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Interpersonal Violence in the Late Pleistocene
A Comprehensive Reanalysis of the Nile Valley Cemetery of Jebel Sahaba

Violences interpersonnelles durant le Pléistocène supérieur
Réévaluation du cimetière de Jebel Sahaba

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Abstract: The Late Pleistocene and Early Holocene period are punctuated by major climatic changes whose effects on human populations remain poorly understood. In the Nile Valley, possible refuge areas during the periods of high climatic constraints, hyper-arid environmental conditions are documented until the onset of the Holocene.
Dated to the terminal phase of the Late Pleistocene, the Jebel Sahaba archaeological site 117 is the earliest cemetery in the Nile Valley. Excavated during the 1960s by the team of Pr. F. Wendorf, the 61 buried individuals of this funerary complex are well-known for exhibiting, in more than half of the cases, traces of interpersonal violence. The presence of cutmarks, traumatic lesions and embedded lithic artefacts in the human remains have been described since their first publication, and since then, this assemblage as served as possible evidence of organized warfare.
Here, we present an integrative approach to the reassessment of the Jebel Sahaba collections to discuss the cultural behavior of human groups in the Nile Valley during this period of fluctuating climatic and environmental conditions.
Between 2013 and 2019, we have conducted a thorough reassessment of the anthropological and archaeological evidence from the site in order to characterize the nature of the osseous lesions at a microscopic level, and to describe the archaeological assemblage. This analysis led to the identification of undocumented healed and unhealed lesions on new individual and/or previously identified victims, to the discovery of new lithic artefact embedded in the bones and the reappraisal of the nature of these lesions. In addition, the biological identities of all the individuals have been re-evaluated allowing for discussion of the demographic profile and burial selection of the Jebel Sahaba funerary assemblage.
We underline the projectile origin of most of the bone lesions and highlight the repetition of interpersonal violence acts at a lifetime scale given the number of individuals exhibiting healed and unhealed trauma. We reject the hypothesis that the Jebel Sahaba cemetery reflects a single warfare event; rather finding that the evidence supports the presence of sporadic and recurrent episodes of interpersonal violence in the Nile Valley, at the end of the Late Pleistocene.
Keywords: Warfare, projectile impact marks, indiscriminate violence, Sudan, Palaeolithic, funerary complex.

Résumé : La transition entre la fin du Pléistocène supérieur et le début de l'Holocène est rythmée par des changements climatiques importants dont l'impact sur les populations humaines reste mal connu. Dans la vallée du Nil, zones de refuge potentielle durant les périodes de fortes contraintes climatiques, des conditions environnementales hyper-arides sont documentées jusqu'au début de l'Holocène.
Daté de la fin du Pléistocène supérieur, le site archéologique de Jebel Sahaba 117 est le plus ancien cimetière de la vallée du Nil. Ce complexe funéraire a été fouillé au cours des années 1960 par l'équipe du Pr F. Wendorf. Les 61 individus enterrés recensés alors sont

connus pour présenter des traces de violences interpersonnelles. La présence de stries sur les ossements, de lésions traumatiques et d'artefacts lithiques incrustés dans les restes humains a été mise en évidence dès leur première publication, ce qui a servi de support à l'hypothèse que cet assemblage témoigne de guerres préhistoriques organisées.

Nous présentons ici une approche intégrative à la réévaluation des collections de Jebel Sahaba pour discuter du comportement culturel des groupes humains dans la vallée du Nil pendant cette période de fluctuations climatiques et environnementales.

Entre 2013 et 2019, nous avons mené une réévaluation exhaustive des données anthropologiques et archéologiques du site afin de caractériser la nature des lésions osseuses à un niveau microscopique, et de décrire l'assemblage lithique associé à ce cimetière. Cette analyse a conduit à l'identification de lésions cicatrisées et non cicatrisées non documentées sur de nouveaux individus et/ou sur des victimes préalablement identifiées, à la découverte de nouveaux fragments lithiques incrustés dans des ossements et à la réévaluation de la nature de ces lésions. En outre, l'identité biologique de chaque individu a été révisée, ce qui a permis de discuter de la nature même du cimetière.

Nos résultats soulignent l'origine par voie de projectiles de la plupart des lésions osseuses et mettent en évidence la répétition de ces actes de violence interpersonnelle à l'échelle de la vie des individus, étant donné que plusieurs d'entre eux présentent des traumatismes guéris et cicatrisés. Nous rejetons l'hypothèse d'un cimetière lié à un événement unique de guerre, favorisant plutôt l'hypothèse de conflits sporadiques de faible ampleur dans la vallée du Nil, à la fin du Pléistocène supérieur.

Mots-clés : guerre, marque d'impact de projectile, violence interpersonnelle, Soudan, Paléolithique, complexe funéraire.

INTRODUCTION

The end of the Late Pleistocene and the beginning of the Holocene were marked by major climatic changes (Battarbee et al., 2004). Their impact on the inhabitants of the Nile Valley is still poorly understood and the analysis of sites from this period can provide unique insights into human responses to such environmental change. In Africa, geological evidence reveals that the generally dry conditions of the Last Glacial Maximum (LGM, ~ 23-18 kya; Gasse, 2000) were followed by the African Humid Period (~ 15-5.5 kya), which ended abruptly in the second half of the Holocene with the onset of more arid conditions (DeMenocal et al., 2000). In the Nile Valley, climatic conditions are depicted as hyper-arid during the second half of the Late Pleistocene (Paulissen and Vermeersch, 1987). Around 15-14 kya, the sudden overflow of lake Victoria into the White Nile establishes the present Nile-flow regime, causing regular and severe flooding of the Nile Valley all the way down to Egypt (Williams et al., 2006). Only after the Younger Dryas (~ 12.9-11.7 kya), do the monsoon conditions of the African Humid Period become more stable, creating more favorable conditions for the human occupation of the Nile Valley. There is little evidence for human occupations from the end of the Late Pleistocene to the beginning of the Holocene (~ 15-10.5 kya), with sites restricted to the floodplain of Upper Egypt and Nubia (Nicoll, 2004; Kuper and Kröpelin, 2006; Vermeersch and Van Neer, 2015). Of these, few have yielded complete human remains including the sites of Jebel Sahaba (site 117), Tushka (site 8905), Wadi Kubbaniya, and the site 6-B-36 from Wadi Halfa (Hewes et al., 1964; Wendorf 1968a; Wendorf and Schild, 1986).

Culturally, different lithic industries have been identified with sites associated with the end of the Late Pleistocene, among which the Fakhurian, the Kubbaniyan, the Idfuan, the Ballanan-Silsilian, the Afian, the Isnan and the Qadan (Wendorf, 1968a and 1968b; Lubell, 1974; Wendorf et al., 1989; Schild and Wendorf, 2010; Vermeersch, 2010; Leplongeon, 2021). Each of these occurs in restricted geographical areas along the Nile, mainly in Upper Egypt. They do not seem to be related to specific activities and are characterized by distinctive sets of lithic tools and/or technology that appear to be associated with distinct small hunting-fishing-gathering groups (Vermeersch, 2010). Each of these lithic groups is believed to represent a cultural tradition that reflects group identity within this restricted habitable area (Schild and Wendorf, 2010). The occurrence of large graveyards at the end of the Late Pleistocene reinforces the idea of strong social units within residential groups (Wendorf and Schild, 2004). In this context of supposed environmental pressure and geographical constrain, the identification of traces of interpersonal violence on the skeletal remains of at least half of the individuals buried in Jebel Sahaba have attracted much attention and generated debates regarding the emergence of violence and warfare during the Late Pleistocene (see Anderson, 1968; Keeley, 1996; Thorpe, 2003; Wendorf and Schild, 2004; Guilaine and Zammit, 2005).

Evidence of conflict is not uncommon in the Nile Valley. The oldest documented case appears to be from Wadi Kubbaniya, where the remains of a partial skeleton encased in cemented sediment provide early evidence of interpersonal violence (Wendorf and Schild, 1986). Two bladelets were found within the physical space of the skeleton, between the 11th and 12th ribs and the 2nd and 3rd lumbar vertebral bodies. A chip of flint was also found logged inside an area of partially healed trauma on the epicondylar ridge of the left humerus. A healed fracture of the right ulna also provides further evidence of earlier trauma (Angel and Kelley, 1986; Wendorf and Schild, 1986). Based on bone robustness and maturation, this individual was determined to be a young adult male (Angel and Kelley, 1986). Sediments and lithics suggest a date as early as 20 kya (Wendorf and Schild, 1986). Embedded lithic and healed fractures have also been documented on several individuals buried in the Wadi Halfa cemetery, associated with Qadan lithic indus-

try (site 6-B-36; Hewes et al., 1964; Saxe, 1971; Greene and Armelagos, 1972). However, the most emblematic and widely cited example of early widespread violence is the cemetery of Jebel Sahaba. Early analyses of the skeletons by J. E. Anderson (1968) and B. Butler (1968) revealed evidence of interpersonal violence on the bones of at least half of the Jebel Sahaba individuals. In addition, abundant lithic artefacts that appear to be from the Qadan industry were discovered within the subsequently disappeared initial volumes of the bodies, where the soft tissues would have been, or directly embedded in the bones (Wendorf, 1968c).

The site of Jebel Sahaba (site 117), now submerged underneath the lake created by the Aswan High Dam, is located about 3 km north of the modern town of Wadi Halfa. While in use, the cemetery was located one kilometer east of the ancient shore of the Nile (Wendorf, 1968c). The site was discovered as part of the UNESCO-funded salvage campaigns of the sites that were to be flooded by the construction of the Aswan high dam (Wendorf, 1968c). R. Paepe and D. Perkins, part of the Columbia University Nubian Expedition, initially documented the site in 1962 (Solecki et al., 1963). The individuals associated with this first excavation are referred as JS C-1, JS C-2 and JS C-3 in the Jebel Sahaba collection (Wendorf, 1968a). In 1965, within the framework of the Southern Methodist University field season, F. Wendorf visited the site and further tested the areas immediately adjacent to the first excavation (Wendorf et al., 1966). The successful recovery of additional human remains led to a full-scale excavation and 49 skeletons (JS 1 to JS 49)

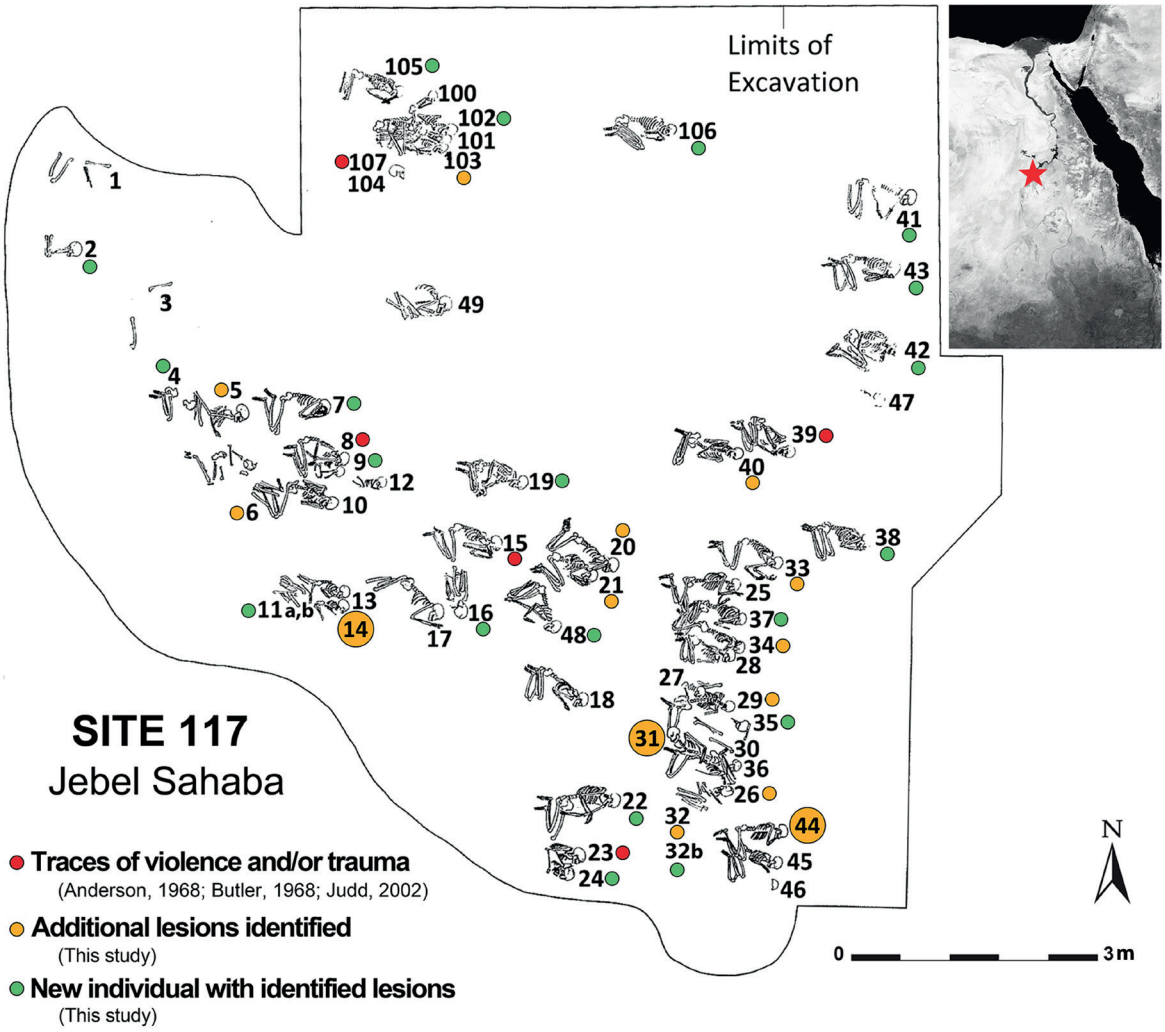

Fig. 1 – Location of the Jebel Sahaba cemetery, site 117, in the Nile Valley and map of the excavated area and burials (modified following Wendorf, 1968c). Red dots, individuals exhibiting signs of violence and/or traumatic lesions (Anderson, 1968; Butler, 1968; Judd, 2002); orange dots, additional newly identified lesions in the latter individuals; green dots, individuals newly identified as showing signs of violence and/or traumatic lesions; large dots, individuals discussed in detail in the text.

***Fig. 1** – Localisation du cimetière de Jebel Sahaba, site 117, dans la vallée du Nil, et plan de la zone fouillée avec les sépultures (d'après Wendorf, 1968c). Points rouges, individus présentant des signes de violence et/ou des lésions traumatiques (Anderson, 1968 ; Butler, 1968 ; Judd, 2002) ; points orange, lésions supplémentaires nouvellement identifiées chez ces derniers individus ; points verts, individus nouvellement identifiés comme présentant des signes de violence et/ou des lésions traumatiques ; points élargis, individus discutés en détail dans le texte.*

were uncovered in 1965, with an additional six excavated in 1966 (JS 100 to JS 107; Wendorf, 1968c; here: fig. 1).

The northern part of the cemetery was stripped by erosion, revealing disturbed and heavily cemented human remains. The rest of the cemetery consisted of well-preserved skeletons buried in oval pits cut into a weakly cemented sediment and covered by thin sandstone slabs (Wendorf, 1968c). Most were primary individual burials, with some double and multiple interments, as well as secondary deposits caused by later burials (Wendorf and Schild, 2004). In total, 61 skeletons were recovered, with most individuals carefully buried in contracted position on their left side, with the head toward the east, facing south. In most cases, the hands were positioned close to the face and the lower limb was flexed with the feet close to the pelvis (Wendorf, 1968a). Although no occupation deposits were found in the vicinity of the cemetery, more than 100 lithic artefacts were found inside or around the burials. They demonstrate strong resemblances with the Qadan lithic industry, particularly specific tool types such as crescent-like backed pieces described as "lunate" (see Wendorf, 1968c). Since all/most of these artefacts were found in the initial volume of the cadaver once occupied by the now decayed soft tissues or embedded in the bones, they cannot be considered as grave goods, nor can the Jebel Sahaba individuals be referred to as belonging to the Qadan population (Wendorf, 1968c). However, this lithic assemblage provides valuable information on the function of certain type of Qadan lithic artefacts and the chronology of the cemetery. Most pieces are unretouched flakes and chips that would, in different context, be identified as debitage artefacts rather than tools. In the case of Jebel Sahaba, their association to weaponry appears indisputable and may stem from an opportunistic or planned use of the cutting edge, suggesting highly flexible cultural behaviors (Wendorf, 1968c; Becker and Wendorf, 1993). The Qadan sequence is documented in Upper Egypt and Lower Nubia from the end of the Late Pleistocene (~ 18 kya) until the Holocene (Wendorf, 1968c; Schild and Wendorf, 2010). The antiquity of the site was confirmed using 10 direct radiocarbon dates carried out on five individuals from Jebel Sahaba (table 1; Wendorf and Schild, 2004; Antoine et al., 2013; Zazzo, 2014).

The oldest date, 13740 ± 600 BP (Pta-116; 14979-18568 cal. BP), is based on the analysis of bone collagen from the femur of JS 43 in 1988 (Wendorf and Schild, 2004). Due to the poor collagen preservation at the site, the original date had been challenged (e.g. Grine, 2016) or ignored (e.g. Lahr et al., 2016; Kissel and Kim, 2019) by some; and an additional nine dates were recently performed using bone, enamel and dentine bioapatite on four other individuals (JS 15, JS 22, JS 42 and JS 103; Antoine et al., 2013; Zazzo, 2014). The bioapatite results ranged from 7251 to 11660 BP, with the dates derived from the enamel being systematically younger (7251-9687 BP) than the ones obtained from bone and dentine apatite of the same individuals (10032-11660 BP; table 1). There is a higher risk of contamination when dating the mineral fraction of bones and teeth due to possible isotopic exchanges between carbonate in bioapatite and dis-

Prep #	Sample #	Sample ID	Anatomical part	Fraction dated	14C age	Error	Target #	Calibrated range (cal BP, 95.4%)		Ref.
Muse103	DS-1	skeleton 15	lower right M3	enamel apatite	7251	31	UBA-20124	8170	7981	1
Muse111	DS-9	skeleton 15	lower right M3	dentine+root apatite	11660	52	UBA-20132	13727	13362	1
Muse110	DS-2	skeleton 15	long bone fgmt	bone apatite	11049	43	UBA-20125	13090	12843	1
Muse104	DS-3	skeleton 22	upper left M3	enamel apatite	8512	40	UBA-20126	9544	9467	1
Muse99	DS-4	skeleton 22	pelvis fgmt	bone apatite	11133	50	UBA-20127	13160	12911	1
Muse105	DS-5	skeleton 42	lower right M3	enamel apatite	9043	45	UBA-20128	10285	9967	1
Muse100	DS-6	skeleton 42	pelvis fgmt	bone apatite	11093	49	UBA-20129	13104	12850	1
-	-	skeleton 43	-	bone collagen	13740	600	Pta-116	18568	14979	2
Muse102	DS-7	skeleton 103	upper right M2	enamel apatite	9687	55	UBA-20130	11229	10792	1
Muse101	DS-8	skeleton 103	pelvis fgmt	bone apatite	10032	46	UBA-20131	11802	11319	1

Table 1 – Results of the direct radiocarbone dates of the Jebel Sahaba individuals (1: Zazzo, 2014; 2: Wendorf and Schild, 2004). Calibration software: Oxcal version 4.4.2 (Bronk Ramsey, 2009). Calibration curve: IntCal 2020 (Reimer et al., 2020).

***Tableau 1** – Résultats des datations directes au radiocarbone des individus de Jebel Sahaba (1 : Zazzo, 2014 ;2 : Wendorf et Schild, 2004). Logiciel de calibration : Oxcal version 4.4.2 (Bronk Ramsey, 2009). Courbe de calibration : IntCal 2020 (Reimer* et al., *2020).*

solved inorganic carbon from the environment during fossilization, especially when a precipitation of secondary carbonates occurs (Zazzo and Saliège, 2011). For Jebel Sahaba, this phenomenon is well documented, with calcified crust deposits over the grave pits, as well as on some skeletal remains (Wendorf, 1968c). Contamination usually results in the dates being too young (Zazzo and Saliège, 2011). Consequently, the dentine date (UBA-20132 11660 BP, 13362-13727 cal. BP) provides the best apatite age estimate for the site and indirectly confirms the validity of the bone collagen date performed in the 1980s (Zazzo, 2014). Broadly dated between 13400 and 18600 cal. BP, the Jebel Sahaba cemetery is the earliest known funerary complex from the Nile Valley.

Since its discovery and original publication by F. Wendorf (1968a), the Jebel Sahaba cemetery has been used as possible evidence of organized warfare triggered by territorial disputes (Keeley, 1996; Kelly, 2000; Thorpe, 2003; Guilaine and Zammit, 2005; Daković, 2014). Many elements of the original findings, particularly the timing, nature and extent of the violence, but also the lithic association, have been challenged since (e.g. Jurmain, 2001; Ferguson, 2013; Kissel and Kim, 2019; Usaï, 2020). However, no integrative study of the traces of violence left on the human remains of the site has been undertaken to reassess this Prehistoric site (Thorpe, 2003). Several questions remain unanswered that would benefit from the latest interpretative anthropological forensic methods. Was the Jebel Sahaba cemetery the result of a single event, of sporadic episodes of interpersonal violence, or was it used as a place for the burial of specific individuals? Some traces or cutmarks on the bones seem to be the result of projectile penetration while other are described as deliberate cutting. Are they the result of specific funerary treatments or actual traces of violence? Finally, what can a reassessment of the lithic assemblage contribute to our understanding of the site?

A systematic macroscopic and microscopic reanalysis of the human remains curated at the British Museum was used to fully reevaluate and characterize the nature of the osseous lesions. Combined with a reevaluation of the lithic assemblage described by F. Wendorf in association with the burials, as from the surface around the skeletons, the new results offer a unique synthetic perspective on human behaviors at the end of the Late Pleistocene.

1. MATERIAL AND METHODS

In 2001, F. Wendorf donated all of the archives, artefacts and skeletal remains from his 1965-1966 Nile Valley excavations to the British Museum (Judd, 2007; Antoine and Ambers, 2014). M. Judd's preliminary osteological analysis noted discrepancies between field notes, photographs and associated skeletal remains, including the absence of three individuals, JS 1, JS 3 and JS 30, as well as some of the bones with embedded lithic artefacts described by J. E. Anderson (1968; Judd, 2007). As they were not a part of the British Museum donation, their whereabouts remain uncertain and they were therefore not included in this reanalysis. Judd's survey of the skeletal remains also noted the presence of bones or teeth from additional individuals. Our reanalysis also found supernumerary bones and teeth. Jebel Sahaba can now be regarded as including the remains of at least 64 individuals, three of whom are missing from the British Museum collection.

The analysis involved a full reevaluation of the age and sex using the latest anthropological methods. In some individuals, assessments were limited by the state of preservation of the skeletal remains. Biological sex was based on the morphology and dimensions of the pelvis (Brůžek, 2002; Murail et al., 2005; Brůžek et al., 2017). When the pelvis was not sufficiently complete, the cranium and mandible were also used (after Buikstra and Uberlaker, 1994) to assign sex preceded by the letter "p" for "probable" (i.e. pM = probable Male). Due to the requirements of child birth, the pelvis is a more reliable indicator of biological sex and the dimorphic traits of the skull can vary between populations. Moreover, the individuals from Jebel Sahaba are characterized by a robust phenotype which adds complexity to the interpretation of their cranial features (Anderson, 1968; Greene and Armelagos, 1972). Hence, when cranial morphology was the only method available, a question mark was added to denote the limitation of the approach (i.e. pM? = possible Male). Finally, when the cranium and the pelvis were absent, individuals are classified as undetermined (UND). The age-at-death of the immature individuals is predominantly based on the stage of dental development following C. F. Moorrees et al. (1963a and 1963b). In the rare occasions where the teeth were not present or preserved, the state of skeletal growth and development were used (after Maresh, 1970; Fazekas and Kosa, 1978; Scheuer and Black, 2000). In adults, A. Schmitt (2005)'s method was employed to score the remodeling of the iliac sacro-pelvic surface (ISPS), allowing for a conservative diagnosis of mature individuals whose population senescence characteristics are unknown. Given the strong dependence of the senescence processes on population, environmental and behavioral factors (Brůžek et al., 2005), when the ISPS was not preserved, we chose to cautiously assign the mature individuals into the following broad age groups based on the level of dental wear ([> 20 years] = individual with dental wear below category 4; [> 30 years] = individual with dental wear above Molnar's category 3; Molnar, 1971). In the rare instances for which dental remains were absent, mature individuals were designated as adults [> 20 years] if no sign of articular remodeling or entheseal changes where observable. In all the other cases, the individual was assigned to the age group [> 30]. In order to discuss potential demographic characteristics of the Jebel Sahaba cemetery, we grouped the individuals in six conventional age cohorts ([0-< 1], [1-4], [5-9], [10-14], [15-19] and [20-29 years]) that allow for comparisons with theoretical mortality values of a population with a life expectancy at birth of between 25 and 35 years (Ledermann, 1969).

Immature individuals falling into two cohorts based on age-at-death estimate standard deviations were assigned to the most probable one according to P. Sellier (1996).

Extensive and detailed microscopic analyses of all areas exhibiting taphonomic and/or anthropogenic traces were conducted using a digital microscope (Dino-Lite Premier) with a 5 Megapixels resolution, a polarizer and a 50x - 250x magnification range. Following the recommendations of M. J. Smith et al. (2007), each potential lesion was checked for embedded lithic fragments and described. Non-anthropogenic traces, mainly related to gnawing and termite activity, were differentiated using macroscopic and microscopic criteria (fig. 2; see Shipman and Rose, 1983; Backwell et al., 2012; Fernández-Jalvo and Andrews, 2016). Although trampling marks were unlikely, the Jebel Sahaba individuals having been buried in pits filled with sediment and covered by sandstone slabs, the diagnostic criteria from M. Domínguez-Rodrigo et al. (2009) were used to exclude such taphonomic changes.

Projectile Impacts Marks (PIMs) were characterized using projectile bone damage identification criteria derived from experimental archaeological research

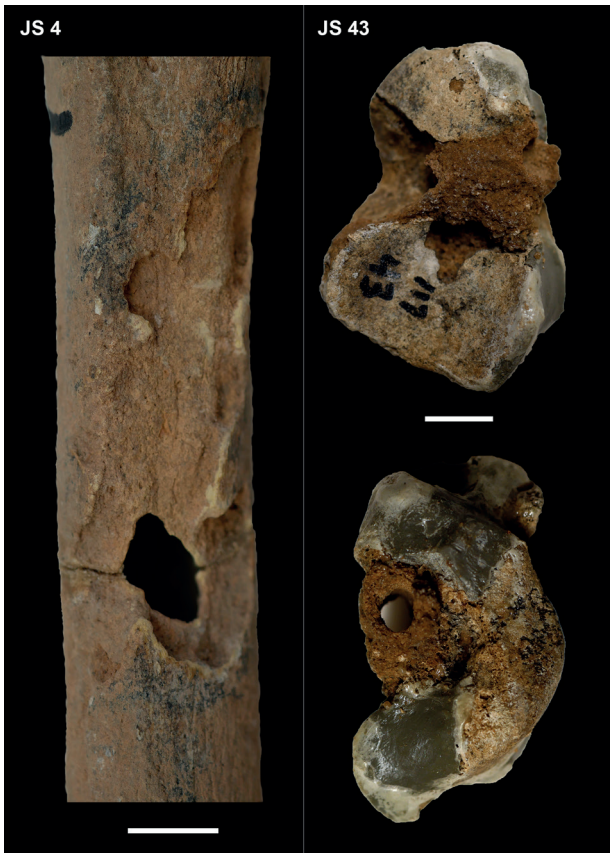

Fig. 2 – Examples of taphonomic bone alteration and residue caused by termite activity. Left, right humerus from JS 4 showing borehole and sub-cortical galleries; right, right talus from JS 43 with surface residue.

***Fig. 2** – Exemples d'altérations osseuses taphonomiques et de résidus causés par l'activité des termites. À gauche, humérus droit de JS 4, illustrant les perforations et les galeries sous-corticales ; à droite, talus droit de JS 43 avec résidu de surface.*

(Morel, 2000; Pétillon and Letourneux, 2003; Smith et al., 2007; Castel, 2008; O'Driscoll and Thompson, 2014; Duches et al., 2016). Although based on the hunting of small and large ungulates, these experimental studies provide a clear system of projectile trauma classification that is often lacking in analyses of interpersonal violence (Smith et al., 2007). Although embedded lithic or bone artefact fragments are the most direct diagnostic features used to identify projectile impact marks, a growing number of studies are now available to support the classification and interpretation of cutmarks and other puncture or perforation wounds (Smith et al., 2007; O'Driscoll and Thompson, 2014; Duches et al., 2016). The terminology and classification used in this study are characterized by the level of hard tissue projectile penetration defined by C. A. O'Driscoll and J. C. Thompson (2014). The term "drag" denotes cut-like marks with internal parallel longitudinal microstriations at the bottom of the groove and on its borders (fig. 3 and fig. 4). They are characterized by straight and continuous trajectories similar to slicing cutmarks (Duches et al., 2016). However, they differ from the latter in that they are deeper, with a wide and flat groove floor, and an abrupt angle between its floor and lateral borders (Duches et al., 2016). They also display a range of specific secondary traits such as cracking, flaking, scraping and bisecting marks (O'Driscoll and Thompson, 2014; Duches et al., 2016). Bisecting marks are related to bouncing and the movement of the projectile when it comes into contact with bone (O'Driscoll and Thompson, 2014). The shoulder effects found in slicing cutmarks are less pronounced in PIMs, most probably due to the rapidity and singularity of the impact (Shipman and Rose, 1983; Duches et al., 2016; Fernández-Jalvo and Andrews, 2016). Finally, the anatomical location of the PIMs can also be used to differentiate them from slicing cutmarks (Morel, 2000; O'Driscoll and Thompson, 2014). When the cause of the cut could not be ascertained, the generic term of cutmark is used (Potts and Shipman, 1981). A projectile embedded in bone is defined as a "puncture" by C. A. O'Driscoll and J. C. Thompson (2014) and this type of impact can be associated with the crushing, beveling, flaking and splitting of bone (fig. 5 and fig. 6). When the projectile fully penetrates the bone, the term "perforation" is favored (Castel, 2008).

In a number of cases, the cause of the lesion could not be identified due to poor preservation and uncharacteristic changes, and the term "trauma" is used. This category also covers all the healed or unhealed bone fractures, blunt force trauma and perforations with no PIM signs. The term "fracture" is defined as a partial or complete break in the continuity of a bone (Lovell, 1997). Finally, the term "lesion" refers to an injury whose nature or interpersonal origin could not be determined (fig. 7). The presences of bone callus or abscesses were also recorded. Signs of new bone formation or remodeling linked to healing processes were carefully noted and classified as "healed", implying a delay of at least three weeks between the injury and death (Lovell, 1997).

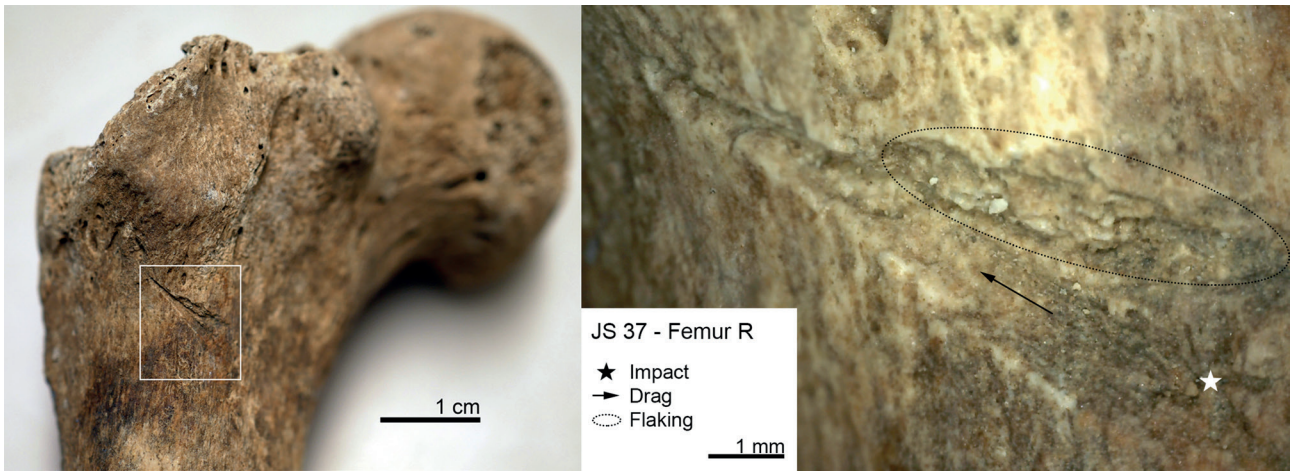

Fig. 3 – Illustration of the drag type of projectile impact marks (PIM) seen on the Jebel Sahaba individuals.
Left, macroscopic view of the drag; right, composite microscopic image of the drag illustrating the flaking.
Fig. 3 *– Illustration des types de marques d'impact de projectile (MIP) identifiés sur les individus de Jebel Sahaba.*
À gauche, vue macroscopique d'une éraflure ; à droite, image microscopique composite de l'éraflure avec un écaillage osseux.

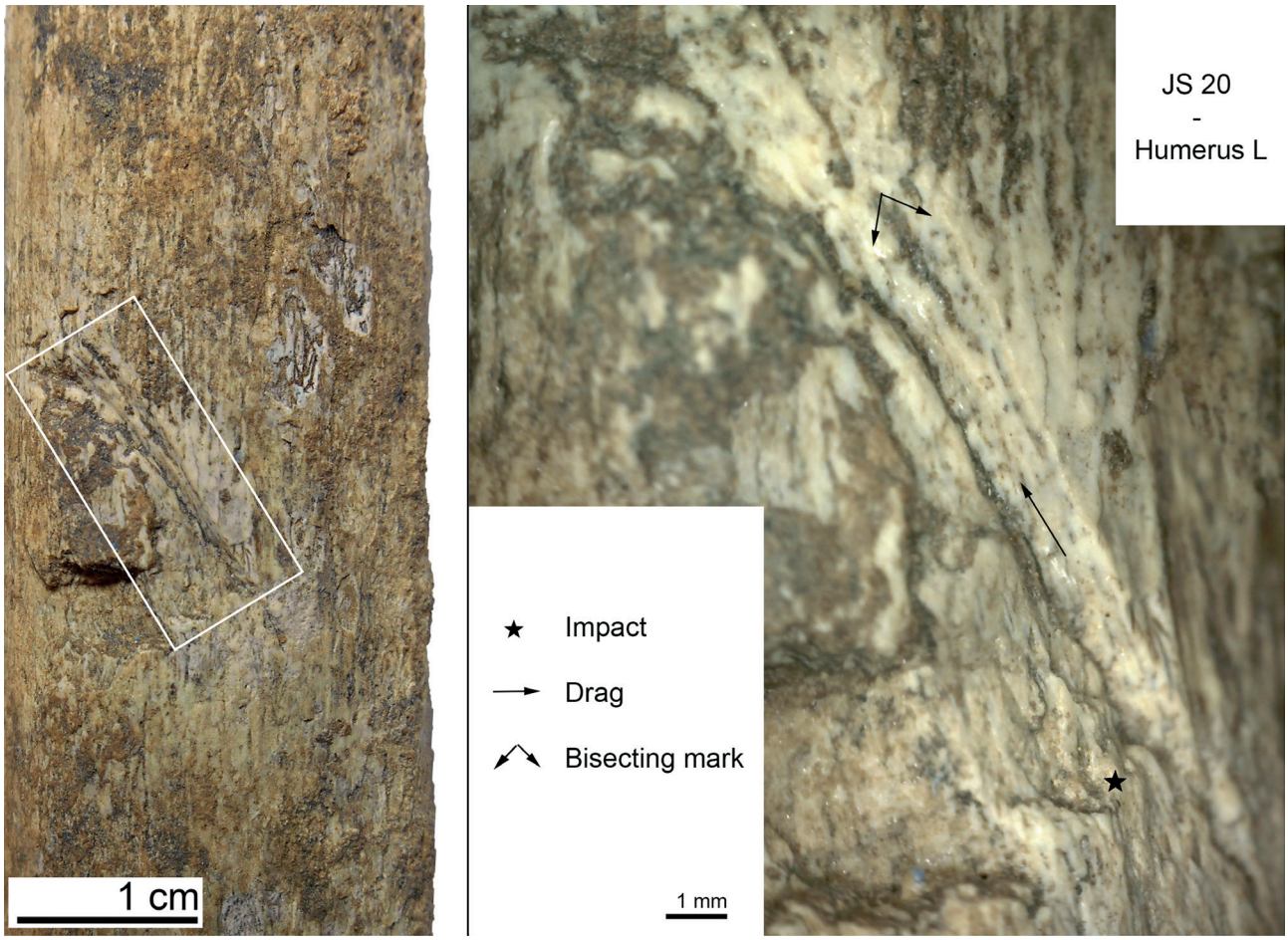

Fig. 4 – Illustration of the drag type of projectile impact marks (PIM) seen on the Jebel Sahaba individuals.
Left, macroscopic view of the drag; right, composite microscopic image of the drag illustrating bisecting marks.
Fig. 4 *– Illustration des types de marques d'impact de projectile (MIP) identifiés sur les individus de Jebel Sahaba.*
À gauche, vue macroscopique d'une éraflure ; à droite, image microscopique composite de l'éraflure avec les marques de bissection.

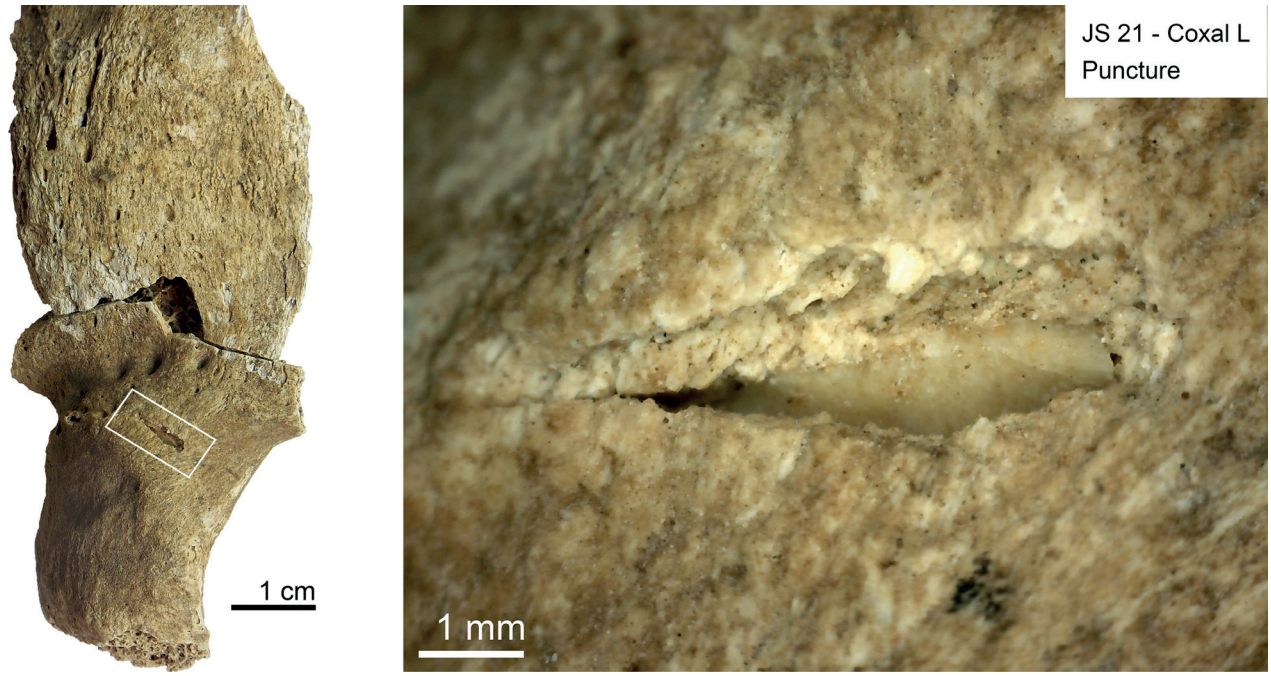

Fig. 5 – Illustration of the puncture type of projectile impact marks (PIM) seen on the Jebel Sahaba individuals. Left, macroscopic view of the puncture with embedded artefact; right, microscopic image of the puncture.
***Fig. 5** – Illustration des types de marques d'impact de projectile (MIP) identifiés sur les individus de Jebel Sahaba. À gauche, vue macroscopique d'un percement avec fragment lithique fiché ; à droite, image microscopique du percement.*

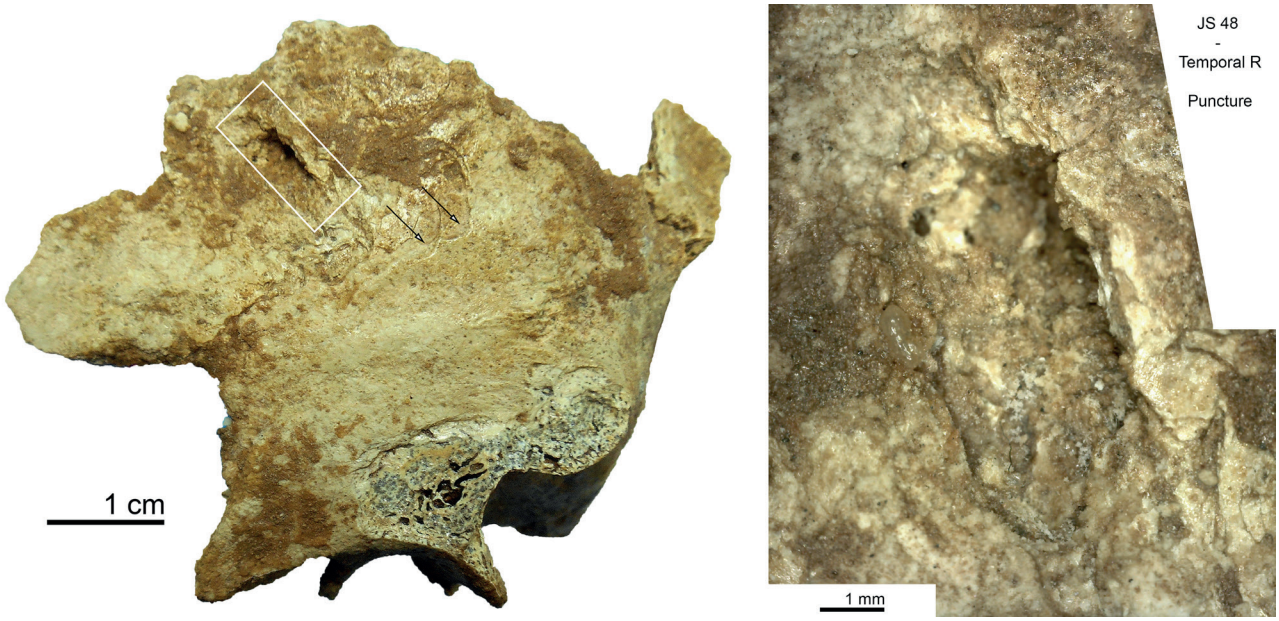

Fig. 6 – Illustration of the puncture type of projectile impact marks (PIM) seen on the Jebel Sahaba individuals. Left, macroscopic view of the puncture; right, composite microscopic image of puncture illustrating crushing fractures associated to the extraction of the projectile.
***Fig. 6** – Illustration des types de marques d'impact de projectile (MIP) identifiés sur les individus de Jebel Sahaba. À gauche, vue macroscopique du percement ; à droite, image composite microscopique du percement illustrant les fractures d'écrasement associées à l'extraction du projectile.*

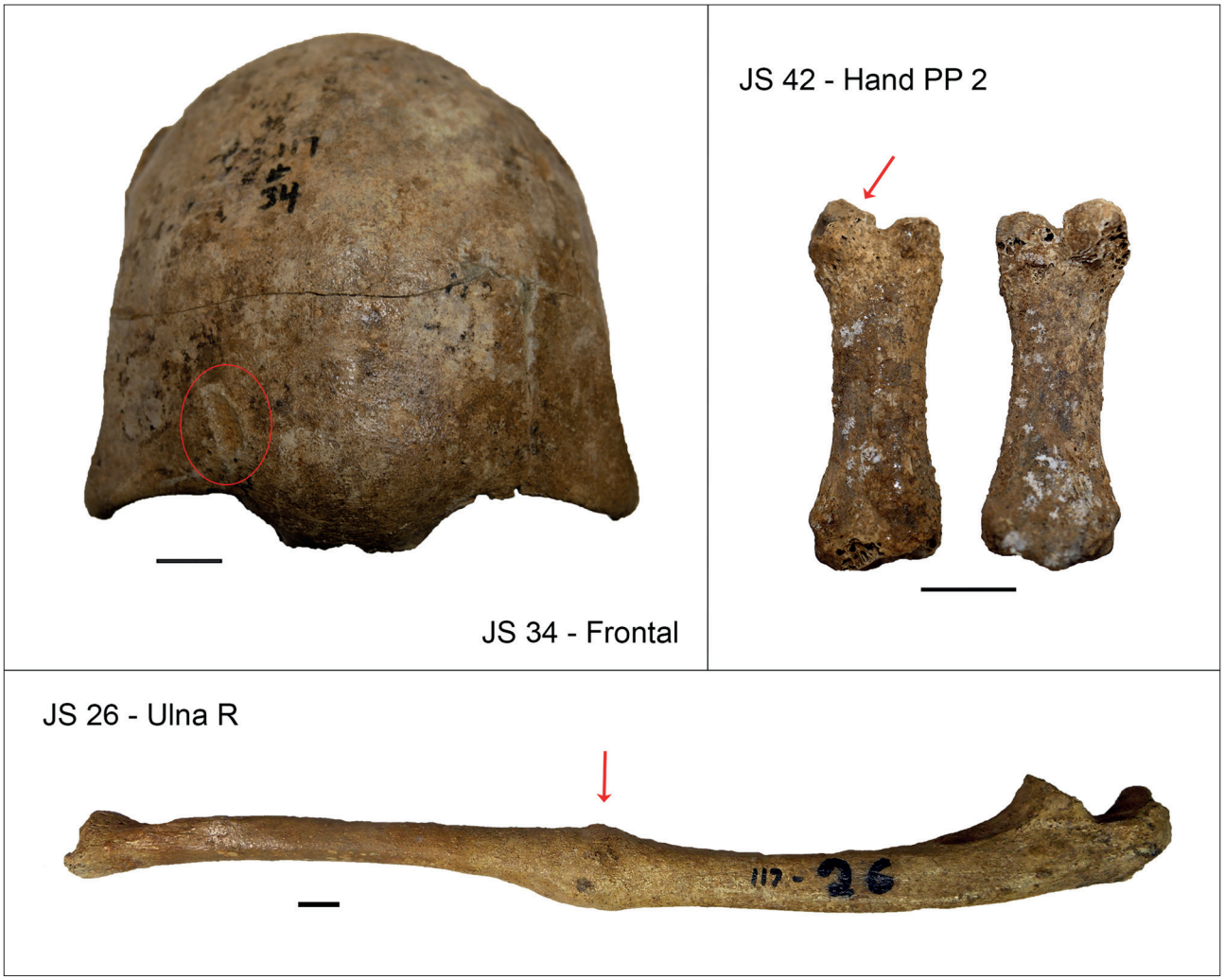

Fig. 7 – Illustration of healed lesions recorded on the Jebel Sahaba individuals. Upper left quadrant, ovoid healed injury on the frontal bone; upper right quadrant, healed fracture of the distal extremity of the hand's second proximal phalanx; bottom, healed parry fracture of the ulna. Black bar = 1 cm.

***Fig. 7** – Illustration des lésions cicatrisées documentées sur les individus de Jebel Sahaba. En haut à gauche, blessure ovoïde cicatrisée sur l'os frontal ; en haut à droite, fracture cicatrisée de l'extrémité distale de la deuxième phalange proximale de la main ; en bas, fracture cicatrisée de la diaphyse de l'ulna. Barre noire = 1 cm.*

2. RESULTS

The individuals examined and the occurrence of healed and unhealed traumas and lesions are listed in the table S1. New analyses confirmed most of the lesions originally described by J. E. Anderson (1968) and B. Butler (1968), as well as the identification of a substantial number of additional traumas and lesions in new and previously identified individuals (fig. 1).

2.1 Reassessment of the evidence of interpersonal violence

Using new methods and interpretation models, a total of 106 previously unidentified lesions were observed, including 52 that can now be interpreted as PIMs. These have transformed our understanding of the site by revealing that a further 21 individuals had clear signs of interpersonal trauma in addition to the 20 described by F. Wendorf (1968c) and J. E. Anderson (1968; here: fig. 1).

Of the 61 individuals studied, 41 (67.2 %) exhibit at least one type of healed or unhealed lesion (lesions of unknown origin, traumas or projectile impact marks; table 2). This includes three-quarters of the adults (74.4%; n = 32), with only half of the non-adults affected (50%; n = 9). The difference, however, is not statistically significant: P (χ^2) > 0.05. Our analyses also show that out of these 61 individuals, 27.9% (n = 17; value corrected from Crevecoeur et al., 2021) exhibited signs of perimortem traumas (unhealed traumas and/or PIMS), and 62.3% (n = 38) displayed healed and/or unhealed traumas.

Both sexes have the same percentage of healed and unhealed lesions. Among the adults with traces of injury, 36.6% (n = 15) display signs of both healed and unhealed lesions, with males (n = 8) and females (n = 8) similarly affected. Only one non-adult has both healed and unhealed lesions. Interestingly, this individual is an

	Total (n = 61)		Female (n = 19)		Male (n = 20)		Indeterminate (n = 6)		Mature (n = 43)		Immature (n = 18)	
	n	%	n	%	n	%	n	%	n	%	n	%
No lesion	20	32,8	5	26,3	5	25,0	1	16,7	11	25,6	9	50,0
Lesions	41	67,2	14	73,7	15	75,0	5	83,3	32	74,4	9	50,0
Healed lesions	37*	90.2*	14	100,0	15	100,0	5	100,0	32	100,0	5	55,6
Unhealed lesions	20*	48.7*	8	57,1	8	53,3	0	0,0	15	46,9	5	55,6
H&U lesions	16	39,0	8	57,1	8	53,3	0	0,0	15	46,9	1	11,1
1. Traumas & PIMs	38	92,7	14	100,0	15	100,0	3	60,0	30	93,8	8	88,9
Healed Traumas & PIMs	31*	81.6*	11	78,6	15	100,0	3	100,0	27	90,0	4	50,0
Unhealed Traumas & PIMs	17*	44.7*	7	50,0	6	40,0	0	0,0	12	40,0	5	62,5
H&U Traumas & PIMs	10	26,3	4	28,6	6	40,0	0	0,0	9	30,0	1	12,5
2. Fractures	22	36,1	9	47,4	11	55,0	2	33,3	21	48,8	1	5,6
3. PIMs	25	61,0	10	71,4	10	66,7	1	20,0	19	59,4	6	66,7
Healed PIMs	11*	44.0*	4	40,0	6	60,0	1	100,0	10	52,6	1	16,7
Unhealed PIMs	17*	68.0*	7	70,0	6	60,0	0	0,0	12	63,2	5	83,3
H&U PIMs	3	12,0	1	10,0	2	20,0	0	0,0	3	15,8	0	0,0
4. Embedded lithic	11	26,8	3	21,4	6	40,0	0	0,0	9	28,1	2	22,2
Healed PIMs	4	36,4	0	0,0	4	66,7	0	0,0	4	44,4	0	0,0
Unhealed PIMs	8	72,7	3	100,0	3	50,0	0	0,0	6	66,7	2	100,0
H&U PIMs	1	9,1	0	0,0	1	16,7	0	0,0	1	11,1	0	0,0

Table 2 – Number of individuals exhibiting at least one type of lesion grouped by age-at-death or sexual diagnosis. The percentage in the two first lines are calculated on the minimal number of individuals for each category, while the percentage in the numbered lines are computed based on the recorded number of individuals with lesions for each category. The percentage in the underlying lines represents the proportion of individuals with healed, unhealed and healed and unhealed lesion occurrence within the numbered line category. n = number; % = percentage; PIM = projectile impact marks; H&U = healed and unhealed; * = number corrected from Crevecoeur et al, 2021.

Tableau 2 *– Nombre d'individus présentant au moins un type de lésion, regroupés par sexe ou par âge au décès. Le pourcentage dans les deux premières lignes est calculé sur le nombre minimum d'individus pour chaque catégorie, tandis que le pourcentage dans les lignes numérotées est calculé sur la base du nombre d'individus présentant des lésions pour chaque catégorie. Le pourcentage dans les lignes sous-jacentes représente la proportion d'individus présentant des lésions cicatrisées, non cicatrisées, et cicatrisées et non cicatrisées dans la catégorie des lignes numérotées. n = nombre ; % = pourcentage ; PIM = marques d'impact de projectile ; H&U = cicatrisé et non cicatrisé ; * = nombre corrigé par rapport à Crevecoeur* et al.*, 2021.*

adolescent belonging to the oldest immature age cohort [15-19] (table 3). Most individuals with lesions (92.7%; n = 38) had some that were traumatic in origin, and over half of these individuals had a projectile impact (61.0%; n = 25). This percentage is similar in adults and non-adults, and between males and females. Embedded lithic fragments were recorded in the PIMs of 11 individuals (26.8%; n = 11), and with a higher proportion in males (n = 6).

The location of the lesions also reveals some patterning to the traumas or PIMs (table 4). First, the number of healed fractures are mainly concentrated on the upper limb and the shoulder girdle (84.8%; n = 28). Fifty percent of these upper limb fracture involve the hands, with both the proximal phalanges and the metacarpals affected, and one-third are located on the forearm. Of the latter, defensive parry fractures of the ulna are the most common (table 4 and fig. 7; Lovell, 1997). A significant difference – $P(\chi^2) > 0.05$ – between males and females was observed, with parry fractures of left and right sides, without favoring a side, mostly found on female individuals (88.9%; n = 8). Although not significant, hand bone fractures are more frequent in male individuals (58%; n = 7).

Projectile impact marks are most commonly observed on the lower limb and on the pelvic girdle compared to other anatomical parts (44.3%; n = 70; table 4). Similarly, this anatomical region has the highest frequency of puncture PIMs and embedded lithic artefacts (respectively 50.0%; n = 12; and 55.0%; n = 11). The sex of the individual does not appear to have influenced the frequency of these marks on different parts of the body. Drag marks are present on both upper and lower part of the body, with lower limbs marks mostly found on the femur (94.1%; n = 16) and equally distributed across males and females, as well as well as the left and right sides. In the upper limbs, the clavicles and humeri exhibit the highest number of projectile marks (n = 11). The direction of the strike reveals no differences between males and females, with both displaying a similar number of projectile marks

	Total (n=18)		Demographic age-at-death classes									
			[0-<1] (n=2)		[1-4] (n=5)		[5-9] (n=6)		[10-14] (n=3)		[15-19] (n=2)	
	n	%	n	%	n	%	n	%	n	%	n	%
No lesion	9	50,0	2	100,0	3	60,0	4	66,7	0	0,0	0	0,0
Lesions	9	50,0	0	0,0	2	40,0	2	33,3	3	100,0	2	100,0
Healed lesions	5	66,7	0	0,0	0	0,0	1	50,0	2	66,7	2	100,0
Unhealed lesions	5	44,4	0	0,0	2	100,0	1	50,0	1	33,3	1	50,0
H&U lesions	1	11,1	0	0,0	0	0,0	0	0,0	0	0,0	1	50,0
Traumas & PIMs	8	88,9	0	0,0	2	100,0	2	100,0	3	100,0	1	50,0
PIMs	6	66,7	0	0,0	2	100,0	1	50,0	2	66,7	1	50,0
Fractures	1	5,6	0	0,0	0	0,0	0	0,0	0	0,0	1	50,0

Table 3 – Detail of the type and number of lesions for the immature individuals in relation to the demographic age-at-death class. The percentage in the two first lines are calculated on the minimal number of individuals for each category, while the percentage in the underlying lines are computed based on the recorded number of individuals with lesions for each category. n = number; % = percentage; PIM = projectile impact marks; H&U = healed and unhealed.

Tableau 3 *– Détail du type et du nombre de lésions pour les individus immatures en fonction de la classe démographique d'âge au décès. Le pourcentage dans les deux premières lignes est calculé sur le nombre minimum d'individus pour chaque catégorie, tandis que le pourcentage dans les lignes sous-jacentes est calculé sur la base du nombre enregistré d'individus présentant des lésions pour chaque catégorie. n = nombre ; % = pourcentage ; PIM = marques d'impact de projectile ; H&U = cicatrisé et non cicatrisé.*

	Traumas & PIMs								Total lesions
	Traumas		PIMs					Total	
	Fractures	Perforations/ BFT	Drags	Punctures	Perforations	Total	Embbeded lithic		
Number of Lesions	33	4	40	24	6	70	20	107	139
Number of individuals	22	4	17	14	3	25	11	38	41
% of individuals	36,1	6,6	27,9	23,0	4,9	41,0	18,0	62,3	67,2
Anatomical repartitition									
1. Cranium (%)	3,0	100,0	20,0	25,0	66,7	25,7	15,0	21,5	20,9
% Frontal	-	75,0	50,0	50,0	25,0	44,4	33,3	47,8	48,3
% Parietal	-	-	-	33,3	50,0	22,2	66,7	17,4	13,8
% Temporal	-	25,0	12,5	16,7	-	11,1	0,0	13,0	13,8
% Occipital	-	-	-	-	25,0	5,6	0,0	4,3	10,3
2. Upper limb & Shoulder girdle (%)	84,8	-	35,0	8,3	-	22,9	10,0	41,1	36,0
% Shoulder girdle	7,1	-	35,7	50,0	-	37,5	50,0	18,2	20,0
% Humerus	10,7	-	35,7	-	-	31,3	50,0	18,2	18,0
% Ulna	28,6	-	14,3	-	-	12,5	-	22,7	20,0
% Radius	3,6	-	14,3	-	-	12,5	-	6,8	10,0
% Forearm	32,1	-	28,6	-	-	25,0	-	29,5	30,0
% Hand bones	50,0	-	0,0	50,0	-	6,3	-	34,1	32,0
3. Trunk (%)	3,0	-	2,5	16,7	-	7,1	20,0	5,6	5,8
4. Lower limb and Pelvic girdle (%)	9,1	-	42,5	50,0	33,3	44,3	55,0	31,8	37,4
% Coxal	-	-	5,9	66,7	-	29,0	63,6	26,5	23,1
% Femur	-	-	94,1	25,0	-	61,3	27,3	55,9	53,8
% Tibia	-	-	-	-	-	-	-	-	3,8
% Fibula	33,3	-	-	8,3	-	3,2	9,1	5,9	5,8
% Foot bones	66,7	-	-	-	100,0	6,5	-	11,8	13,5

Table 4 – Number and type of lesions recorded on the Jebel Sahaba individuals. Percentage of each of these lesions in relation to the anatomical parts, and percentage of infliction to specific bones. PIM = projectile impact marks; BFT = blunt force trauma; % = percentage.

Tableau 4 *– Nombre et type de lésions enregistrées sur les individus de Jebel Sahaba. Pourcentage de chacune de ces lésions par rapport aux parties anatomiques, et pourcentage d'affliction pour des ossements spécifiques. PIM = marques d'impact de projectile ; BFT = traumatisme par objet contondant ; % = pourcentage.*

that had entered from the back or the front of the body. In the case of both sexes, several individuals (n = 6) were identified as exhibiting marks consistent with both posterior and anterior impacts. Finally, the analysis reveals that all types of traumas were observed on the cranium. Most of the perforations caused by blunt force traumas and/or projectile impacts are observed on the cranium of non-adults (87.5% of the perforations; n = 7).

Three cases best illustrate the complexity and range of lesions found in the Jebel Sahaba individuals regardless of their age-at-death, sex or burial type.

Case 1: the double burial of the children JS 13 and JS 14 was discovered approximately 25 cm below the surface without any slab covering. Individuals JS 13 was lying next to and facing the back of child JS 14. Both were placed on their left side, with their head oriented toward the east in a contracted position. Both individuals are under the age of 6 years old. JS 13 is estimated to have been approximately 5 years old (their dental remains demonstrate a development consistent with 4.7 years ± 1; Moorrees, 1963a). JS 14 is estimated as having been closer to 4 years old based on a post-cranial measurement (femoral length = 225 mm; Maresh, 1970). Five lithic artefacts were found in association with the two individuals (Wendorf, 1968c). According to F. Wendorf, a "distal truncated and retouched flake" (i.e. a backed asymmetrical mono-points with an oblique cutting edge; see our own typological classification below and examples) was found at the base of the skull of JS 13 and "a backed and straight oblique distal truncated flake" (i.e. backed symmetrical mono-points) was found in the infilling of the infra-cranium. With JS 14, a "partially backed flake" was located at the base of the skull and a "basal truncated and straight oblique distal truncated flake" was found at the back of the mouth (i.e. two other examples of backed symmetrical mono-points following our classification) and an unretouched microlith chip was discovered inside the skull.

No osseous lesion were visible on JS 13 but the cranium and post-cranium of JS 14 both have unhealed trauma caused by projectile impacts (fig. 8).

The majority of the lesions are located on the calvaria and none of them had previously been documented. The frontal bone exhibits a blunt force trauma at the level of the glabella based on the pattern of the fracture lines. Several drag marks and an oblong perforation are present on the left side of the frontal squama, as well as scraping drag marks close to the bregma. A puncture site with faulting and part of an embedded artifact is also visible approximately one centimeter above the left orbit (fig. 9). A perforation is also present on the right parietal and on the occipital. The frontal and occipital perforation exhibit internal bevelling consistent with projectile impacts (Smith et al., 2007). The edges of the parietal perforation are partly broken which complicates its characterization, but its traumatic nature is undeniable. A further set of marks is visible on the left femur, including two groups of drags on the antero-lateral border of the proximal part of the diaphysis. The first group has two subparallel incisions with wide flat floors marked with parallel microstriations. Bone flaking is also present at the end of the trajectory. The second drag mark is located about one centimeter below the proximal one, and oriented slightly more anteriorly, with a bisecting pattern at its end. Based on these cutmark characteristics, the projectile most likely arrived from the medial side of the femoral diaphysis, in a downwards motion and towards the lateral side (fig. 10).

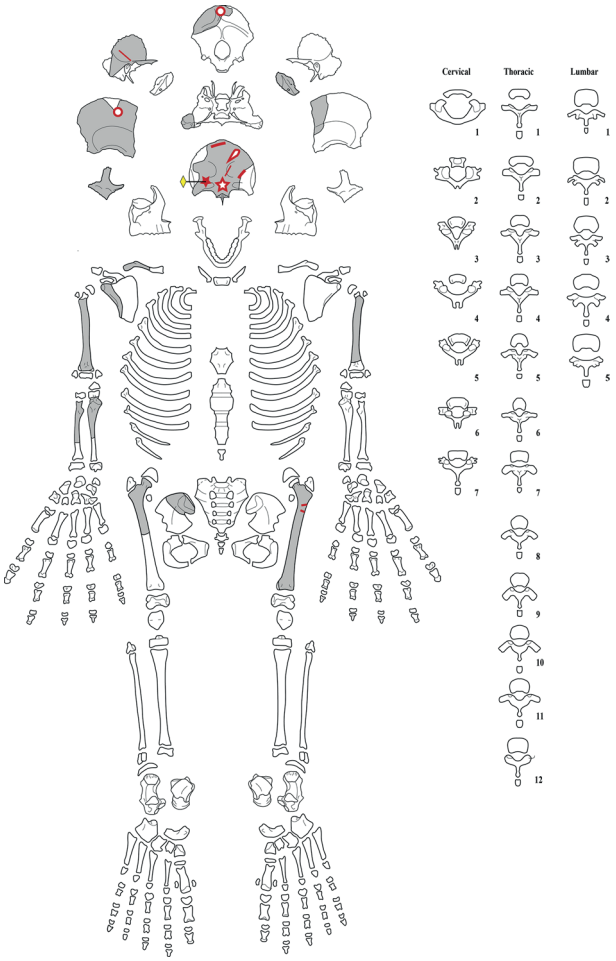

Fig. 8 – Location of the observed osseous lesions on JS 14. Grey parts represent preserved bones. Star, blunt force trauma; full star, unhealed puncture; open circle, perforations; yellow diamond, embedded artefact in a puncture; dash on the femur, drags traces of projectile impacts; line, cutmark.

***Fig. 8** – Localisation des lésions osseuses observées sur JS 14. Les parties grises représentent les os conservés. Étoile, traumatisme par objet contondant ; étoile pleine, percement non cicatrisé ; cercle, perforations ; losange jaune, artefact fiché dans un percement ; tiret sur le fémur, éraflures liées au passage d'un projectile ; ligne, trace de coupure.*

Case 2: skeleton JS 31 was buried approximately 30 cm below the surface and covered by sandstone slabs, with his right leg placed partially under JS 26 and over JS 36. The remains belong to a probable male most likely over 30 years old [> 30] based on the heavy dental wear as well as significant bone remodeling (osteoarthritis on the cervical vertebras, right elbow and left talus). The posi-

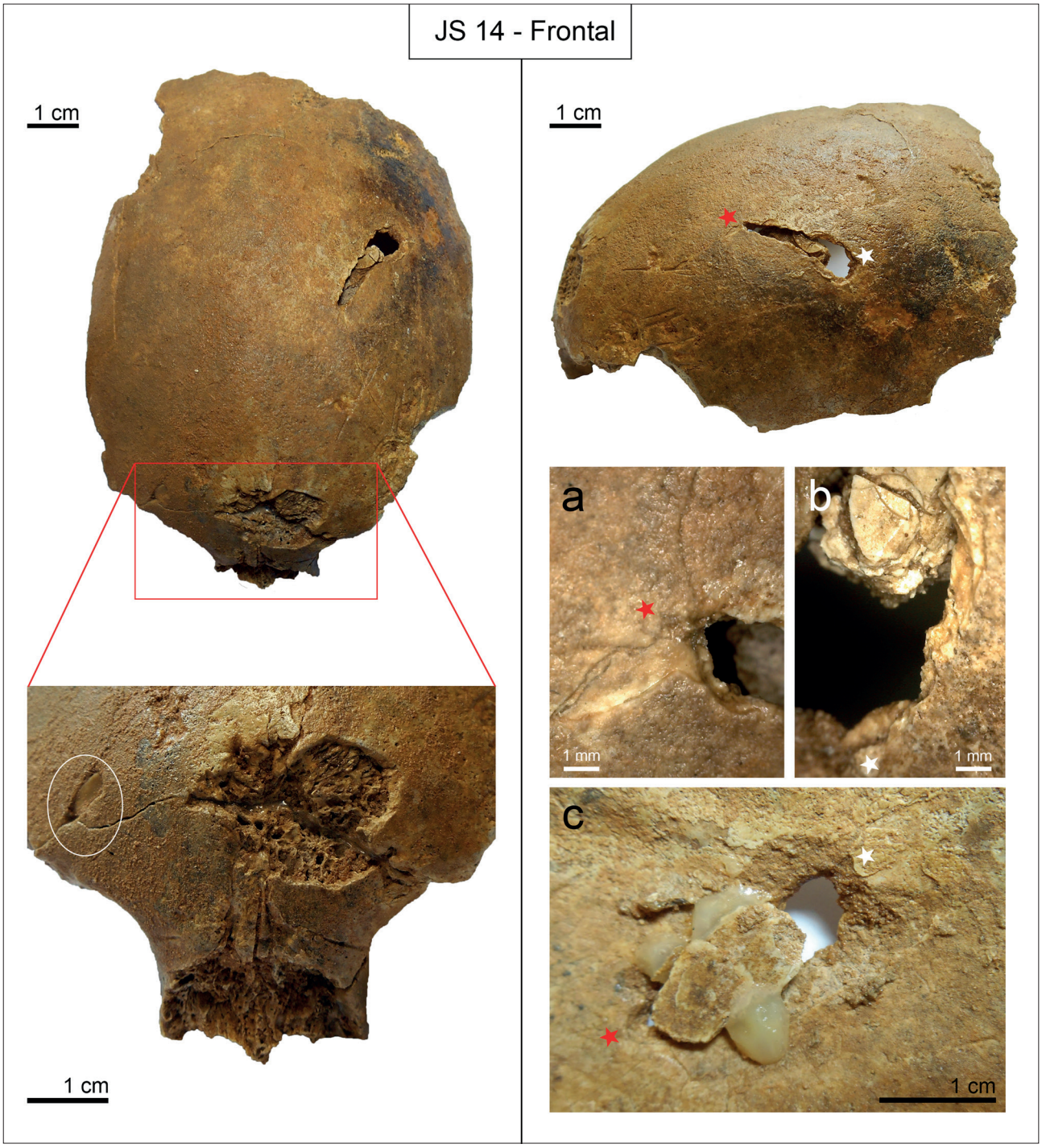

Fig. 9 – Lesions of the frontal bone on JS 14. Left, superior view of the frontal bone with, below, the magnification in frontal view of the red box showing the blunt force trauma and the embedded lithic (white oval) with hinge fractures; right, left lateral view of the frontal bone displaying the projectile perforation. Red and white stars are reference points for the magnified area; a, hinge fractures at the level of the entrance of the projectile; b, crushing fractures on the border of the perforation; c, endocranial view of the internal beveling. Note the miss-glued piece of bone associated to the perforation, part of the original conservation works.

***Fig. 9** – Lésions sur l'os frontal de JS 14. À gauche, vue supérieure de l'os frontal avec, en bas, le grossissement en vue frontale du rectangle rouge montrant le traumatisme par objet contondant, l'artéfact lithique fiché (ovale blanc) et les lignes de fractures ; à droite, vue latérale gauche de l'os frontal montrant une perforation oblongue associée à la pénétration d'un projectile. Les étoiles rouge et blanche sont des points de référence pour situer la zone agrandie ; a, lignes de fractures au niveau de l'entrée du projectile ; b, fractures par écrasement au bord de la perforation ; c, vue endocrânienne du biseau interne. Notez le morceau d'os mal collé associé à la perforation, lié aux travaux de conservation d'origine.*

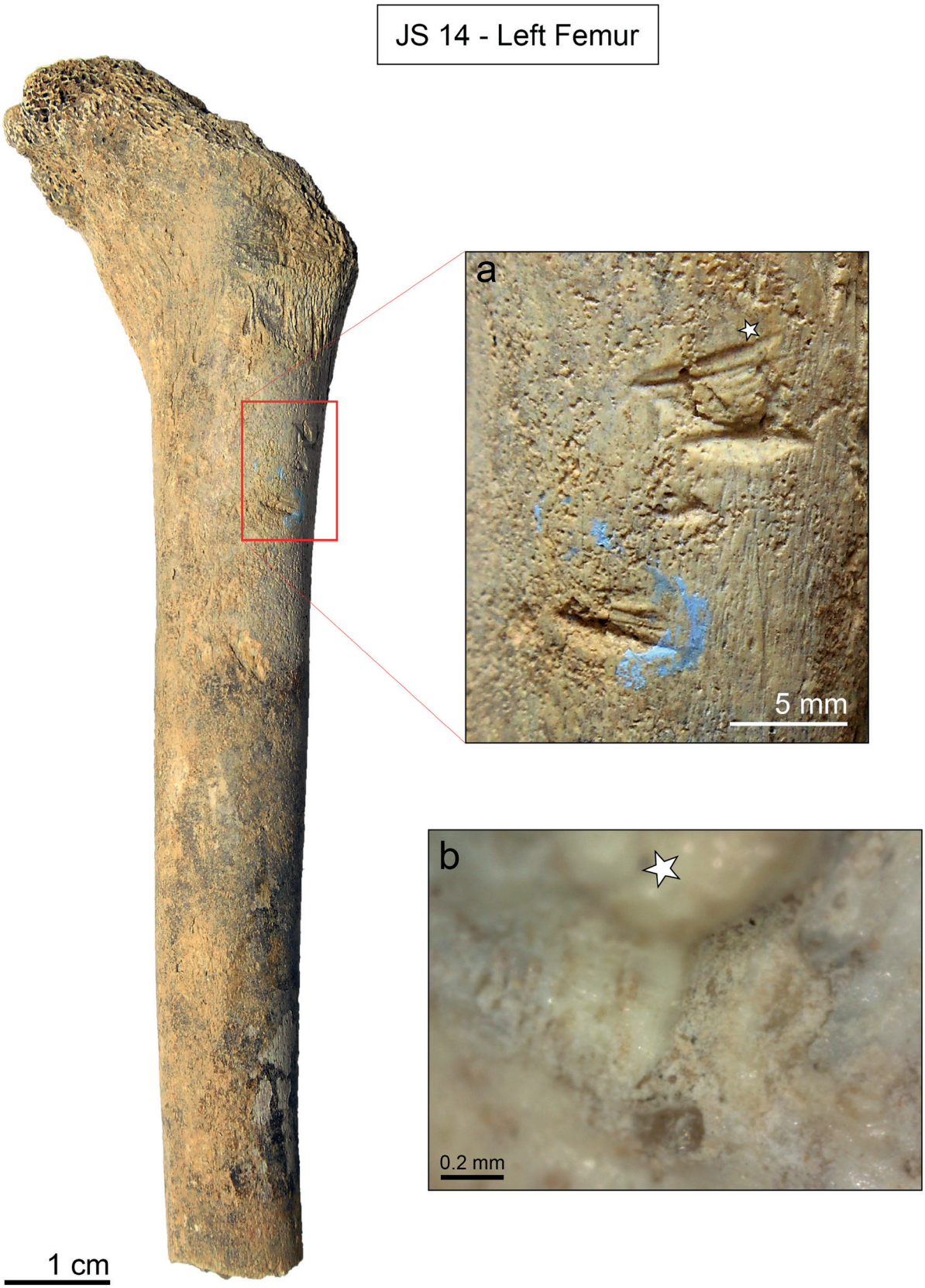

Fig. 10 – Projectile impact marks on the left femur of JS 14. Left: Anterior view of the preserved part of the left femur; a, close up on the two sets of drag marks located on the antero-lateral side of the shaft; white star put as reference point for the magnified area; b, detailed view of the superior drag revealing the wide flat bottom of the groove and the parallel microstriations (magnification 245x).

***Fig. 10** – Marques d'impact de projectile sur le fémur gauche de JS 14. À gauche : vue antérieure de la partie conservée du fémur gauche ; a, gros plan sur les deux séries d'éraflures situées sur le côté antéro-latéral de la diaphyse ; l'étoile blanche est un point de référence pour situer la zone agrandie ; b, vue détaillée de l'éraflure supérieure révélant la morphologie de fond de sillon, large et plat, et les microstriations parallèles (grossissement 245x).*

tion of the body, laid on his back, with the head toward the northwest, the right upper limb extended alongside the torso and the left one across the stomach, differs from the associated group of multiple burials (JS 26, JS 27, JS 29, JS 30, JS 32 and JS 36; fig. 1).

Seventeen lithic artefacts found *in situ* were in direct association with his remains, with two embedded in the bone and 15 within the physical space of the body. Some were found inside the rib cage, close to the vertebral column, in the joint of the right scapula and humerus, next to the proximal end of the left humerus, and between the left tibia and the fibula, as well as on the right ilium (Wendorf, 1968c, p. 973-974). The artefacts are one "J-shaped geometric" (i.e. crescent-like backed piece in our own typological classification), retouched or unretouched microlith flakes and chips, "backed, convex backed and backed and basal truncated flakes" (each of them belonging to one of these three types illustrated below: crescent-like backed piece; backed symmetrical mono-points; backed asymmetrical mono-points with an oblique or transverse cutting edge). F. Wendorf also originally recorded the two embedded chips, with one initially interpreted as in a thoracic vertebra and the other in the right pubic symphysis. However, J. E. Anderson (1968) revised their identification as the lower cervical vertebra and left pubis, with the bone around both lithics showing severe reactive changes (in Anderson, 1968, fig. 15C; in Wendorf, 1968c, fig. 36). These two bones are, unfortunately, not part of the collection donated to the British Museum and their whereabouts are unknown. A previously unnoticed lithic artefact logged in the right femoral diaphysis was also identified during this reanalysis, bringing the total to three embedded lithics (fig. 11).

The lesions observed on JS 31 are located on the post-cranial skeleton. The reanalysis of the skeletal remains revealed previously unidentified healed and unhealed projectile impact marks, as well as healed lesions that are most likely the result of earlier interpersonal injuries. In addition to the embedded lithic artefacts in the now lost seventh cervical vertebra and the left pubic symphysis, several unhealed PIMs were identified including a puncture with crushing, faulting and flaking of the bone surface on the anterior surface of the left scapula. An incision was also observed on the subscapular fossa, about 2 cm below the scapular notch (fig. 12) and a deep V-shaped drag 2 cm in length is present halfway up the humerus on the posterior-medial side. Another long cutmark on the posterior-lateral face of the left ilium is harder to interpret and may not have been caused by a projectile. JS 31 also has a healed fracture of the distal extremity of the right first metacarpal. The right femur offers further evidence of healed lesions, with the presence of a bone callus on the lateral side of the proximal part of the shaft, and of a healed projectile wound on the anterior side at midshaft. Three previously unidentified embedded lithic chips are trapped in the healing bulge of the latter (fig. 13). The lesion on the proximal part of the diaphysis may relate to the healing of a partial fracture.

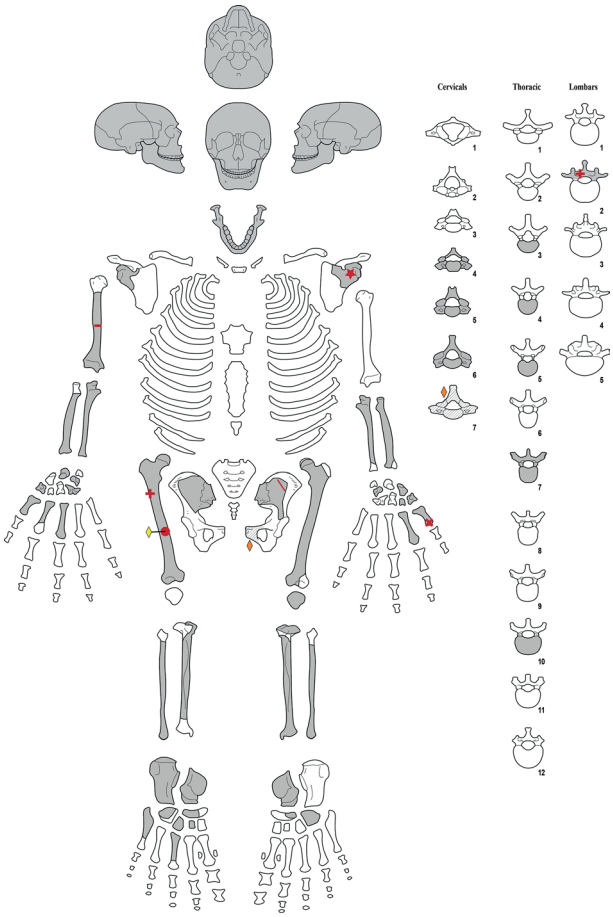

Fig. 11 – Location of the observed osseous lesions on JS 31. Grey parts represent preserved bones; striped areas are missing bones; full star, unhealed puncture; dash, drags traces of projectile impacts; line, cutmark; plus sign, healed lesions; time sign, healed fracture; full circle, healed puncture; yellow diamond, embedded artefact in a puncture; orange diamond, embedded artefact in lost bone.

***Fig. 11** – Localisation des lésions osseuses observées sur JS 31. Les parties grises représentent les os conservés ; les zones hachurées représentent des os ou fragments d'os manquants. Étoile pleine, percement non cicatrisé ; tiret, éraflures liées au passage d'un projectile ; ligne, trace de coupure ; signe plus, lésions cicatrisées ; signe multiplié, fracture cicatrisée ; cercle plein, percement cicatrisé ; losange jaune, artefact fiché dans un percement ; losange orange, artefact fiché dans un os perdu.*

Case 3: JS 44, a possible female individual that appears to have been older than 30 years, was buried about 35 cm below the surface and covered by sandstone slabs. The remains were found in close proximity to JS 45 and JS 46, both of whom were buried deeper than JS 44. Excavated by the Finnish expedition, it remains unclear if these individuals were interred at the same time. Like most of the Jebel Sahaba individuals, JS 44 was buried on her left side, in a contracted position with her head toward the east. Twenty-one lithic artefacts were found in close association with the skeleton, one of which was embedded in the fourth rib, close to the vertebra. The others are located close to the mandible, in the pelvis and rib cage, against the distal end of the right femur, and between lumbar ver-

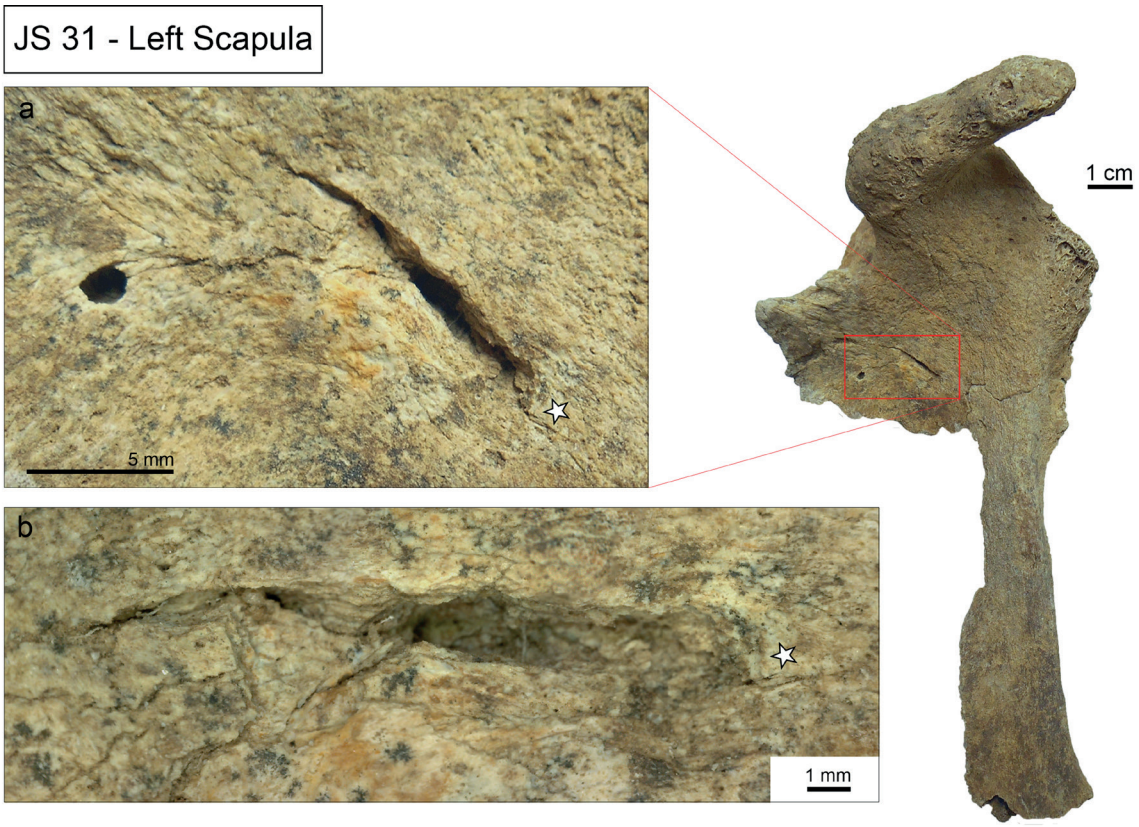

Fig. 12 – Projectile impact puncture on the left scapula of JS 31: a, red rectangle close up on the subscapular fossa showing the puncture associated with flaking and faulting; b, composite microscopic image of the puncture displaying the crushing of the bone in the lower border of the puncture (magnification 40x).

***Fig. 12** – Percement par impact de projectile de l'omoplate gauche de JS 31 : a, Rectangle rouge en gros plan sur la fosse sous-scapulaire montrant le percement avec un écaillage osseux et des lignes de fractures ; b, image microscopique composite du percement montrant l'écrasement de l'os dans le bord inférieur du percement (grossissement 40x).*

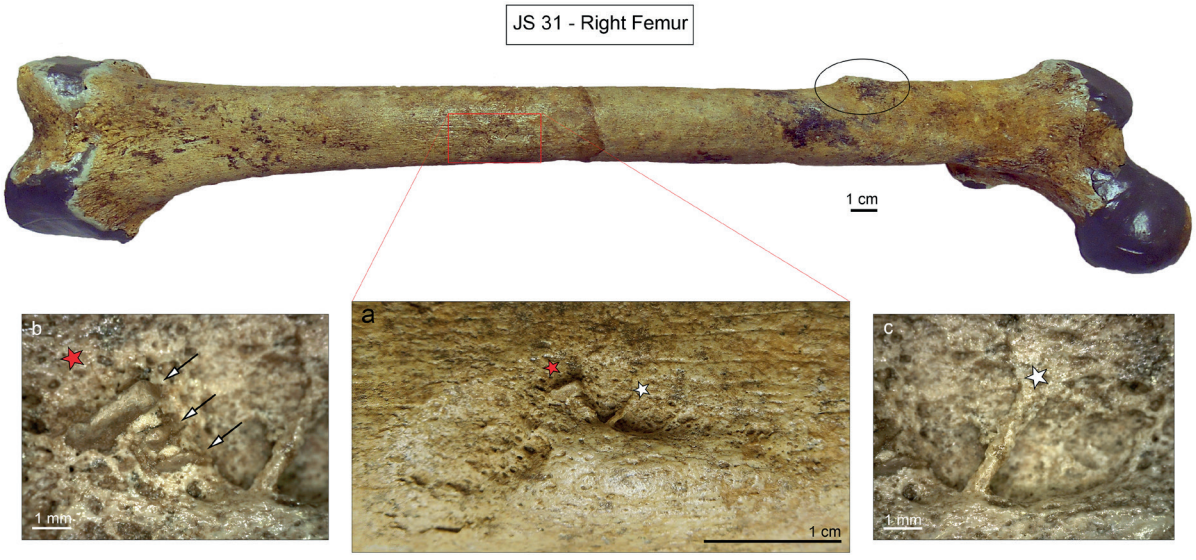

Fig. 13 – Healed lesions on the right femur of JS 31. Red rectangle, healed projectile lesion; black ellipse, bone callus; a, red rectangle close up of the healed projectile injury with red and white stars as reference points for the magnified area b and c; b, microscopic view of the three embedded lithic chips marked by arrows; c, microscopic view of a bony bridge separating two geometric marks indicating the presence of two lost lithic chips (magnification 50x).

***Fig. 13 – Lésions** cicatrisées sur le fémur droit de JS 31. Rectangle rouge, lésion cicatrisée liée à un projectile ; ellipse noire, cal osseux ; a, gros plan du rectangle rouge illustrant la lésion cicatrisée liée à un projectile avec des étoiles rouge et blanche comme points de référence pour situer les zones agrandies b et c ; b, vue microscopique des trois éclats lithiques fichés dans l'os et marqués par des flèches ; c, vue microscopique d'un pont osseux séparant deux marques géométriques indiquant la présence de deux éclats lithiques perdus (grossissement 50x).*

tebras (Wendorf, 1968c, p. 978). According to F. Wendorf (1968c), the artefacts include two "J-shaped geometrics" (corresponding to two different categories in our own typological classification, i.e. a crescent-like backed piece and a backed symmetrical mono-points), unretouched flakes and chips, and "backed, convex backed, backed and straight oblique distal truncated, and straight basal truncated flakes" (each of them belonging to one of the same three types illustrated below: crescent-like backed piece; backed symmetrical mono-points; backed asymmetrical mono-points with an oblique or transverse cutting edge). F. Wendorf also noted two cases of chip and/or flake alignments during the excavation which were interpreted as evidence of composite projectile use (Wendorf, 1968c). The fourth rib with embedded "backed flake" is, unfortunately, also not present in the British Museum Wendorf collection, and could therefore not be reassessed.

As with JS 31, all the lesions observed on JS 44 are located in the post-cranial skeleton (fig. 14), with healed fractures present on the left clavicle, right ulna and radius, and one left rib. The fracture of the left clavicle shaft is located on the acromial end of the diaphysis, revealing a slight torsion and a displacement of the bone fragments. The right forearm healed fracture is oblique, with a displacement (translation and rotation) of the two broken pieces (fig. 15). The trauma broke the proximal part of the ulna's diaphysis and the distal part of the radius shaft. The clavicle and forearm fractures most probably occurred during the same event. Given the oblique nature in the forearm and acromial involvement in the clavicle, they might be the result of an indirect trauma, such as a bad fall, rather than a defensive parry fracture (see Lovell, 1997).

The other lesions, however, are clearly the result of projectile impacts. A triangular notch on the lateral face of the ilium, about 1 cm from the greater sciatic notch, has a lithic fragment embedded in the incision. The laminated aspect of the bone overlying the flake suggests there was an attempt to extract the projectile (fig. 16). The morphology of the mark also indicates the projectile travelled from the postero-medial to the antero-lateral side of the left pelvic bone, which suggest the projectile was travelling back to front. In addition to the now missing fourth rib, PIMs were also observed on right femur. Two parallel drags less 1 cm long and approximately 2 cm from each other are visible on the posterior side of the diaphysis. These two drags exhibit a flat bottom with parallel microstriations. The most distal one shows flaking marks on the proximal border (fig. 17). It is worth noting that the angle of penetration into the bone differs for both drags, the most proximal one being more tangential. These drag marks reflect a projectile trajectory that came from the disto-lateral to the proximo-medial part of the bone. An upward direction suggest that the individual was hit while running or that the projectile was drawn from a lower position. In addition, the spacing between these two drags and their morphology are consistent with penetration from a single composite projectile. This hypothesis is strengthened by F. Wendorf's field observation of *in situ* lithic alignments associated with JS 44.

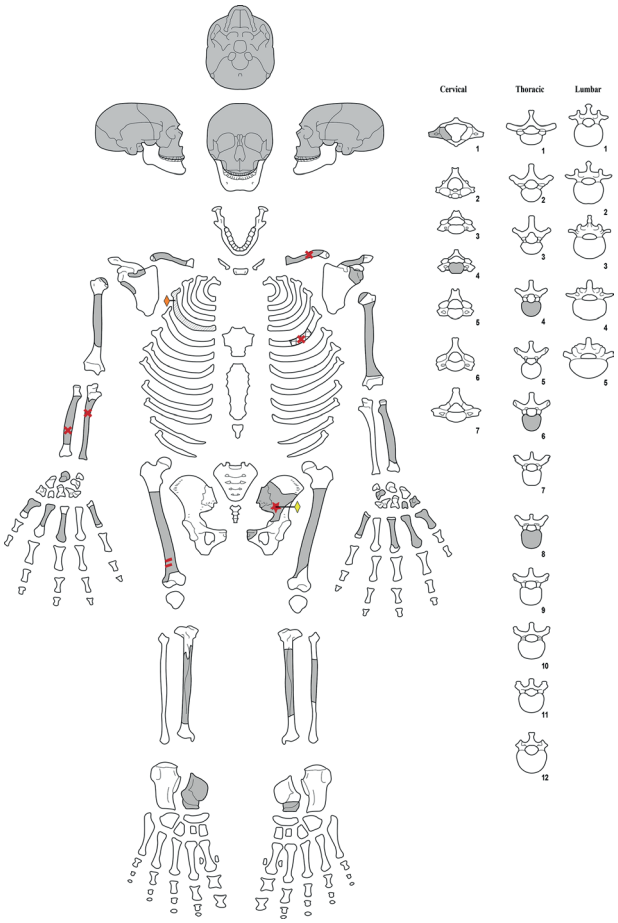

Fig. 14 – Location of the observed osseous lesions on JS 44. Grey parts represent preserved bones; striped area is a missing bone; crisscross area is a rib whose exact anatomical position is unknown. Full star, unhealed puncture; dash, drags traces of projectile impacts; time sign, healed fracture; yellow diamond, embedded artefact in a puncture; orange diamond, embedded artefact in lost bone.

***Fig. 14** – Localisation des lésions osseuses observées sur JS 44. Les parties grises représentent les os conservés ; la zone rayée représente un os manquant ; la zone quadrillée est un fragment de côte dont le rang n'est pas certain. Étoile pleine, percement non cicatrisé ; tiret, éraflure liée au passage d'un projectile ; signe multiplié, fracture cicatrisée ; losange jaune, artefact fiché dans un percement ; losange orange, artefact fiché dans un os perdu.*

2.2 Burial selection and mortality profile

In view of the high number of individuals with evidence of interpersonal violence, the frequency of projectile impact marks, and the presence of several double or multiple burials, the site's mortality profile was analyzed to investigate possible patterns in burial selection (see Sellier, 1996; Castex et al., 2009). Should the cemetery reflect a single "warfare" event, an unbalanced demographic profile (e.g. the overrepresentation of a certain sex or age class less likely to die otherwise) is probable (see Bridges, 1996). At Jebel Sahaba, the individuals that could be sexed (n = 39) revealed no bias, with 48.7% females and 51.3% males. The age distri-

Fig. 15 – Healed fractures on JS 44. From top to bottom, left clavicle superior view, right radius anterior view and right ulna anterior view.
***Fig. 15** – Fractures cicatrisées sur JS 44. De haut en bas, vue supérieure de la clavicule gauche, vue antérieure du radius droit et vue antérieure de l'ulna droit.*

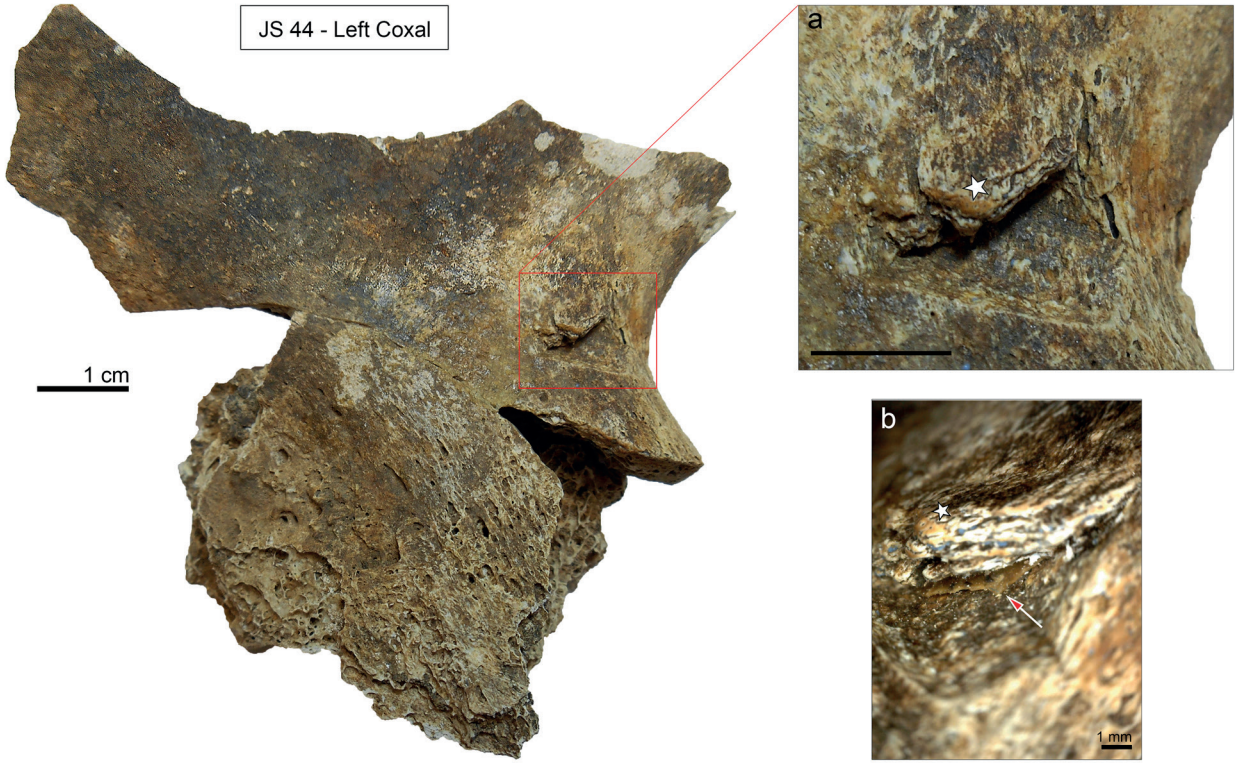

Fig. 16 – Lateral view of the left pelvis of JS 44 with a projectile impact puncture with an embedded lithic flake. a, red rectangle close up of the PMI with white star as reference point for the magnified area b; b, microscopic view of the puncture showing the laminated aspect of the superior border and the lithic artefact inside the puncture indicated by the red arrow (magnification 30x).
***Fig. 16** – Vue latérale du coxal gauche de JS 44 avec un percement lié à un impact de projectile contenant un éclat lithique toujours fiché dans l'os. a, Gros plan du rectangle rouge centré sur la MIP avec l'étoile blanche comme point de référence pour la zone agrandie b ; b, vue microscopique du percement montrant l'aspect feuilleté du bord supérieur, l'artefact lithique fiché dans le percement est indiqué par la flèche rouge (grossissement 30x).*

Fig. 17 – Parallel drags on JS 44 located on the posterior surface of the right femur diaphysis, at the level where the lateral supracondylar line, which delimitates the lateral part of the popliteal plane, meets to lateral side of the femoral diaphysis. a, red rectangle close up showing the two parallel drags and the direction of the projectile with the arrows; white star as reference point for the magnified area b; b, microscopic close up on the distal drag showing the flaking of the superior border at the origin of the drag; red star as reference point for the magnified area c (magnification 45x); c, composite microscopic view of the proximal part of the distal drag displaying the wide flat bottom of the groove and the parallel microstriations (magnification 235x).

***Fig. 17** – Éraflures parallèles présentes sur JS 44 au niveau de la face postérieure de la diaphyse fémorale droite, à l'endroit où la ligne supra-condylaire latérale, qui délimite la partie latérale du plan poplité, rejoint la face latérale de la diaphyse fémorale. A, gros plan du rectangle rouge montrant les deux traînées parallèles, la direction du projectile est indiqué par le sens des flèches, et l'étoile blanche marque le point de référence pour la zone agrandie b ; b, vue microscopique de l'éraflure distale montrant l'écaillage du bord supérieur à l'origine l'éraflure ; l'étoile rouge marque le point de référence pour la zone agrandie c (grossissement 45x) ; c, vue microscopique composite de la partie proximale de la traînée distale révélant la morphologie de fond de sillon, large et plat, et les microstriations parallèles (grossissement 235x).*

bution shows a clear underrepresentation of non-adults ([< 20] = 29.5%) compared to the theoretical percentage ([<20] = 54.5% ± 9.5%) for a population with a life expectancy at birth of between 25 and 35 years (Ledermann, 1969). However, this imbalance is mostly due to the lack of perinates, neonates and young children (age classes [0-1] and [1-4]) whose mortality quotient stands outside the lower limits of the theoretical values (fig. 18).

As with the young adults, the remaining non-adults do not exhibit any unusual distribution, and neither category is overrepresented at the site. Interestingly, the small proportion of very young children is not unusual in pre-Neolithic funeral assemblages and could relate to demographic factors, cultural behaviors such as the separate burial of young infants, or poor preservation (Saxe, 1971; Bocquet-Appel, 2002; Bocquet-Appel and Naji, 2006). In the case of Jebel Sahaba, differential preservation does not appear to have been a factor as a majority of the non-adults remains are well-preserved.

2.3 Reassessment of the lithic assemblage

With the exception of a few flakes and points, the surface artefacts (i.e. found into the fill surrounding the burials) differ in term of typology and raw material from the ones found inside the burials and within the physical space of the skeletons. According to F. Wendorf and R. Schild (2004), 116 pieces were found in direct association with 24 individuals. This number, however, differs from the number of listed artefacts in their tables (n = 112), as well as those described in the original publication (n = 118; Wendorf, 1968c). Their 2004 paper does not appear to include burials JS C-1, JS C-2 and JS C-3, excavated by the Columbia Expedition, and the lithic artefact found with JS 41 was not reported in F. Wendorf and R. Schild (2004) as its exact position in the deposit was noted as unknown in F. Wendorf (1968c).

Of F. Wendorf's 1968c publication, 118 artefacts, including seven embedded ones, were found directly associated with 27 individuals. Our reassessment has led to the identification of a further 13 pieces embedded in the bones. We counted the multiple fragments found in one PIM as one artefact (table S2). Based on these findings, a new total of 132 artefacts were found in direct association with 28 individuals. In addition to the lithic assemblage from the surface (n = 72), our reassessment included 115 pieces from the original collection. The three pieces from burials JS 25, JS 45 and JS 47 are not in the British Museum collection. A supplementary piece was, however, found associated to burial JS 26. This piece was mixed with the surface material, probably from the beginning, which could explain its absence in F. Wendorf's inventory (although the piece was drawn in Wendorf, 1968c, fig. 34dd). We also included five pieces found near burials JS 101 to JS 107. Although not directly in contact with the skeletons, their association to the individuals in this multiple burial is suggested by F. Wendorf (1968c, p. 988). We have taken into account these artefacts in our reas-

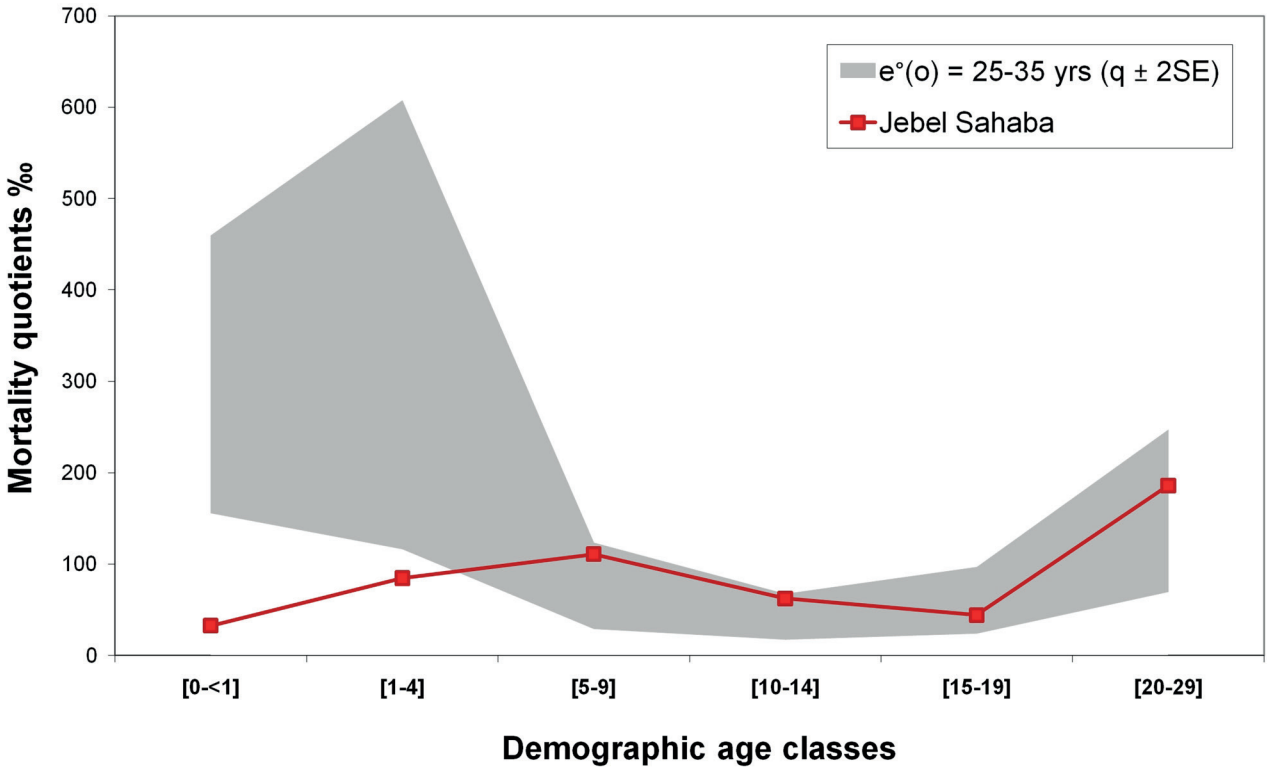

Fig. 18 – Mortality quotients by age class at Jebel Sahaba compared to the theoretical mortality rates of S. Ledermann (1969) for a population with a life expectancy at birth of between 25 and 35 years.

***Fig. 18** – Quotient de mortalité par classe d'âge à Jebel Sahaba comparé aux taux de mortalité théoriques de S. Ledermann (1969) pour une population préindustrielle ayant une espérance de vie à la naissance comprise entre 25 et 35 ans.*

sessment, but we remained cautious as to their association with the burials. Our reexamination confirms the diversity of shape of the artefacts with a tendency toward small size pieces. Despite a strong typological variability, most lithic artifacts found inside the burials can be identified as projectiles or armature elements, including the unretouched parts. This industry, however, is hard to characteristics and compare to other from the same period as it is based on an assemblage consisting of elements that mostly relate to a single function: the manufacture of weapons. However, technological and typological elements fit well with the definition of the Qadan industry (Shiner, 1968). The current reassessment also revealed strong similarities to the Tushka area B industry previously attributed to the Qadan (Albritton and Wendorf, 1968; Wendorf, 1968b; Becker and Wendorf, 1993). In Jebel Sahaba burials, as in Tushka area B, the lithic artefacts were mainly produced using a bipolar technique on anvil with small flint nodules or small pebbles. This kind of knapping generates flakes with very diverse morphologies. However, certain intentions are discernable, particularly a desire to obtain elongated flakes with asymmetrical sections. Another method, however less represented, enters into Levallois production *sensu lato*. On the other hand, no blades or bladelets productions are identified in this assemblage.

Our reassessment of the 115 lithic artefacts revealed 62 points (see below), 43 unretouched flakes and microchips, and seven undetermined pieces (fig. 19 and fig. 20). In addition, one Levallois core (fig. 19c), one scraper (fig. 19d) and one burin (fig. 19e) were noted. However, it should be underlined that the association of the Levallois core and the burin with the skeletons is described as less certain by F. Wendorf, compared to the others artefacts mentioned in associated with the burials. Among the points, three main morphologies can be distinguished: backed asymmetrical mono-points with an oblique or transverse distal cutting edge (n = 22; fig. 19, q to v), backed symmetrical mono-points (n = 16; fig. 19, f to l) and crescent-like backed pieces (n = 9; fig. 19, m to p). In addition, there are indeterminate points (n = 10; mostly fragments which could belong to one of the previous categories). There are also unretouched symmetrical mono-points (n = 5; fig. 19, a and b), some of which are the only ones that can be tentatively assigned to Levallois industry. On the other hand, we note the absence of elongated bi-points corresponding to "typical" lunate. The range in size is fairly diverse, with most points microlithic (around 2-2.5 cm long), while others are more robust (3 to 4 cm long). This is especially the case among the backed symmetrical mono-points and the unretouched symmetrical mono-points. Significantly, preliminary functional analysis shows that some artefacts bear impact fractures.

Morphological diversity co-occurs within burials. Of the 21 pieces found in association to burial JS 44, for example, six are micro- and three unretouched flakes, five are backed symmetrical mono-points, three backed mono-points with an oblique or transverse distal cutting edge, three crescent-like backed pieces and one is an indeterminate point.

Based on this reanalysis, almost half of the elements used as weapons are unretouched flakes and microflakes, that would have been missed in any other context (fig. 20), as noticed by F. Wendorf (1968c). Most appear to be laterally shafted composite elements used as part of projectiles. The points would have been mounted at the end of shafts, with crescents laterally shafted. Their diversity in both size and shape suggests the use of several types of weapons, particularly light arrows but also much heavier arrows or spears. Finally, the use of points with oblique or transverse distal cutting edges appears to indicate that one of the main lethal properties sought is to slash and cause blood loss. The fact that many were found inside the volume of the skeleton indicates their efficiency at penetrating the body. Those found are likely to be the ones that had detached themselves from their shaft and were not successfully removed prior to burial.

Finally, a remark is necessary regarding the artefacts within the fill of the surrounding burials. In a recent paper, D. Usaï (2020) uses their existence as a basis for questioning the association of all the artifacts discovered at Jebel Sahaba with the burials. Her hypothesis is that the excavation of the burials in older archaeological levels would have fortuitously mixed all these artefacts with the contents of the tombs. The counter-argument to this hypothesis is based on two categories of information: 1) the clear spatial correlation that exists between many of the lithic remains previously described and the numerous traces of impact that a majority of the bodies bears; 2) the fact that the remains found in direct association with the bodies form an assemblage that is completely different from the one collected from within the fill surrounding the burials. Within this latter assemblage, a large part of the pieces is composed of varieties of rock not represented in the lithic industry explicitly associated with the skeletons. These pieces are notably in silicified wood, quartz or quartzite (29 out of 71 pieces studied). Finally, a careful examination shows that only about 10% of these elements are similar to the artefacts explicitly associated with the skeletons, underlining that these assemblages are of different origins. Moreover, and contrary to what D. Usaï (2020) asserts, the number of pieces associated with the bodies in the burials that are not compatible with weapon remains is very small: a scraper (JS 29), a Levallois core (JS 41), and a burin (JS 110). Besides, the core is noted as "found in fill adjacent to skeleton, exact position unknown" (Wendorf, 1968, p. 977) and the burin is described as "found with or near burials" (Wendorf, 1968, p. 988). This leads us to conclude that there is no artefact, or very few, that could be seen as grave goods, but that most if not all of the artefacts found in direct association with the skeletons do indeed belong to the weapons used to wound them. The comparison we were able to make between the artefacts found in direct association with the burials and the assemblage of Tushka B, unanimously attributed to Qadan, allows us to maintain this cultural attribution not only for the lithic components but also for the burials that deliver its elements.

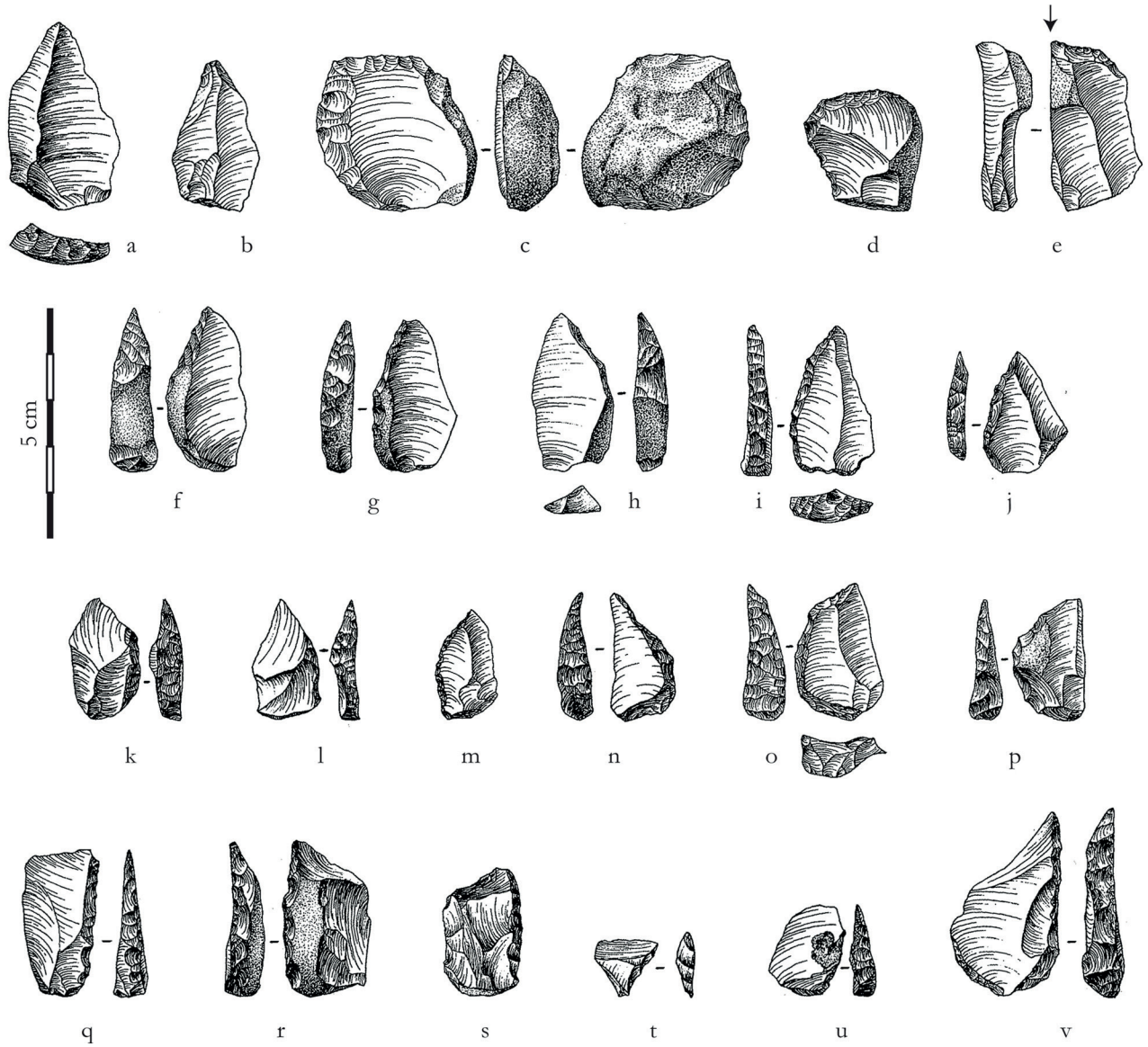

Fig. 19 – Jebel Sahaba, lithic industry sample (modified following Wendorf, 1968c): a-b, unretouched symmetrical mono-points (assimilated with caution to Levallois points); c, Levallois core; d, scraper; e, burin; f to l, backed symmetrical mono-points; m to p, crescent-like backed pieces; q to v, backed asymmetrical mono-points with an oblique or transverse distal cutting edge. Burials JS 14 (g-h); JS 21 (i, m, v); JS 29 (d); JS 31 (q-r); JS 33 (s); JS 34 (n); JS 35 (a, t); JS 41 (c); JS 44 (f, j to l, p, u); JS 103 (b), with or near JS 110 (e), JS-C1-3 (o).

Fig. 19 : *Jebel Sahaba, échantillon de l'industrie lithique (d'après Wendorf, 1968c) : a-b, mono-pointes symétriques non retouchées (hypothétiques pointes Levallois) ; c, nucléus Levallois ; d, grattoir ; e, burin ; f à l, mono-pointes symétriques à dos ; m à p, pièces à dos assimilables à des géométriques de type de croissant ; q à v, mono-pointes asymétriques à dos avec un tranchant distal oblique ou transversal. Tombes JS 14 (g-h) ; JS 21 (i, m, v) ; JS 29 (d) ; JS 31 (q-r) ; JS 33 (s) ; JS 34 (n) ; JS 35 (a, t) ; JS 41 (c) ; JS 44 (f, j à l, p, u) ; JS 103 (b), avec ou près de JS 110 (e), JS-C1-3 (o).*

3. DISCUSSION

Since its discovery in the 1960's, the Jebel Sahaba cemetery has been regarded as the oldest evidence of organized warfare caused by environmental constrains (e.g. Thorpe, 2003; Guilaine and Zammit, 2005; Daković, 2014). However, the lesions observed on the Jebel Sahaba skeletons and the nature of the funerary complex had not been reassessed (or benefited from the use of modern anthropological methods) since F. Wendord's 1968a publication. It remained unclear if the site was the result of a single conflict, a specific burial place for individuals who died a violent death or evidence of sustained interpersonal violence in Late Pleistocene hunter-gatherer groups (Wendorf and Schild, 2004).

F. Wendorf (1968c) and J. E. Anderson (1968) had highlighted the projectile nature of several lesions, particularly those bearing embedded lithic artefacts. Here, macroscopic and microscopic methods were used to distinguish projectile injuries from slicing cutmarks and taphonomical modifications (see Shipman and Rose,

1983; Morel, 2000; Pétillon and Letourneux, 2003; Smith et al., 2007; Castel, 2008; Domínguez-Rodrigo et al. 2009; Backwell et al., 2012; O'Driscoll and Thompson, 2014; Duches et al., 2016; Fernández-Jalvo and Andrews, 2016). More than half of the injured individuals buried at Jebel Sahaba exhibit clear projectile impact marks (61.0%; n = 25), with most showing signs of trauma (92.7%; n = 38). Irrespective of age and sex, the majority have clear signs of interpersonal violence involving projectile weapons. The number of individuals with both healed and unhealed traumas also increases with age from adolescence (n = 1), to young adults (n = 2) and adults (n = 13). Importantly, the co-occurrence of ante-mortem and perimortem lesions on several Jebel Sahaba individuals had not previously been noted and indicates that acts of interpersonal violence occurred repeatedly within their lifetime.

As with experimental studies on ungulates (Castel, 2008; Duches et al., 2016), drag marks are the most frequent PIMs observed at Jebel Sahaba. In ungulates, these are usually followed by punctures, particularly on the appendicular skeleton (Castel, 2008; Duches et al., 2016), which was also the case at Jebel Sahaba. As underlined by M. J. Smith et al. (2007), microscopic fragments of the actual weapons also often end up embedded in the bones, either at impact or while attempting to remove the weapon. J.-C. Castel (2008) experimental work also reveals that 45.0% of ungulates PIMs include at least one small embedded lithic fragment. At Jebel Sahaba, artefacts were found in one third of the drag and puncture impact marks (31.3%; n = 20). Of these, the great majority were in puncture marks (70.8%; n = 17).

The PIMs patterns support the use of composite weapons made of shafted retouched and unretouched flakes, including light and heavy projectiles. This is corroborated by the alignment of flakes and chips within the physical space of the skeletons, the reassessment of the lithic assemblage and cases of parallel drags less than 2 cm apart consistent with ethnographical and experimental spear and arrow shaft diameters (Dias-Meirinho, 2011; Pétillon et al., 2011; Duches et al., 2016).

Identifying interpersonal violence on skeletal remains is not always straightforward and often depends on the type of trauma and the archaeological context (Walker, 2001; Jackes, 2004). Clear examples of fatal interpersonal blunt (e.g. Sima de Los Huesos SH17; Sala et al., 2015) and sharp force trauma (e.g. Shanidar 3; Trinkaus, 1983) go as far back as the Middle Paleolithic. The oldest Palaeolithic projectile trauma date to the Epigravettian period (~ 31-26 kya; Fu et al., 2016), with an example of an embedded point in the second thoracic vertebra of a child from Grimaldi (Henry-Gambier, 2001) and an incision on the first thoracic vertebra of Sunghir 1 caused by a projectile or a hand-held blade (Trinkaus and Buzhilova, 2012). Based on the available evidence, the number of projectile injuries appears to increase over time and cases of fatal trauma in Europe become more frequent during the Mesolithic (Estabrook, 2014). During this period, burial assemblages containing multiple individuals with perimortem trauma also begin to appear, with famous

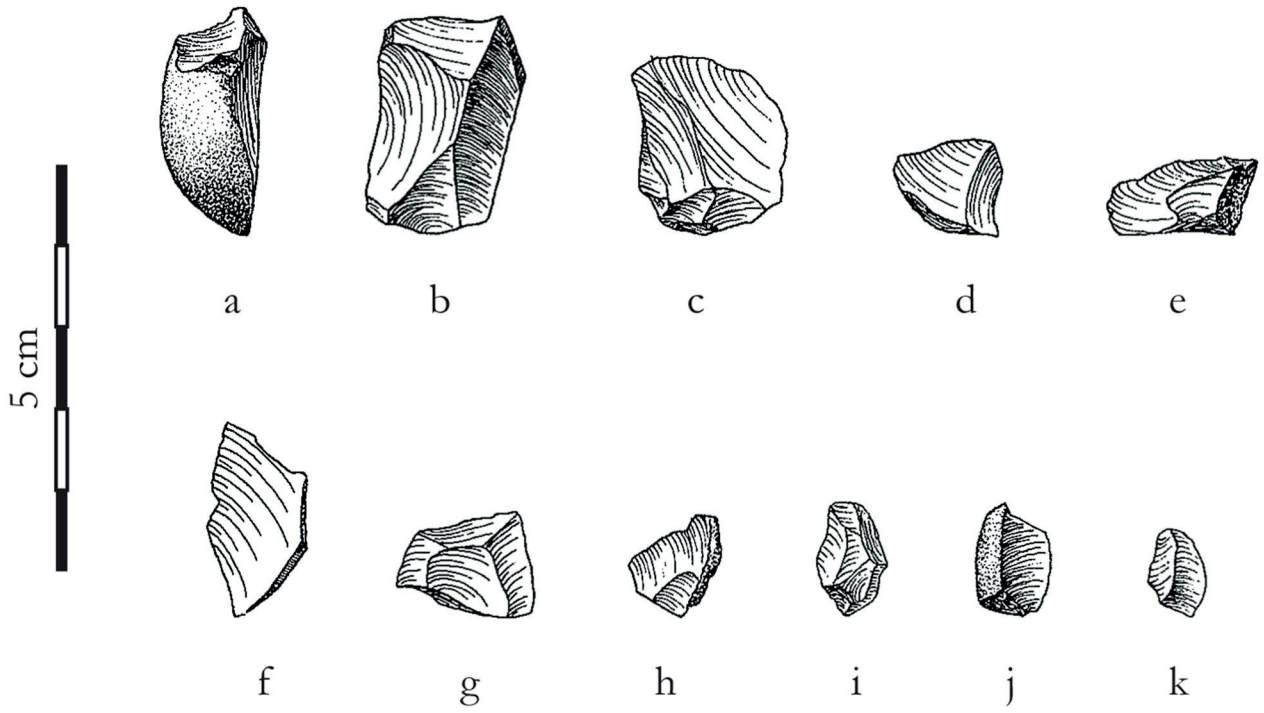

Fig. 20 – Unretouched flakes and microflakes (complete or fragmented; modified following Wendorf, 1968c) samples from Burials JS 21 (c), JS 23 (e), JS 29 (a), JS 31 (b), JS 33(d), JS 44 (f to k).

Fig. 20 *Échantillons d'éclats et de micro-éclats non retouchés (entiers ou fragmentés, d'après Wendorf, 1968c) des sépultures JS 21 (c), JS 23 (e), JS 29 (a), JS 31 (b), JS 33(d), JS 44 (f à k).*

examples at Ofnet in Germany (Frayer, 1997) and the Vasilyevka III burial ground in the Dnieper rapids region of the Ukraine (Lillie, 2004). These examples, however, differ from Jebel Sahaba. At Ofnet (circa 9 kya), females and children dominate the group and skull trauma is more frequently found in adult males (Frayer, 1997; Orschiedt, 2005). Although the interpersonal nature of the bludgeoning identified on six cranium is clear and was probably caused by warlike conflict, the deliberate grouping of 34 selected skulls and associated cervical vertebra, likely from decapitated individuals, with pierced red deer teeth in two multiple burials reflects a specific mortuary behavior (Orschiedt, 2005). The cemetery from Vasilyevka III (circa 12 kya), however, shares some similarities with Jebel Sahaba. Around 60 individuals in single, double or multiple burials were found mainly in flexed positions. Five adults were identified with single or multiple embedded microliths associated with composite projectiles (arrow and spear) including three females, one male and one undetermined individual (Lillie, 2004). In the case of Ofnet, although all individuals seem to have been subjected to a violent death, only 18% of them show clear signs of trauma on the bones selected for burial. Of the lesions observed at Jebel Sahaba, only 13.1% of the individuals have unhealed trauma to the cranium and cervical vertebrae. Similarly, at Vasilyevka III, only 8% of individuals have at least one embedded lithic compared to 18% at Jebel Sahaba. In all cases, detectable lesions and lithics only reveal part of the story.

The site of Nataruk provides the closest parallel of interpersonal violence to Jebel Sahaba (Lahr et al., 2016). Situated west of lake Turkana and dating to around 10.5-9.5 kya, the individuals found in Nataruk appear to exhibit signs of violent death through projectile impact marks (punctures and perforation), sharp and blunt force trauma, as well as fractures. Lesions mainly located on the skulls, cervical vertebras, lower limbs and hand are described (Lahr et al., 2016), although some researchers have made a case against this being a massacre site, arguing that the burials are not contemporaneous and that the cranial damage is inconsistent with blunt force trauma (Stojanowski et al., 2016). The Nataruk example also differs from Jebel Sahaba in that there is no clear pattern of deliberate burial, no signs of trauma on children and a lack of healed trauma in the adults.

Violent behavior in past and present hunter-gatherer societies appears to vary, in part reflecting the period, culture and the level of organization of mobile and semi-sedentary societies (e.g. Keeley, 1996; Kelly, 2000; Thorpe, 2003; Guilaine and Zammit, 2005; Allen and Jones, 2014). If semantic and ideological debates still surround the use of the term warfare for Prehistoric conflicts (Boulestin, 2020), ethno-archaeological examples suggest that the concept of warfare can encompass all form of antagonistic relationships from feuds, individual murders, ambush attacks, raids and trophy taking to bloody clashes and larger armed conflicts (cf. Keeley, 1996; Kelly, 2000; Guilaine and Zammit, 2005; Allen, 2014; Allen and Jones, 2014; Leblanc, 2014; Darmangeat, 2019). The level of warfare can vary, with some conflicts being all-encompassing, constant and deadly, while others are episodic events of various intensity that occur sporadically (Jones and Allen, 2014; Leblanc, 2014). Irrespective of time and space, some similarities are nevertheless observable. Many reported cases from Australia, Africa, North and South America reveal differences in the frequency and type of trauma between males and females, and acts of violence on non-adults are rare. Often, young males show higher levels of trauma, while females more frequently exhibit parry fractures (e.g. Standen and Arriaza, 2000; Chatters, 2014; Pilloud et al., 2014; Schwitalla et al., 2014; Gordón, 2015; Allen et al., 2016; Pfeiffer, 2016). Cranial injuries on the frontal and parietal bones are common, although the type of weapon used and the nature of the conflict clearly influences the nature, located and distribution of the lesions (e.g. Standen and Arriaza 2000; Chatters, 2014; Pardoe, 2014; Pilloud et al., 2014; Schwitalla et al., 2014; Allen et al., 2016). Comparisons with Jebel Sahaba, although tentative in view of the large timescale and regions involved, reveal some interesting differences. In other ethno-archaeological cases, healed traumas are the most common occurrence, while archaeological examples from Ofnet or Nataruk appear to display mostly perimortem lesions. At Jebel Sahaba, the co-occurrence of healed and unhealed lesions strongly supports sporadic, though recurrent, episodes of interpersonal violence between Nile Valley groups at the end of the Late Pleistocene. The projectile nature of at least half of the lesions suggests inter-group attacks, rather than intra-group or domestic conflicts, and the frequency of healed wounds confirms that these events were not always lethal and could occur several times during the life of an individual. A catastrophic single mass burial is highly unlikely and is not supported by the archaeological evidence or the demographic analysis. With the exception of a higher percentage of parry fractures in females, there appears to be no patterning in the distribution of trauma or PIMs by either age of sex. Based on the lesions, the projectile direction also reveals an equal number of posterior and anterior strikes that do not support face-to-face battles. Rather, the involvement of a range of ages and both sexes, with primary (n = 26), double (n = 4) and multiple (n = 4) burials, including some with evidence of disturbance due to the addition of later individuals (Wendorf, 1968c), indicates small episodes of recurring violent events such as raids or ambushes against this community. This appears to have taken place within a brief timespan given the homogeneity of burial location and practices.

Designated special burial locations for the victims of violence are documented in ethnological and historical records (Kamp, 1998; Jackes, 2004). At Jebel Sahaba, the percentage of individuals with traces of perimortem traumas and/or lithic artefacts found within the physical space of the skeleton is 54%. If multiple burials are treated as simultaneous deaths and individuals without detectable signs of a violent death, but buried in direct association with others that are included, the percentage is closer to 64%. The nearby and possibly contempora-

neous burial sites at Tuskha (site 8905; Wendorf, 1968b) and Wadi Halfa (site 6-B-36; Hewes et al., 1964) do not seem to document comparable level of evidence for violence but a careful review of the data may suggest otherwise. In Tushka, 19 human skeletons from different periods were uncovered. Among them, 12 individuals buried in contracted position on their left side are thought to be dated between 15-11 kya based on geological and archaeological data, taphonomic observations and several radiocarbon dates (Albritton and Wendorf, 1968). Two double burials are present, the remaining individuals are in single burials, and no direct association of lithic artefact was noted during the excavation. Unfortunately, the surface of the cortical bone cannot be analyzed due to its poor state of preservation. The site of Wadi Halfa (6-B-36), also associated with Qadan lithic industry, displays some similarity with Jebel Sahaba, including burial practices (Saxe, 1971). Out of the 36 individuals buried at the site, seven have healed fractures of the ulna (three parry fractures), hand bones (two phalanges and one metacarpal) and lower limb (one fibula), as well as of healed trauma to the cranium (one frontal and one parietal; see Greene and Armelagos, 1972). An additional individual also shows evidence of an unhealed projectile trauma with an embedded stone point in a cervical vertebra (Greene and Armelagos, 1972). These lesions are only present on adult individuals regardless of the sex (4 males, 4 females). D. L. Greene and G. L. Armelagos (1972) also reported some new bone formation associated with longitudinal grooves on two humeri belonging to two of the individuals with signs of trauma. A. Saxe (1971) suggested that the differential mortality rates between males and females of adult age (defined here as the [25-30] age class) in the Wadi Halfa cemetery could indicate that males were engaging in warfare more than female individuals. The percentage of individuals with traumas at Wadi Halfa (22.2%; n = 8) is much lower than at Jebel Sahaba (62.3%; n = 38). However, some projectile impact marks may not have been recognized during the analysis of the human remains. The frequency of the more easily visible healed parry fractures is similar at both sites (8.3%, n = 3, for Wadi Halfa; and 9%, n = 6, for Jebel Sahaba). In both, fractures of the upper limb also dominate (84.8%, n = 28, for JS; and 85.7%, n = 6, for Wadi Halfa in ulnas and hand bones). Finally, there is little doubt that the individuals in the Jebel Sahaba cemetery were carefully buried by the members of their own community. Individual associations are likely to mirror their relationship during life with, for example, several examples of females and children in three out of the four double burials and one of the multiple burials (JS 100, JS 103) with the remains of two women and three children. If Jebel Sahaba was indeed a special burial place, this applied to all members of the community and followed expected demographic patterns. Therefore, it is most likely that the level of interpersonal violence observed in the site reflects broader inter-group behavioral relationships in the Nile Valley at the end of the Late Pleistocene rather than specific funerary practices.

Finally, the high level of interpersonal violence observed at the site may, in part, have been driven by the climatic changes associated with the beginning of the African Humid Period. The erratic and severe flooding of the Nile caused by an overflow of lake Victoria around 15-14 kya most certainly impacted settlements and the subsidence strategies of human populations all the way up to Egypt prior to the more stable monsoon conditions that emerged at the beginning of the Holocene (Williams et al., 2006). During the Last Glacial Maximal, few human remains have been recovered in the Nile Valley. This is mirrored by a drastic reduction in the archaeological, record with little evidence for the presence of humans along the lower Nile from Marine Isotopic Stage 4 (~ 71 kya) to the Last Glacial Maximum (Vermeersch and Van Neer, 2015). During this time period, the survival of small groups in the fewer sustainable areas in Upper Egypt and Lower Nubia is supported by the unusual phenotypic diversity, probably related to population fragmentation and isolation, found in the Late Pleistocene fossils of this region (e.g. Anderson, 1968; Greene and Armelagos, 1972; Irish, 2005; Crevecoeur, 2008; Pagani and Crevecoeur, 2019; Leplongeon, 2021). With variation of lithic industries noted at the end of the Late Pleistocene indicating different cultural traditions and the co-occurrence of large cemetery spaces suggesting some level of sedentism (Schild and Wendorf, 2010), severe territorial competition between the region's hunter-fisher-gatherer groups is likely to have occurred when faced with forced adaptation to such drastic environmental changes (e.g. Lillie, 2004; Jones and Allen, 2014; Schwitalla et al., 2014; Allen et al., 2016). Climate change is most likely to have been a driving force behind violent competition for resources over time.

4. CONCLUSIONS

For the first time since F. Wendorf's (1968a) original publication, a complete reassessment of the Jebel Sahaba cemetery, often considered to be the oldest evidence of organized warfare, was used to clarify the nature, extent and dating of the violence experienced by the individuals buried at the site. Using modern approaches and methods, the reappraisal undeniably supports the interpersonal nature of the lesions and confirms the projectile origin of most of the trauma. The reassessment of the lithic artefacts associated with each burial reveals that most were elements of composite projectile weapons. Our analyses also show that out of 61 individuals, 27.9% had signs of perimortem traumas and 62.3% displayed healed and/or unhealed traumas (excluding here undiagnosed lesions) regardless of the age-at-death or sex, including children as young as 4 years old. Although double and multiple burials with up to four individuals are present, probably indicating simultaneous deaths, several burials exhibit signs of later disturbance caused by subsequent interments. Furthermore, the data

does not support a single catastrophic event. In addition, the demographic profile of the Jebel Sahaba cemetery is inconsistent with a mass burial. While acknowledging the possibility that the Jebel Sahaba cemetery may have been a specific place designated for the burial of victims of violence, the presence of numerous healed traumas and the reuse of the funerary space both support the occurrence of recurrent episodes of small-scale, sporadic interpersonal violence at the end of the Pleistocene. Most are likely to have been the result of skirmishes, raids or ambushes. Territorial and environmental pressures triggered by climate changes at the end of this period are most likely responsible for the frequent conflicts between culturally distinct Nile Valley semi-sedentary hunter-fisher-gatherers groups. New direct radiocarbon dates also confirm the antiquity of the site, and suggest that it is at least 13.4 kya old (or comprised between 13.4-18.2 kya), thus making Jebel Sahaba the oldest cemetery in the Nile Valley and one of the earliest sites displaying extensive interpersonal violence in the world.

The early inhabitants of the Nile Valley appear to have lived in an environment where violence was a regular part of both life and human behavior. Unlike many examples of early warfare and interpersonal violence (see review in Kissel and Kim, 2019), the violence at Jebel Sahaba differs in that it was clearly frequent, extensive and intense, with many skeletons displaying multiple lesions. It also appears to have been indiscriminate of age and sex, involving both younger children and women. The broader significance of what happened at Jebel Sahaba can be hard to contextualize in view of the vagaries of the archaeological record, with the cemetery only representing one side of the story. Our limited understanding of the Nile Valley social and cultural diversity during the Pleistocene also hinders more complex interpretations. As argued by M. Kissel and N. C. Kim (2019), outbreaks of interpersonal violence are unlikely to simply be reactive outcomes to environmental conditions or social signals, but must also be grounded in culturally constituted motivations for violence. It is also unclear how, if at all, the individuals buried at the site acted towards other groups and whether recurrent episodes of small scale sporadic violence can truly be viewed as warfare. What remains clear, however, is that Late Pleistocene groups were capable of repeated acts of extensive and indiscriminate violence towards most, if not all, members of a community.

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Individual	Biological identity				Healed				Unhealed			
	Sexual diagnosis	Mature/ Immature	Age-at-death estimates	Demographic class	Lesions	Traumas	PIMs	Embedded lithic	Lesions	Traumas	PIMs	Embedded lithic
JS 2	UND	IMM	[5-9]/[10-14]	[5-9]		x						
JS 4	UND	IMM	[15-19]/[20-30]	[15-19]	x							
JS 5	pM	MA	[20-49]	[> 30]	x	x			x			
JS 6	M	MA	[> 40]	[> 30]	x		x	x			x	
JS 7	pF?	MA	[> 30]	[> 30]		x						
JS 8	pF?	MA	[> 30]	[> 30]		x	x					
JS 9	UND	IMM	[1-4]/[5-9]	[1-4]							x	
JS 10	pM?	MA	[25-39]	[> 30]								
JS 11A	pM?	MA	[20-35]	[20-29]		x						
JS 11B	UND	MA	[> 30]	[> 30]	x							
JS 11C	UND	IMM	[0]/[0<1]	[0-<1]								
JS 12	UND	IMM	[5-9]	[5-9]								
JS 13	UND	IMM	[1-4]/[5-9]	[1-4]								
JS 14	UND	IMM	[1-4]	[1-4]						x	x	x
JS 15	pF?	MA	[20-35]	[20-29]	x		x					
JS 16	pF?	MA	[> 30]	[> 30]			x				x	
JS 17	pM?	MA	[20-35]	[20-29]								
JS 18	pM	MA	[> 50]	[> 30]								
JS 19	M	MA	[> 30]	[> 30]	x	x						
JS 20	pM?	MA	[> 30]	[> 30]		x			x		x	x
JS 21	pF	MA	[30-49]	[> 30]	x						x	x
JS 22	M	MA	[25-39]	[> 30]			x	x				
JS 23	pF?	MA	[> 30]	[> 30]	x						x	x
JS 24	UND	IMM	[5-9]	[5-9]							x	
JS 25	pF?	MA	[> 50]	[> 30]								
JS 26	F	MA	[20-49]	[> 30]		x					x	
JS 27	UND	IMM	[0-1]/[1-4]	[1-4]								
JS 28	pF	MA	[20-49]	[> 30]								
JS 29	M	MA	[20-49]	[> 30]		x					x	x
JS 31	pM	MA	[> 30]	[> 30]	x	x	x	x	x		x	x
JS 32	UND	MA	[25-35]	[20-29]		x	x					
JS 32b	UND	MA	[> 30]	[> 30]		x						
JS 33	pF?	MA	[25-35]	[20-29]		x					x	
JS 34	pF?	MA	[20-49]	[> 30]	x	x						
JS 35	UND	MA	[20-35]	[20-29]	x							
JS 36	pF?	MA	[> 30]	[> 30]								
JS 37	pF?	MA	[> 30]	[> 30]	x						x	
JS 37b	M	MA	[> 30]	[> 30]								
JS 38	M	MA	[> 30]	[> 30]	x	x	x					
JS 39	pM	MA	[> 30]	[> 30]	x	x						
JS 40	pM	MA	[15-19]/[20-25]	[20-29]	x	x						
JS 41	pF	MA	[> 30]	[> 30]	x	x			x			
JS 42	pM	MA	[20-29]	[20-29]	x	x					x	

Individual	Biological identity				Healed				Unhealed			
	Sexual diagnosis	Mature/ Immature	Age-at-death estimates	Demographic class	Lesions	Traumas	PIMs	Embedded lithic	Lesions	Traumas	PIMs	Embedded lithic
JS 43	UND	MA	[> 50]	[> 30]	x	x						
JS 44	pF?	MA	[> 30]	[> 30]		x					x	x
JS 45	pF?	MA	[> 30]	[> 30]								
JS 46	pM	MA	[> 30]	[> 30]								
JS 47	UND	IMM	[5-9]	[5-9]								
JS 48	pM	IMM	[15-19]	[15-19]		x					x	
JS 49	pF	MA	[> 30]	[> 30]								
JS C1	M	MA	[>50]	[> 30]			x	x	x			
JS C2	UND	IMM	[1-4]/[5-9]	[5-9]								
JS C3	UND	MA	[> 30]	[> 30]								
JS 100	UND	IMM	[1-4]/[5-9]	[5-9]								
JS 100 extra	UND	IMM	[0-<1]	[0-<1]								
JS 101A-B	UND	IMM	[1-4]	[1-4]								
JS 102	pF	MA	[> 30]	[> 30]	x	x	x					
JS 103	UND	IMM	[10-14]	[10-14]							x	x
JS 104-107	pF?	MA	[> 30]	[> 30]	x	x						
JS 105	UND	IMM	[10-14]/[15-19]	[10-14]	x	x						
JS 106	M	IMM	[10-14]/[15-19]	[10-14]			x					

Table S1 - Inventory of Jebel Sahaba individuals showing their biological identity (sexual diagnosis and age-at-death estimates) and the type of lesions recorded for each of them. Lesions are separated in two main columns for healed and unhealed injuries. Each column is subdivided by type of lesions – lesions (when the origin is unknown); traumas (for bone fracture, blunt force traumas and perforations whose projectile origin is not ascertained) and PIMs (for projectile impact marks). The presence of embedded lithic artefacts in association to PIMs is also listed. UND = undeterminate; M = male; pM = probable male; pM? = possible male; F = female; pF = probable female; pF? = possible female; MA = mature; IMM = immature.

Tableau S1 *– Inventaire des individus du Jebel Sahaba, montrant leur identité biologique (diagnostic sexuel et estimation de l'âge au décès) et le type de lésions enregistrées pour chacun d'eux. Les lésions sont séparées en deux colonnes principales pour les blessures cicatrisées et non cicatrisées. Chaque colonne est subdivisée par type de lésions : lésions (lorsque l'origine est inconnue) ; traumatismes (pour les fractures osseuses, les traumatismes par objet contondant et les perforations dont l'origine par projectile n'est pas déterminée) et les PIM (pour marques d'impact de projectile). La présence d'artefacts lithiques fichés dans les ossements en association avec des MIPs est également répertoriée. UND = indéterminé ; M = homme ; pM = probable homme ; pM ? = possible homme ; F = femme ; pF = probable femme ; pF? = possible femme ; MA = mature ; IMM = immature.*

Individual	Sex	Demographic age class	Presence of lesions	Burial	Grave pit		Artefact associated (Wendorf, 1968)		New embedded artefacts (this study)
					Depth	Cover	Volume of the body	Embedded	
JS 2	UND	[5-9]	x	Disturbed	At surface				
JS 4	UND	[15-19]	x	Disturbed	15 cm	Slabs			
JS 5	pM	[> 30]	x	Individual	10 cm	Slabs			
JS 6	M	[> 30]	x	Disturbed	10 cm	Slabs			1
JS 7	pF?	[> 30]	x	Individual	25 cm				
JS 8	pF?	[> 30]	x	Double	30 cm				
JS 9	UND	[1-4]	x	Double	30 cm				
JS 10	pM?	[> 30]		Individual	30 cm				
JS 11A	pM?	[20-29]	x	Disturbed	10 cm				
JS 11B	UND	[> 30]	x	Disturbed	10 cm				
JS 11C	UND	[0-<1]		Disturbed	10 cm				
JS 12	UND	[5-9]		Individual	10 cm				
JS 13	UND	[1-4]		Double	25 cm		2		
JS 14	UND	[1-4]	x	Double	25 cm		3		1
JS 15	pF?	[20-29]	x	Individual	35 cm				
JS 16	pF?	[> 30]	x	Individual	35 cm				
JS 17	pM?	[20-29]		Individual	35 cm		1		
JS 18	pM	[> 30]		Individual	30 cm	Slabs			
JS 19	M	[> 30]	x	Individual	40 cm	Slabs			
JS 20	pM?	[> 30]	x	Double	40 cm	Slabs	6		1
JS 21	pF	[> 30]	x	Double	40 cm	Slabs	17	2¤	6
JS 22	M	[> 30]	x	Individual	40 cm	Slabs			1
JS 23	pF?	[> 30]	x	Double	10-20 cm		2	1¤	
JS 24	UND	[5-9]	x	Double	40 cm		1		
JS 25	pF?	[> 30]		Multiple	45 cm	Slabs	1¤		
JS 26	F	[> 30]	x	Multiple	30 cm	Slabs	5 (+1*)		
JS 27	UND	[1-4]		Disturbed	20 cm	On slabs			
JS 28	pF	[> 30]		Multiple	20 cm		1		
JS 29	M	[> 30]	x	Multiple	40 cm	Slabs	7		
JS 31	pM	[> 30]	x	Individual	30 cm	Slabs	15	2¤	1
JS 32	UND	[20-29]	x	Disturbed	60 cm				
JS 32b	UND	[> 30]	x	Disturbed					
JS 33	pF?	[20-29]	x	Individual	60 cm	Slabs	8		
JS 34	pF?	[> 30]	x	Multiple	60 cm	Slabs	2		
JS 35	UND	[20-29]	x	Disturbed	50 cm	Slabs	6		
JS 36	pF?	[> 30]		Individual	40 cm	Slabs			
JS 37	pF?	[> 30]	x	Multiple	60 cm	Slabs	1		
JS 37b	M	[> 30]		Multiple					
JS 38	M	[> 30]	x	Individual	60 cm	Slabs	1		
JS 39	pM	[> 30]	x	Individual	70 cm	Slabs			
JS 40	pM	[20-29]	x	Individual	70 cm	Slabs			
JS 41	pF	[> 30]	x	Individual	40 cm	Slabs	1		
JS 42	pM	[20-29]	x	Individual	35 cm	Slabs	1		
JS 43	UND	[> 30]	x	Individual	35 cm	Slabs			

Individual	Sex	Demographic age class	Presence of lesions	Burial	Grave pit		Artefact associated (Wendorf, 1968)		New embedded artefacts (this study)
					Depth	Cover	Volume of the body	Embedded	
JS 44	pF?	[> 30]	x	Individual	35 cm	Slabs	20	1	1
JS 45	pF?	[> 30]		Individual	40 cm	Slabs	1¤		
JS 46	pM	[> 30]		Disturbed	40 cm	Slabs			
JS 47	UND	[5-9]		Individual	35 cm	On slabs	1¤		
JS 48	pM	[15-19]	x	Individual	50 cm				
JS 49	pF	[> 30]		Individual	45 cm	Slabs			
JS C1	M	[> 30]	x	Multiple	At surface	Slabs	5		1
JS C2	UND	[5-9]		Multiple	At surface	Slabs			
JS C3	UND	[> 30]		Multiple	At surface	Slabs			
JS 100	UND	[5-9]		Multiple	70 cm	Slabs			
JS 100 extra	UND	[0-<1]		Multiple					
JS 101A-B	UND	[1-4]		Multiple	70 cm	Slabs			
JS 102	pF	[> 30]	x	Multiple	70 cm	Slabs	1		
JS 103	UND	[10-14]	x	Multiple	65 cm	Slabs	1	1¤	
JS 104 & JS 107	pF?	[> 30]	x	Disturbed	70-90 cm				
JS 105	UND	[10-14]	x	Individual	90 cm				
JS 106	M	[10-14]	x	Individual	60 cm	Slabs	1		

Table S2 – Inventory of Jebel Sahaba individuals with the burial characteristics and associated artefacts. UND = undeterminate; M = male; pM = probable male; pM? = possible male; F = female; pF = probable female; pF? = possible female. ¤) Artefact absent from the British Museum collection; *) additional artefact compared to the original publication.

Tableau S2 *– Inventaire des individus de Jebel Sahaba avec les caractéristiques funéraires et les artefacts associés aux tombes. UND = indéterminé ; M = homme ; pM = probable homme ; pM ? = possible homme ; F = femme ; pF = probable femme ; pF? = possible femme. ¤) artefact absent de la collection du British Museum ; *) artefact supplémentaire par rapport à la publication originale.*

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