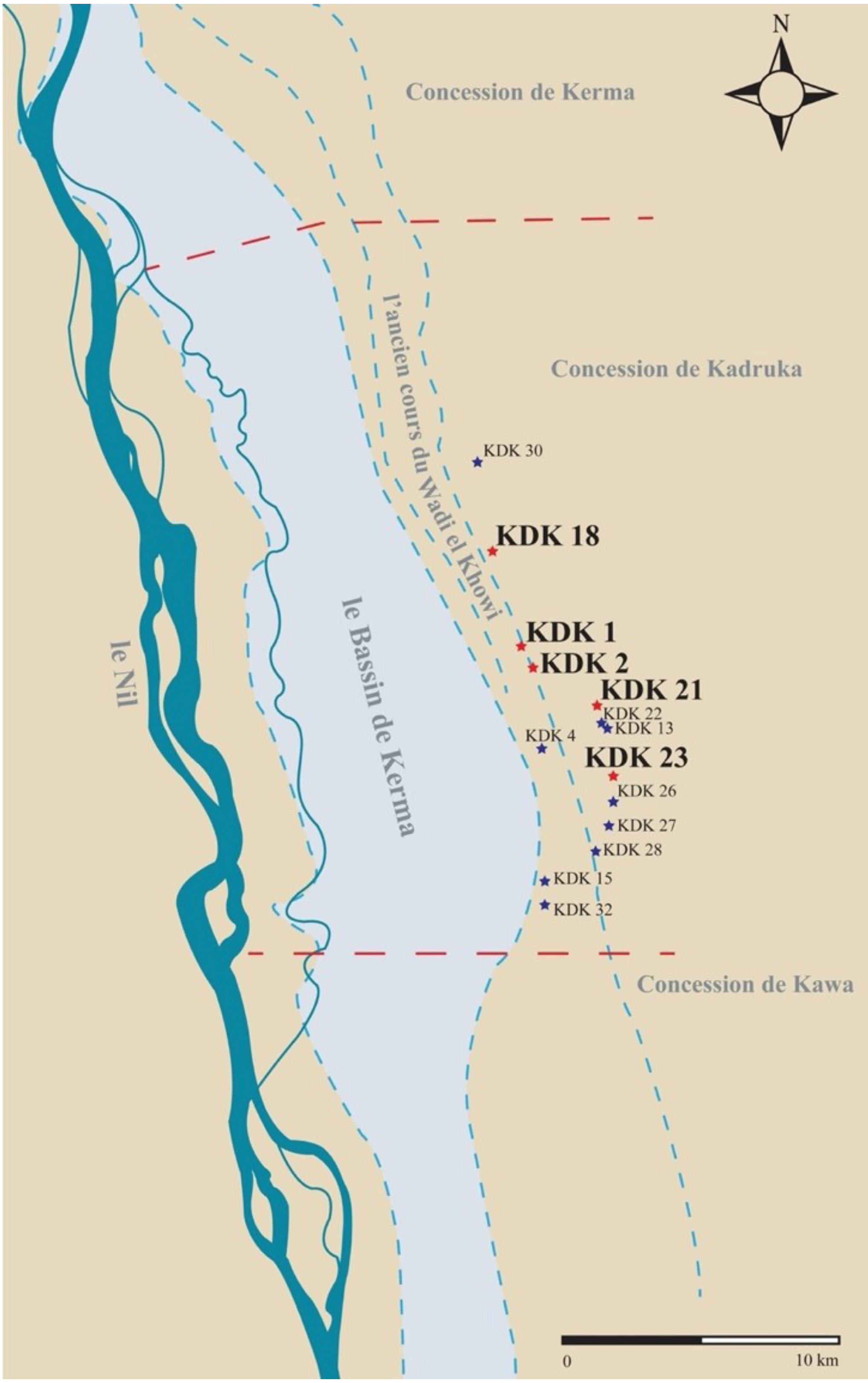

Figure 11: Illustration of the location of the Kadruka sites within an alluvial plain in which the branches of the river are organized as braided channels
Drawing and photographs taken and reworked from SFDAS/J. Reinold archives, illustration: Emma Maines.
https://doi.org/10.34847/nkl.a23a2j3l.

a system, a landscape can be quickly formed and then transformed (Ramette 1981). The work of L. Cez at KDK23 also demonstrates that the mound was covered in vegetation (for example, small shrubs, or tall grasses) which may have stabilized its shape. Floods and/or the rise of the water table in Neolithic times could explain the presence of water in some burials. The generally poor preservation of the bones at these sites could also be influenced by this presence of water, as well as periods of desiccation, and the pH of the soil. Sediment withdrawal faults clearly visible on site are also linked to these periods of drought. Though these geomorphological analyses were not performed on the other Kadruka sites, it can still be said that all the mounds are larger than the area occupied by the cemetery and have similar morphologies, which argue for a similar interpretation of site formation and function. Indeed, in the cases of many of these funerary mounds we may posit the presence of a series of paleo-channels that would have shifted course and in the process contribute to creating island like mounds amidst a network of braided river channels.

Conclusions drawn from a blended practice of taphonomic analysis

It is only through a blended practice of taphonomic analysis that one can achieve such a holistic vision of site function and human practice. Indeed, it is only through the precise observation and analysis of the *minutiae* of burial production, evolution and devolution, as well as considering all available clues about interactions between environment and populations that we gain access to a vision of the Kadruka populations: how they lived and died within a dynamic and changing landscape. The mounds, shaped by the river, were then occupied by Neolithic burials and may be interpreted as "islands of the dead" separated from their related settlements by these river channels. If one imagines such a place, separated from the surrounding landscape by a river branch, one must also imagine the potential symbolism invoked by such a contrast: a place for the living and a place for the dead, separated by a powerful entity: the Nile. Certainly, one must envision the intentionality of this kind of funerary process: one in which the living would have to board a vessel to gain access to the shores of the cemetery, and which would require a methodical organization and pre-formulation of all subsequent funerary practices. The abandonment of a cemetery could also therefore be caused by floods, though we might also imagine that the sites were not necessarily practicable all year round, due to variable humidity and the location and activity of the channels.

In this case, each element of a taphonomic analysis, be it within an English-speaking or French-speaking understanding of the term, directly contributed to a holistic re-imagination of the Kadruka sites as repositories for the Neolithic dead. Furthermore, despite the limitations of an *a posteriori* analysis, our hope is that this work demonstrates the importance of engaging with archives. Indeed, despite *lacunae*, it is possible to draw pertinent and probing hypotheses and conclusions based on previous research and that the interpretations and the data garnered represent a renewal of the analytic framework used to understand practice, population and environment in prehistoric Nubia.

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