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Megalithic Structures of the northern Sahara (Chott el Jérid, Tunisia)

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1. Introduction

One of the distinctive archaeological features of the Sahara are the megalithic structures that in thousands punctuate the desert landscape as part of a larger phenomenon of Holocene North Africa. Stone monuments built to bury animals[1], humans[2] or exclusively as landmarks[3], are found scattered over wide areas across the Sahara since the Middle Holocene, revealing a network of cultural connections among early pastoral communities. The typological variability of stone structures, reflecting a long chronological range and the local availability of raw materials, appears also to be correlated to their different functions.

Although representing dominant features of the archaeological landscape, our knowledge on megalithic structures in the Sahara is still poor, largely due to the research strategies adopted in the past, as well as to logistical and ethical factors.

Early researches appear to be geographically and temporally isolated, oriented to the typological classification of megalithic monuments[4] and to the excavation of isolated structures. These factors did not allow a full understanding of the social meanings of prehistoric and early historic funerary practices and their change over time. By contrast, more recent multidisciplinary research – such as in northern Niger[5], south-west Libya[6], or Western Sahara[7]

[1] Applegate *et al.* (2001); di Lernia *et al.* (2013); Paris (2000); Tauveron *et al.* (2009).
[2] di Lernia (2013); di Lernia, Tafuri (2013); di Lernia *et al.* (2002); Paris (1996).
[3] Brown (1995).
[4] Camps (1961); Reygasse (1950).
[5] Paris (1996).
[6] di Lernia, Manzi (2002); Liverani *et al.* (2013); Mattingly *et al.* (2007).
[7] Clarke, Brooks (2018).

– shows how a regional approach can place the funerary practices in their environmental and economic framework and the social dynamics that determined them. Besides logistics difficulties, the paucity of data from megalithic structures in the Sahara is due to their state of preservation, largely affected by natural and anthropic factors. Given their easy identification, the looting of these structures was a common practice in the past. This fact, combined to the mediocre state of skeletal material and the scarcity (if any) of grave goods, largely discouraged the scientific research. Finally, but no less important, are the ethical concerns that could emerge from the excavation of human burials and the preservation of funerary structures. Some types of tombs, such as the stone tumulus (cairn), are very common from prehistoric times until recent periods. The excavation of megalithic monuments implicates their dismantling: being routinely built using a very simple dry-stone technique, the structures are hard to be correctly rebuilt, clashing with the need of protection and conservation of the local archaeological heritage.

Extreme environmental conditions, poor state of preservation of monuments, uncertain chronological attribution on the basis of surface data and scarcity of systematic previous research are some of the major obstacles that have been tackled by the recent archaeological research carried out in southern Tunisia where, from 2015 to 2018, a multidisciplinary research project has been carried out by the *Institut National du Patrimoine* (Tunis), Sapienza University of Rome and (until May 2018) the University of Kairouan. The research program was addressed to the study of pre-protohistoric and early historic communities of southern Tunisia[8].

One specific aim of the research program was the analysis of megalithic architecture and funerary practices in the late prehistory and protohistory of the northern edges of the Sahara, barely investigated in the past. Most of the research in Tunisia was in fact traditionally focused on the northern expanses of the country, as a result of the colonial influence and of the strong interest towards dolmenic architecture[9]. In the south, the limited available information about megalithic monuments comes from the research carried out by the *Service Géographique de l'Armée Française* at the beginning of the 20th century[10] and, more recently, from studies carried out by F. Paris and M. Ghaki[11].

In this paper we present the methodological aspects of the research, from the desktop phases (published data acquisition and remote sensing analysis) to fieldwork activities (intensive surveys, stratigraphic excavation of selected monuments). GIS analysis of territorial data (desktop and field survey) and information from selected excavations are also discussed. While confirming some of the known critical aspects of investigating megalithic monuments in these regions, our results represent a further contribution to the knowledge of this phenomenon in the Tunisian Sahara.

2. Geographic setting

The whole study region consists of a large transect encompassing several physiographic units from the governorate of Kebili to that of Tataouine, in southern Tunisia (Fig. 1). The northern side is mostly occupied by the Chott el Jérid depression, the Nefzaoua region and by the Jebel Tebaga, a mountain range (476 m a.s.l.) extending from Kebili to El Hamma (Gabes). The Chott el Jérid depression, currently occupied by a salty encrusted surface, has

[8] Ben Nasr *et al.* (2016); Cancellieri, Ben Nasr (2019); di Lernia *et al.* (2017); Lucci *et al.* (2019).
[9] Ghaki (1997); Miniaoui (2013); Tanda *et al.* (2009).
[10] Miniaoui (2013).
[11] Paris, Ghaki (2010).

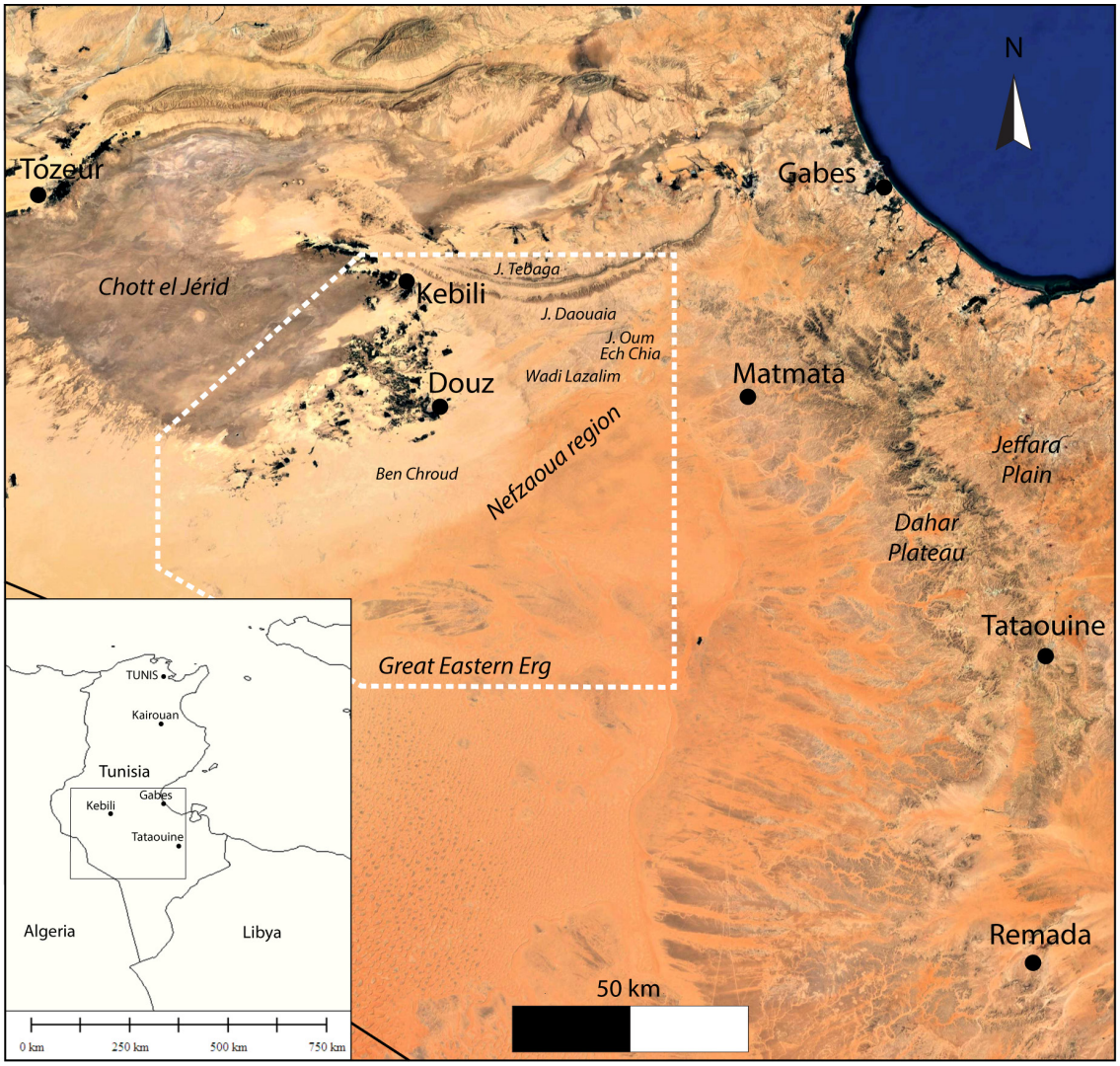

Fig. 1. Map of the research area (satellite imagery Google Earth ©). The white dashed transect indicates the extent of fieldwork activities (2015- 2018).

intermittently hosted water bodies large up to about 30,000 km² from at least the late Middle Pleistocene up to the early Holocene[12]. The southernmost side of the study area reaches the governorate of Tataouine, where the landscape is characterized by large sand dune fields in the west (Great Eastern Erg), by rocky and desiccated areas in the central portion (Dahar Plateau) and by a flat and stony landscape in the eastern edge (Jeffara plain).

Due to security measures related to the challenging socio-political situation that Tunisia experienced after the "Arab Spring" especially in years 2015-2016, field activities were confined to a radius of about 50 km south, south-east of Douz. In the region of Nefzaoua, a flat rocky area located between the Chott el Jérid, the Jebel Tebaga and the western margin of the Dahar plateau (Fig. 2 A), we have thoroughly investigated the area of Wadi Lazalim, a river system flowing from north to south draining part of the Jebel Dhaouaia (290m a.s.l.) and the plain to the south. The hills flanking the course of Wadi Lazalim have flint-bearing limestone layers whose large flint nodules attracted prehistoric communities at different times for their quality and abundance, as many scatters of lithic artefacts testify. The southernmost

[12] Drake *et al.* (2011).

Fig. 2. Main environmental contexts of the study area. A) Nefzaoua Plain. In the background is the Jebel Tebaga; B) Sand dune fields south of Chott el Jérid (Great Eastern Erg).

area investigated is characterized by highly dynamic sand dunes of variable size, dating to the Holocene. Sparse vegetation, typical of the northern edges of the Sahara, typifies the landscape (Fig. 2 B).

3. Material and Methods

3.1 *Desktop Analysis*

The fieldwork was preceded by desktop analyses aimed at data mining of published information (literature and cartographic archives), as well as by the analysis of remotely sensed data (satellite imagery). These activities were preparatory to the field research itself but were also finalized to the implementation of an integrated geodatabase designed to manage data from archives, remote sensing and field work.

Satellite data were used to collect information on the natural features of the territory under study. They also served as data-sources for analytical procedures. Elevation data (source: NASA SRTM 1 arcsec available at http://gdex.cr.usgs.gov/gdex/) and digital elevation models (DEM) allowed to obtain basic descriptive outputs, for example the altimetric characterization and the production of contour line maps, but also enabled the in depth analyses like the classification and interpretation of landforms using geomorphological processing tools available with the most widespread GIS applications (e.g. Qgis).

Desktop analyses were also carried out by both exploring satellite imagery and collecting information from published archives to reconstruct the territorial distribution of megalithic monuments. The first approach, widely adopted in the remote sensing of Saharan contexts[13], was first attempted by scouting Landsat and Google Earth© satellite imagery, while the published archives used for the initial investigation of the territorial distribution of megalithic monuments were the topographic maps produced by the *Service Géographique de l'Armée Française* (reliefs 1904-1908). There, the stone monuments are classified as "*Ruines Megalithiques*" (in English "Megalithic Ruins", hereafter MR), "*Ruines Romaines*" ("Roman Ruins", hereafter RR) and "*Ruines Arabes* ("Arab Ruins", hereafter AR) according to the instructions given by the *Comité des travaux historiques et scientifiques du Ministère de l'Instruction publique* in 1890[14]. Following the method already adopted by F. Paris and M. Ghaki[15], we have used topographic maps from the 1:100,000 coverage. After having re-projected and geo-referenced (WGS84-UTM32N) the sheets covering the study area by means of GIS software (QGIS 3.10), we have mapped all the points symbolizing the presence of monumental structures. Analytical processing was then achieved on the same GIS software platform to run a Kernel density analysis, adopting a 5 km radius[16], to better define the distribution pattern of the megalithic structures (MR), assuming that this group mostly encompassed the monuments of pre-protohistoric age. Further analysis for detailing spatial relations and clustering degrees were performed through the application of Nearest Neighbour Analysis[17] (NNA).

3.2 *Field Survey*

We surveyed one or more transects according to three main desktop-recognized geomorphological units. Fieldwork was carried out in different seasons (spring, autumn), between 2015 and 2018. The transects were progressively numbered from 1 to 6, from North to South (Fig. 3). The surveys in the flat and most accessible areas were carried out by car (team normally consisting of 4 to 6 people in three 4WD cars), along survey strips N-S oriented and 300m far apart. A combined fieldwork strategy was adopted in the mountainous areas and other contexts of difficult accessibility, alternating car surveys along the most accessible wadis and on foot surveys in the roughest and steepest areas.

Geomorphological Unit I, the northernmost investigated area, is predominantly mountainous. Four transects were here investigated in the Jebel Tebaga (T1), in the area of Scbeka (T2), in the Jebel Daouaia (T3) and in the Jebel Oum Ech Chia (234m. a.s.l.), an isolated massif located on the east side of the Nefzaoua plain (T4).

Geomorphological Unit II corresponds to an extended rocky plain between 50 and 100 m a.s.l. in the Nefzaoua region, at about 40 km east of Douz. The area is dotted with low and

[13] Biagetti, di Lernia (2008); Biagetti *et al.* (2017); Mattingly, Sterry (2013).
[14] Miniaoui (2013).
[15] Ghaki, Paris (2013); Paris, Ghaki (2010).
[16] Silvermann (1986).
[17] Baxter (2003).

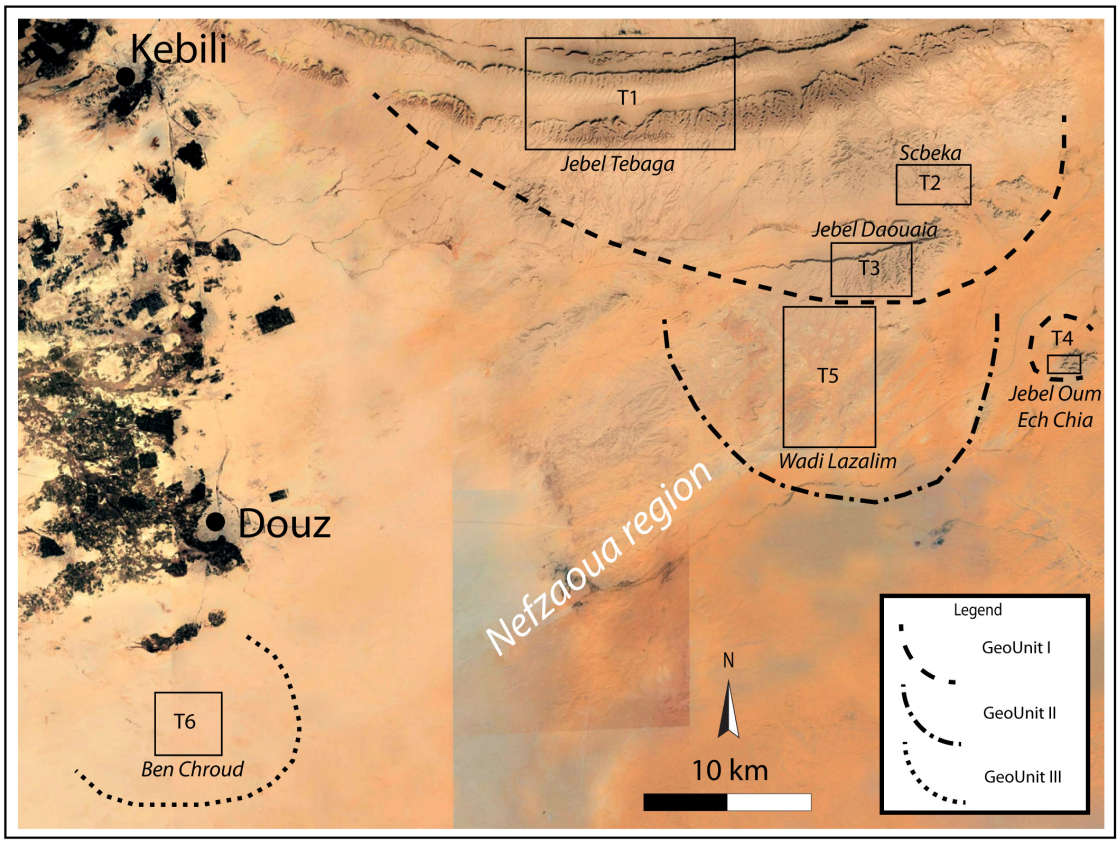

Fig. 3. Location of the transects (1 to 6) selected for intensive surveys and localization of the main Geomorphological Units (satellite imagery Google Earth ©).

isolated hills and incised by a dense network of river valleys, today barely active. Here, the fieldwork was conducted within the area of the Wadi Lazalim drainage basin (T5).

Geomorphological Unit III is located south-east of Chott el Jérid within an almost totally sandy environment characterized by the presence of low dunes separated by relatively small interdune basins and corridors. The fieldwork was conducted within transect T6, in an area called Ben Chroud.

3.3 *Excavations*

A number of structures was selected for excavation on the basis of field survey in order to stratigraphically record the structural characteristics of the monuments, the potential correlation between shape, size and function, and also to better define their chronology. Different location, typology, size and state of preservation were considered in the selection of structures to be investigated. As for the typology of stone structures, we followed the classification largely used in the Sahara[18]. The stratigraphic excavation was carried out by hand. The sediments were totally sieved (2mm mesh). In the case of structures exceeding 5 m in diameter, the excavation was limited to the central area (normally 3x3m) in order to facilitate the rebuilding of the monument. The digital recording of the excavated features was carried out using Structure from Motion (SfM) photogrammetry[19]. The point clouds, 3D models and textur-

[18] Camps (1961); synthesis in Clarke, Brooks (2018); Milburn (1993); Reygasse (1950).
[19] Lucci *et al.* (2019).

ing were processed on a daily basis using Agisoft Photoscan© software. The most significant models and/or point clouds through the excavation sequence were also processed with the Opensource Cloud-Compare software. The obtained 3D models were characterized through colour scale on the basis of the elevations. At the end of the excavations, all the monuments have been rebuilt according to their original shape and size.

4. Results

4.1 *Desktop Analysis and intensive Surveys*

Among the means adopted during desktop analyses for the remote identification of stone monuments we should first discuss that of surveying satellite imagery (Landsat and Google Earth). The resolution of these sources is largely and commonly suitable for medium and large-scale remote sensing in desert areas. Nevertheless, most of the target objects we were looking for (e.g. simple circular stone mounds) resulted not to be easily recognizable within the environmental setting of the study area. The colour of the stone clasts of the monuments, their granulometry (stones size) and geometric characteristics (monument shape and size) – namely the most common features used to identify these kinds of artefacts – are in fact hardly discernible from the natural surfaces where they are located, making this method not much remunerative in this case. The small size of the monuments prevented also their identification through DEM analyses.

Although the use of higher resolution satellite imagery and elevation data could have possibly led to better results, the large territorial scale adopted in the preliminary phase of the research, and the limits posed by the characteristics of the specific environment and its cultural heritage, discouraged it. The succeeding field check of the stone monuments, either located in sandy or rocky surfaces, and their localization on satellite imagery by means of actual GPS coordinates, further confirmed their almost total "invisibility" by remote sensing.

A preliminary territorial analysis of the presence and distribution of stone monuments in the study area was thus achieved by gathering information from published archives. To do this, as described in § 3.1, we have used maps from the 1:100.000 cartographic coverage. The four sheets encompassing the study area, as indicated in Table 1, enabled the mapping of 313 monuments, showing different incidence and representation (Tab. 1).

Table 1 – Number and type of monuments (MR: Megalithic Ruins; RR: Roman Ruins; AR: Arab Ruins) recorded in the 1:100,000 sheets encompassing the study area represented in the maps of Fig. 4.

Sheet name	Type of monument						Total	
	MR		RR		AR			
	n	%	n	%	n	%	n	%
Douz	79	94.0	5	6.0	-	-	84	100
Kebili	42	73.7	15	26.3	-	-	57	100
Oglat Merteba	77	51.3	72	48.0	1	0.7	150	100
Tamezred	3	13.6	19	86.4	-	-	22	100
Total	201	64.2	111	35.5	1	0.3	313	100

Globally, Megalithic Ruins (MR) are the most frequent structures, accounting for about 2/3 of the dataset. Roman Ruins represent the remaining 1/3, whereas the presence of Arab

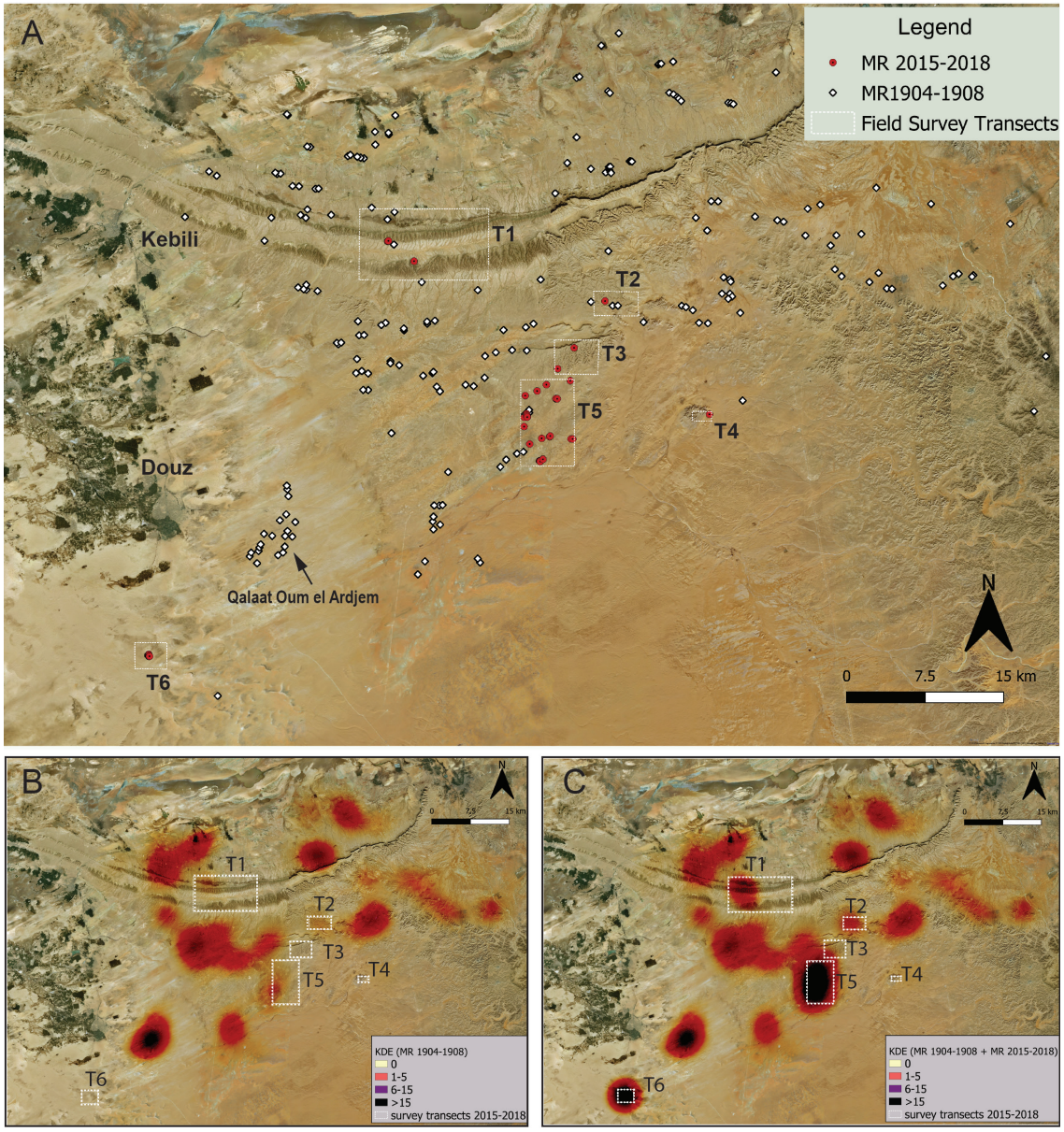

Fig. 4. A: Distribution of stone monuments in the study area according to data-set; B: density map produced on the basis of stone monuments classified as Megalithic Ruins (1904-1908) on the topographic maps 1:100.000 (see text for details); C: density map produced combining MR (1904-1908) and stone monuments identified during 2015-2018 surveys (satellite imagery Bing ©).

Ruins is almost negligible. It has to be signalled that some minor discrepancies exist when these figures are compared with those already published[20]. The Number of Megalithic Ruins reported by the colleagues and those from this study (*t.s. n*) are, per sheet: Douz = 77 (*t.s. 79*); Kebili = 40 (*t.s. 42*); Oglat Merteba = 79 (*t.s. 77*); Tamezred = 8 (*t.s. 3*); Total = 204 (*t.s. 201*). It is likely that some cartographic symbols could have gone unseen or have been misinterpreted, e.g. because of map scanning quality or difficult readability of some maps. Nevertheless, differences are small and do not affect the quantitative reliability of the catalogue, nor they hamper the aims pursued in the present study.

[20] Ghaki, Paris (2010, 2013).

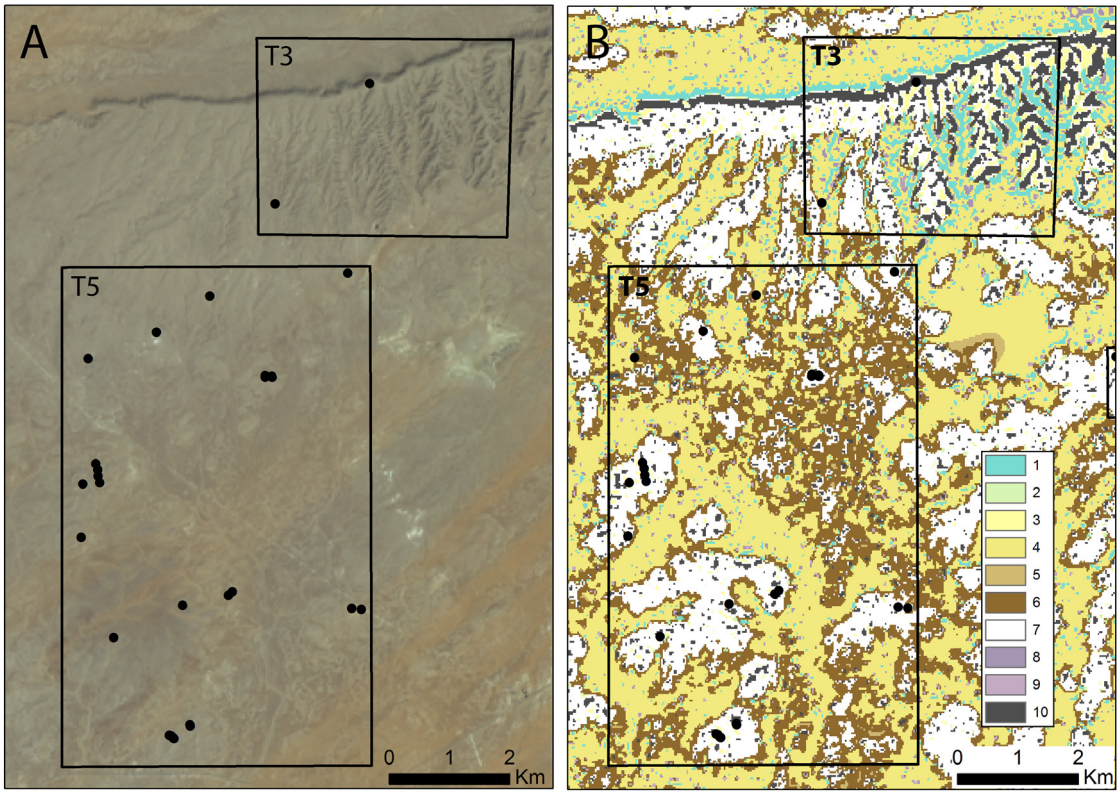

Fig. 5. A: satellite view of the area encompassing transect T3 in the Jebel Daouaia and transect T5 in the Wadi Lazalim drainage basin (satellite imagery: USGS, Landsat 8). B: Example of semi-automatic landform classification based on elevation data (DEM) of the same area as A. The position of sites identified during surveys 2015-2018, indicated by a black dot, reveals a prevalent localization in areas classified as upper slopes/mesas (Key to landform classification in B - 1: canyons, deeply incised streams; 2: midslope drainages, shallow valleys; 3: upland drainages, headwaters; 4: u-shaped valleys; 5: plains; 6: open slopes; 7: upper slopes, mesas; 8: local ridges, hills in valleys; 9: midslope ridges, small hills in plains; 10: mountain tops, high ridges).

Spatial analyses run on geospatial data gathered from published archives and from field work provided some insights on the territorial distribution of the stone monuments in the study area. The density analysis conducted by means of Kernel Density Estimation (KDE) on published datasets has shown rather high concentrations of monuments in the whole east and south-east expanses of the Chott el Jérid area, alternating with parts where they appear more scattered (Fig. 4 B). Running the same analysis by including sites from 2015-2018 surveys reveals the presence of other clusters filling some of the gaps early noted (Fig 4 C), thus suggesting that the spatial data patterning resulting from archive data only, while apparently thorough and representative of vast portions of the region, can be affected by research biases to different extents.

Nearest Neighbour Index performed on significant concentrations in some transects pointed out different spatial patterning, likely linked to the specific geomorphological features. In this regard, the localization of monuments for which a GPS localization is available (surveys 2015-2018) has been superposed to the landform classification based on elevation data (DEM) of the area encompassing transects T3 and T5, respectively in the Jebel Daouaia and in the Wadi Lazalim drainage basin (Fig. 5). The topographic position of such sites reveals a prevalent localization in areas classified as "upper slopes/mesas", thus validating a territorial distribution pattern – already inferable after field observation – in which these specific parts

of the landscape where more likely chosen to build such monuments. The same analysis was also conducted by mapping the position of monuments gathered from cartographic sources onto the landforms' classification, strengthening the hypothesis of a preferential localization of the monuments on elevated and flat areas. Nevertheless, the incertitude in the topographic positioning of the monuments and the errors introduced by the reprojection and the georeferencing of the maps – as already pointed out[21] – currently make the reliability of these observations subject to further validation and field control.

During the systematic surveys, a significant number of previously unknown structures was found (Fig. 4 A). In Geomorphological Unit I (Transect 1-4), the monuments occur either isolated or in small clusters. They are located along the courses of the main wadis, which were likely transit routes. Field observation reveals their preferential localization on slightly elevated position respect to the riverbed, or on the plateaux (Fig.4 A; Fig. 6 A, B). These occurrences are visible in the area of the Jebel Tebaga, where monuments seem to flank the main passageways (wadis) cutting the mountain ranges. The structures are mainly dome (or conical) tumulus, often plundered *ab antiquo* (Tab. 2).

Site 18/24, located on the top of the Jebel Oum Ech Chia (Transect 4), is a cluster constituted by several structures in such a poor state of preservation that neither the shape nor the real number of monuments was fully recognizable (Fig 6 C). Scatters of potsherds on the surface ranging from 2nd to 4th century AD are also recorded (Fig 6 D). The survey in the mountain areas yielded a wealth of structures not previously highlighted and suggests that the mapping made by the *Service Géographique de l'Armée Française* was likely limited to the most accessible areas, such as the plains or the foothills.

As regards the flat zones (Geomorphological Unit II), we mapped 25 previously unreported megalithic structures (mainly tumulus) in the area of Wadi Lazalim (Transect 5), in addition to the already known ones (Fig. 7A). The structures are found mainly isolated or in small clusters on the hill tops or slopes flanking the dry river valleys cutting the basin, as corroborated by the low NNI index (r=0.5; Z-score= <-2.58) indicating a certain (though low) degree of clustering in the distribution pattern. No structures were found in the main course of Wadi Lazalim (Tab. 3), likely avoided because easily subject to seasonal flooding.

The structures are made of prismatic stones of medium-large size (Tab. 3) of limestone or flint, both local. Potsherds (3rd-5th AD) are common in the immediate vicinity of several structures. Unlike the mountain areas, where the gap between the published/mapped structures and those detected during our surveys seems mostly due to accessibility factors, in Transect 5 the state of preservation played a decisive role. Several structures were looted in ancient times, showing a very poor state of preservation, often almost completely destroyed and in some cases unrecognizable. The presence of modern pastoral camps and quarries for the extraction of building materials further affects the preservation of the monuments (Fig. 7 B, C).

Finally, on the southeast side of Chott el Jérid (Geomorphological Unit III), where one of the largest concentrations of "Megalithic Ruins" (Fig. 4 A) corresponds to the necropolis of Qalaat Oum el Ardjem[22], our surveys led to the discovery of previously unreported stone monuments south of Douz (Transect 6).

One of the most important contexts is the necropolis of Ben Chroud (Site 15/11), identified during the 2015 field mission and subsequently selected for detailed investigations[23].

[21] Ghaki, Paris (2013).
[22] Paris, Ghaki (2010).
[23] di Lernia *et al.* (2017); Lucci *et al.* (2019).

Fig. 6. Mountain sites (Geomorphological Unit I). A) Tumulus 18/26 (Scbeka); B) Tumulus 17/23 (Jebel Tebaga); C) Necropolis 18/24 (Jebel Oum Ech Chia); D) Surface pottery (Site 18/24). A) and B) scale is 0.5 m.

Table 2 – Structures attested in Geomorphological Unit I (Transect 1,2,3,4). Stone Size: Small) up to 10 cm; Medium) > 10 cm and up to 25 cm; Big) > 25 cm; State of Preservation: A) good; B) average; C) bad; Surface pottery: -) absent; +) present (1 sherd); ++) common (up to 5 sherds); +++) frequent (> 5 sherds).

Site	Structure	Transect	Location	Coordinates		Type of structure	Shape	Stone type	Diameter (m)	Height (m)	State of preservation	Surface pottery
17/23	T1	1	Tebaga	33,694648	9,249904	Tumulus	dome	big size irregular blocks	5.0	0.6	A	++
17/23	T2	1	Tebaga	33,694648	9,249904	Platform	simple	big size irregular blocks	3.0	0.3	A	++
17/23	T3	1	Tebaga	33,695096	9,250772	Bazina	simple	med/big size irregular blocks	7.0	0.9	A	++
17/23	T4	1	Tebaga	33,694738	9,250311	Tumulus	ND	big size irregular blocks	6.0	0.5	C	++
17/23	T5	1	Tebaga	33,694738	9,250311	Tumulus	ND	big size irregular blocks	6.0	0.5	C	++
17/24	T1	1	Tebaga	33,677469	9,277236	Corbeille	simple	med/big slabs/block	1.5	0.3	B	-
18/26	T1	2	Scbeka	33,642505	9,474029	Tumulus	dome	big size irregular blocks	4.0	0.4	A	-
18/26	T2	2	Scbeka	33,642505	9,474029	Tumulus	dome	big size irregular blocks	4.0	0.4	B	-
18/11	T1	3	Daouaia	33,584273	9,424965	Tumulus	ND	big size slabs	ND	ND	C	-
18/1	T1	3	Daouaia	33,602252	9,441938	Tumulus	dome	big size irregular block	4.0	0.5	B	-
18/24*	ca.10	4	Oum Ech Chia	33,544279	9,581033	Tumulus	ND	med/big size irregular block	ND	ND	C	+++

* almost completely destroyed

Table 3 – Structures found in Geomorphological Unit II (Transect 5). Stone Size: Small) up to 10 cm; Medium) > 10 cm and up to 25 cm; Big) > 25 cm; State of Preservation: A) good; B) average; C) bad; Surface pottery: -) absent; +) present (1 sherd); ++) common (up to 5 sherds); +++) frequent (> 5 sherds). The structures selected for excavations are indicated by *.

Site	Structure	Transect	Location	Coordinates		Type of structure	Shape	Stone type	Diameter (m)	Height (m	State of preservation	Surface pottery
*17/3	T1	5	Lazalim	33,525675	9,416271	Tumulus	dome	small/med size irregular blocks	8.0	0.7	A	+
17/4	T1	5	Lazalim	33,54362	9,39311	Tumulus	dome	small/med size irregular blocks	8.0	1.0	B	++
17/4	T2	5	Lazalim	33,54266	9,39338	Tumulus	dome	small/med/big size irregular blocks	6.0	0.8	B	++
17/4	T3	5	Lazalim	33,54457	9,39303	Tumulus	dome	med/big size irregular blocks	6.0	0.5	B	++
17/4	T4	5	Lazalim	33,54545	9,3927	Tumulus	dome	medium size irregular blocks	5.0	0.4	A	++
17/5	T1	5	Lazalim	33,561182	9,391378	Tumulus	ND	big size slabs/ blocks	4.5	0.9	C	++
17/6	T1	5	Lazalim	33,565113	9,403639	Tumulus	dome	big size irregular blocks	5.0	0.4	B	+
17/7	T1	5	Lazalim	33,570519	9,413189	Tumulus	dome	big size irregular blocks	5.0	0.7	B	++
17/8	T1	5	Lazalim	33,52352	9,44005	Tumulus	dome	small/med size irregular blocks	9.0	0.8	A	-
17/8	T2	5	Lazalim	33,52366	9,43834	Tumulus	ND	small size irregular blocks	5.0	0.3	C	-
17/8	T3	5	Lazalim	33,52366	9,43834	Tumulus	ND	med/big size irregular blocks	3.0	0.3	C	-
17/11	T1	5	Lazalim	33,55859	9,42306	Tumulus	ND	medium size irregular blocks	3.0	0.4	C	++
17/11	T2	5	Lazalim	33,55831	9,423	Tumulus	ND	medium size irregular blocks	3.5	0.3	C	++
17/11	T3	5	Lazalim	33,55832	9,4243	Tumulus	ND	medium size irregular blocks	4.0	0.3	C	++
17/11	T4	5	Lazalim	33,55832	9,4243	Tumulus	ND	medium size irregular blocks	4.0	0.4	C	++

follows

Site	Structure	Transect	Location	Coordinates		Type of structure	Shape	Stone type	Diameter (m)	Height (m	State of preservation	Surface pottery
17/11	T5	5	Lazalim	33,55845	9,42424	Tumulus	dome	med/big size irregular blocks	5.0	0.5	B	++
*17/13	T1	5	Lazalim	33,524238	9,408106	Tumulus	dome	medium size irregular blocks	4.0	0.3	A	-
17/15	T1	5	Lazalim	33,519423	9,395745	Tumulus	dome	med/big size irregular blocks	12.0	1.0	A	+
*17/16	S1	5	Lazalim	33,534460	9,390037	U-Str.	'Fatima'tent	big size irregular blocks	2.5 x2.5	0.3	B	-
17/17	T1	5	Lazalim	33,542456	9,390322	Tumulus	dome	medium size irregular blocks	6.0	0.4	A	-
17/19	T1	5	Lazalim	33,50425	9,40649	Tumulus	dome	small/med size irregular blocks	5.8	0.3	B	-
17/19	T2	5	Lazalim	33,50435	9,40632	Tumulus	dome	small/med size irregular blocks	6.0	0.3	B	-
17/19	T3	5	Lazalim	33,50468	9,40599	Tumulus	dome	small/med size irregular blocks	5.5	0.3	B	-
17/19	T4	5	Lazalim	33,50479	9,40567	Tumulus	dome	small/med size irregular blocks	5.8	0.5	B	-
17/20	T1	5	Lazalim	33,50614	9,40939	Tumulus	conical	med/big size irregular blocks	12.0	1.6	B	++
17/20	T2	5	Lazalim	33,50636	9,40932	Tumulus	dome	med/big size irregular blocks	7.0	0.4	B	++
17/47	T1	5	Lazalim	33,573869	9,437895	Tumulus	dome	medium size irregular blocks	9.0	0.8	A	-
*16/26	T1	5	Lazalim	33,526220	9,416990	Tumulus	conical	med/big size irregular blocks	6.0	0.8	A	+

The site is located on a slightly elevated area in a dune landscape. The necropolis is composed of 15 tumuli, arranged in two main clusters set apart by a natural corridor lacking any archaeological evidence (Fig. 8). The tumuli range in size from 3 to 10 m in diameter and are not more than 1 m high (Tab. 4).

The structures are made of gypsum blocks extracted from local outcrops. They appeared in a good state of preservation, with shape and size clearly readable. Nevertheless, the excavation of some of them (see § 4.2) revealed their looting in ancient times. On the surface we found fragments of pottery dating to the first centuries AD, but not directly associated to the structures. The general mapping of the site was followed by the acquisition of a comprehensive sequence of pictures for 3D photogrammetric models of its highest portion.

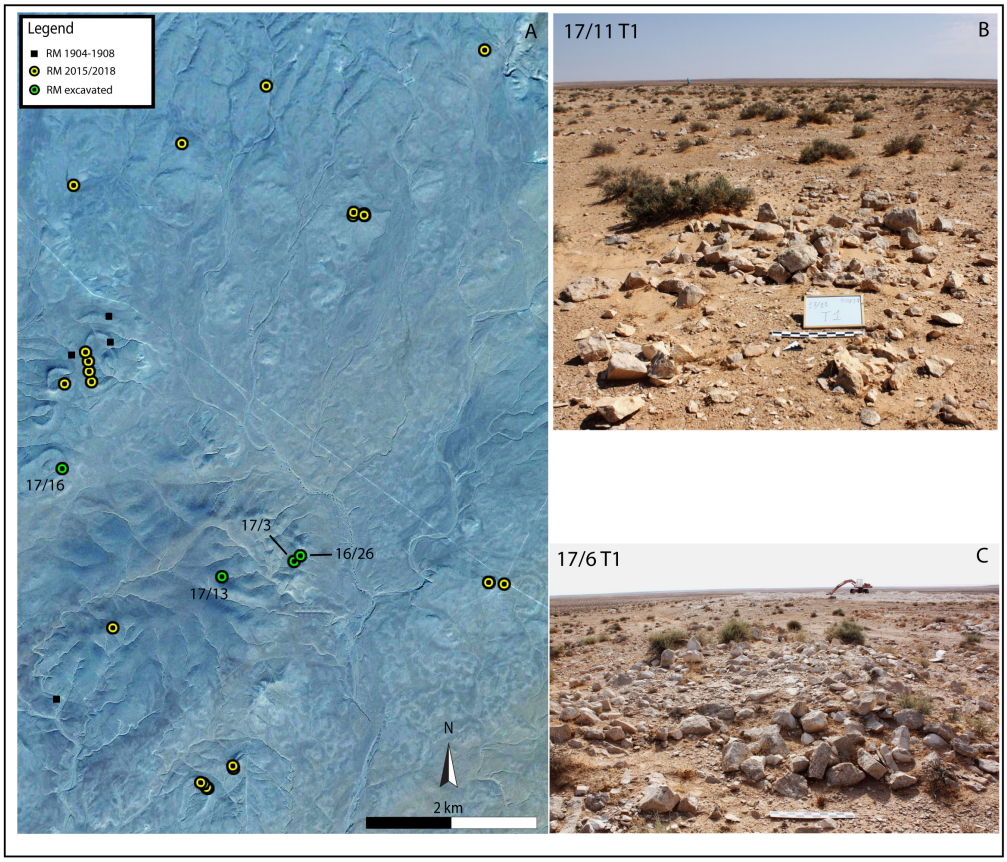

Fig. 7. Transect 5, Wadi Lazalim: A) MR distribution; B-C) Examples of the poor state of preservation of the structures (satellite imagery Google Earth ©).

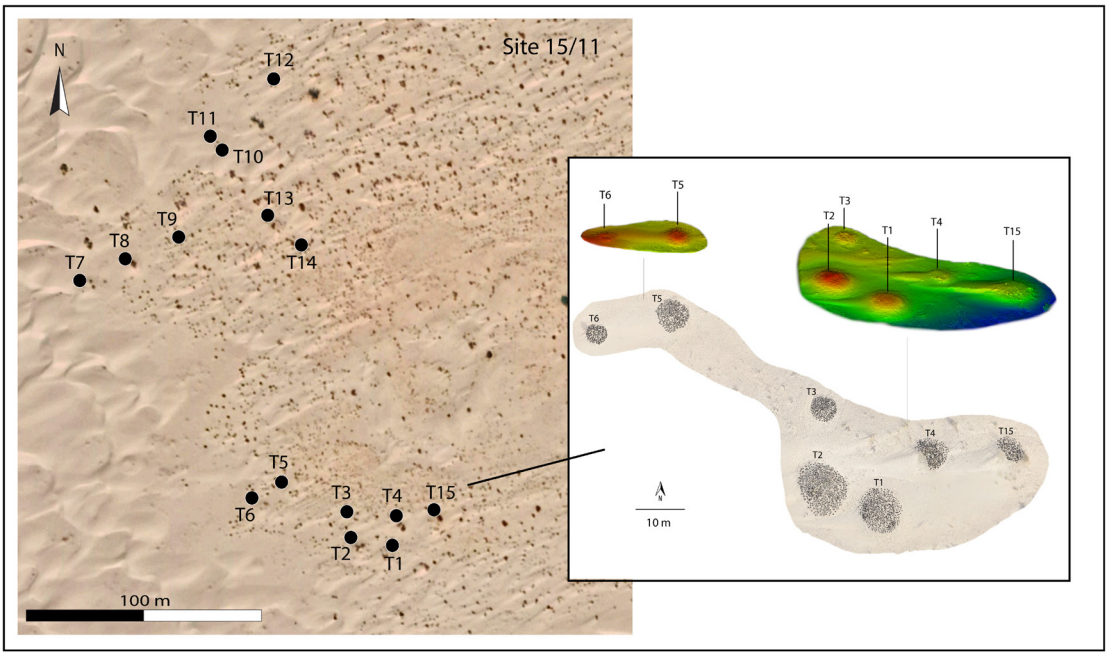

Fig. 8. Necropolis of Ben Chroud (site 15/11) with 3D mapping of the southern portion (satellite imagery Google Earth ©).

Table 4 – Structures attested in Geomorphological Unit III (Transect 6), all belonging to the 'necropolis' of Ben Chroud. Stone Size: Small) up to 10 cm; Medium) > 10 cm and up to 25 cm; Big) > 25 cm; State of Preservation: A) good; B) average; C) bad. The structures selected for excavations are indicated by *.

Site	Structure	Transect	Coordinates		Type of structure	Shape	Stone type	Diameter (m)	Height (m)	State of preservation
15/11	T1	6	33,336698	9,004051	Tumulus	dome	medium size irregular blocks	9.0	0.7	A
15/11	T2	6	33,336728	9,003855	Tumulus	conical	small size irregular blocks	10.0	0.9	A
*15/11	T3	6	33,336822	9,003840	Tumulus	dome	small size irregular blocks	3.0	0.7	A
15/11	T4	6	33,336806	9,004059	Tumulus	dome	small size irregular blocks	5.0	0.5	A
*15/11	T5	6	33,336928	9,003532	Tumulus	dome	medium size irregular blocks	6.0	0.8	A
15/11	T6	6	33,336875	9,003411	Tumulus	dome	small size irregular blocks	4.0	0.4	A
15/11	T7	6	33,337701	9,002607	Platform	simple	small size irregular blocks	4.5	0.3	B
15/11	T8	6	33,337779	9,002810	Tumulus	ND	small/medium irregular blocks	ND	ND	C
15/11	T9	6	33,337862	9,003054	Tumulus	dome	small/medium irregular blocks	5.0	0.4	B
15/11	T10	6	33,338213	9,003245	Tumulus	dome	small/medium irregular blocks	3.0	0.3	B
15/11	T11	6	33,338252	9,003195	Tumulus	dome	medium size irregular blocks	2.5	0.3	A
15/11	T12	6	33,338483	9,003478	Tumulus	dome	big size irregular blocks	4.5	0.5	B
15/11	T13	6	33,337960	9,003460	Tumulus	conical	medium size irregular blocks	6.0	0.7	A
15/11	T14	6	33,337846	9,003613	Tumulus	conical	small/medium irregular blocks	5.5	0.6	A
15/11	T15	6	33,336832	9,004233	Tumulus	dome	small size irregular blocks	6.5	0.8	B

4.2 *Excavations*

4.2.1 *The Structures of Wadi Lazalim*

Given the relative high number of new features identified within Wadi Lazalim's Transect 5, we selected 4 structures of different shape and size, in order to assess relevant features of the monuments.

16/26 T1

Tumulus 16/26 T1 is conical in shape and is 6 m in diameter and 0.8 m in height (Fig. 9 A). A 3x3 m central area was investigated. The structure is composed of an uneven accumulation of medium-sized prismatic stones (Tab. 3) of locally available raw material (limestone and flint nodules). These lay directly on the natural gypsum crust bank that characterizes the entire area (Fig. 9 B, C). The gypsum bank was intact (no chamber/pit). Only a few fragments of "common African" pottery were found: they belong to the same vessel and date to the 3rd century AD.

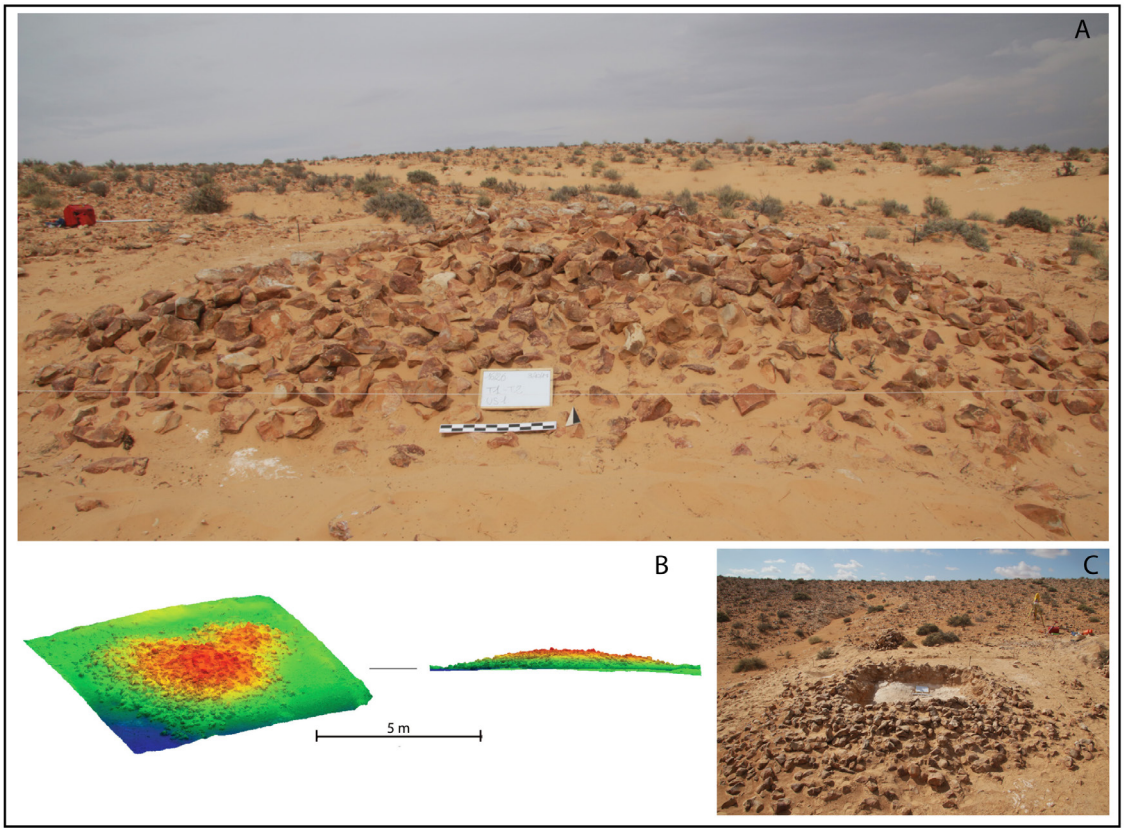

Fig. 9. View (A) of Site 16/26 T1 (scale 0.5m); B) 3D photogrammetric model; C) Tumulus at the end of excavation.

17/3 T1

Tumulus 17/3 T1 is dome-shaped, 8 m in diameter and 0.7 m high (Fig. 10 A). It is located about 100 m away from tumulus 16/26 T1, at the top of a small hill overlooking a large part of Wadi Lazalim' western drainage basin. The structure is mainly composed of medium-sized flint nodules (Tab. 3). Several pottery and bronze fragments were found scattered

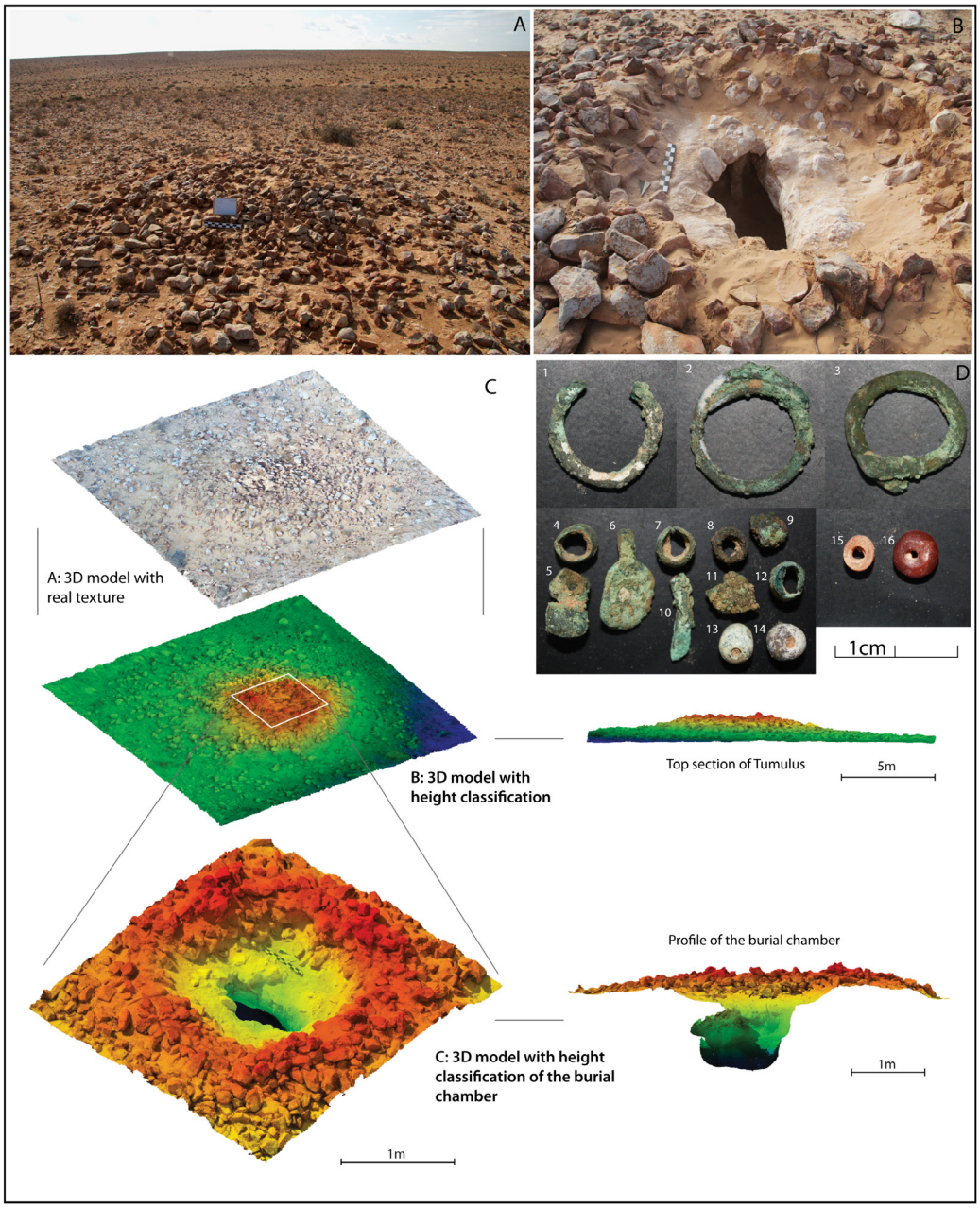

Fig. 10. View (A) of Site 17/3 T1; B) Funerary chamber cut in the bedrock; C) 3D photogrammetric model of the tumulus and the funerary chamber; D) Grave goods found in the tumulus (1,2,3: copper rings; 4,7,12: copper beads; 8: iron bead; 9: iron element not determinable; 5,6: copper flattened elements not determinable; 10,11: copper elements not determinable; 13,14: glass paste perforated beads.

within the stone layers of the tumulus. At the base of the central trench (2x2m), the burial chamber (1 m length, 0.5 m width and 0.9 m depth) was cut into the gypsum crust substrate (Fig. 10 B, C) and mainly filled with fine aeolian sand. Some large slabs of gypsum, found within the chamber infilling, were most likely used to seal the access to the burial pit, or the chamber itself.

The burial chamber filling released a child phalanx together with some grave goods, such as copper items (e.g. rings), iron beads (6), glass paste beads (5), and several '*sigillata*' African fragments (12), all belonging to the same vessel and chronologically referable to the 4th-5th

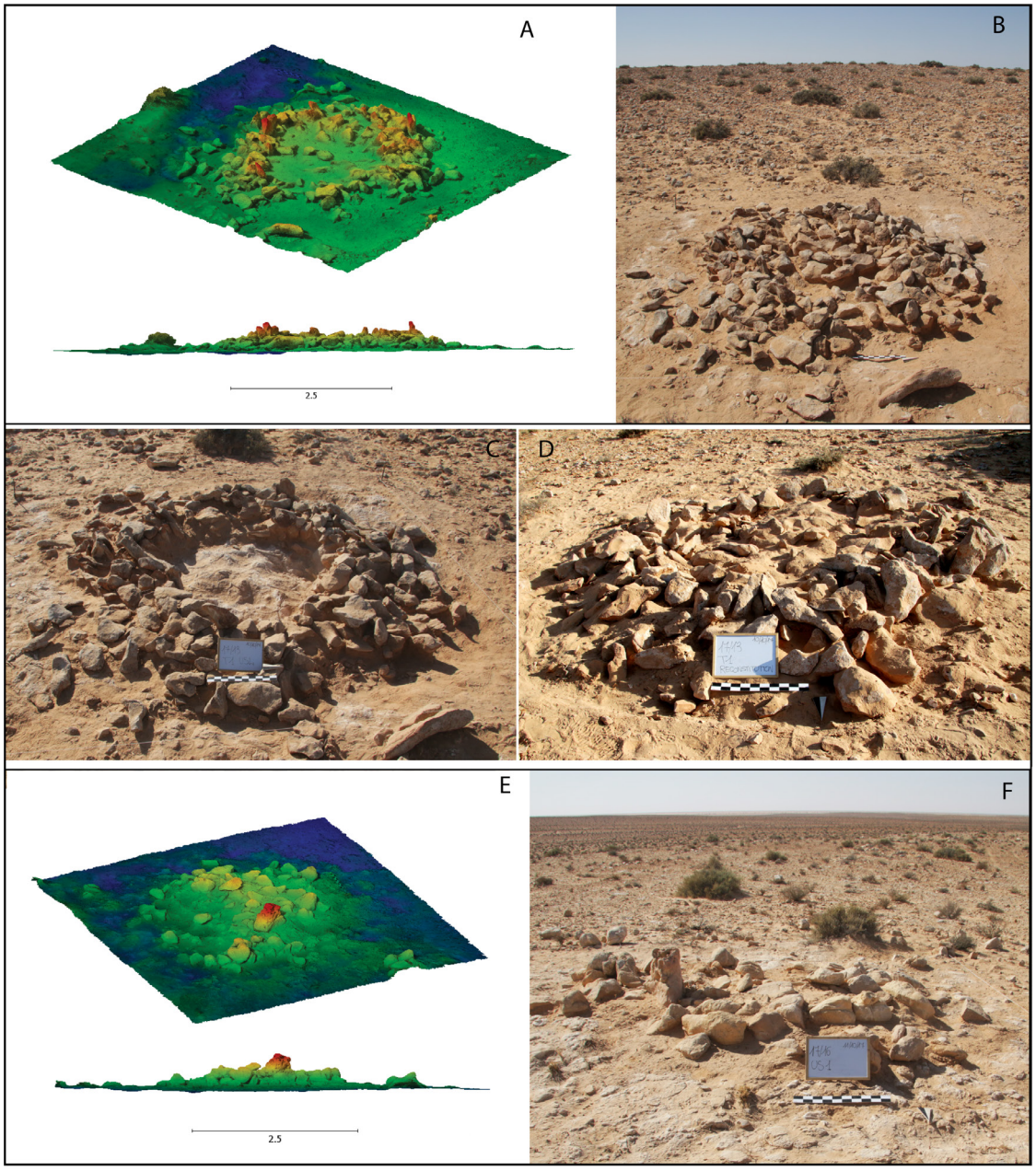

Fig. 11. A) 3D photogrammetric model of Tumulus 17/13; B) Tumulus 17/13 after removal of surface aeolian sand; C) Tumulus 17/13 at the end of excavation; D) Tumulus 17/13 rebuilt; E) Photogrammetric model of Site 17/16 "Fatima Tent"; F) Site 17/16 after removal of surface aeolian sand.

century AD (Fig. 10 D). The features of the chamber's filling and the arrangement of the few grave goods suggest the looting of the tomb *ab antiquo*.

17/13 T1

The structure 17/13 T1 is a monument of circular shape of about 4 m in diameter and 0.3 m in height (Fig. 11 A, B). The stones laid directly on the gypsum crust, where no burial chamber nor other features were present (Fig. 11 C). No archaeological materials were found. The monument was rebuilt according to its original shape and size (Fig. 11 D).

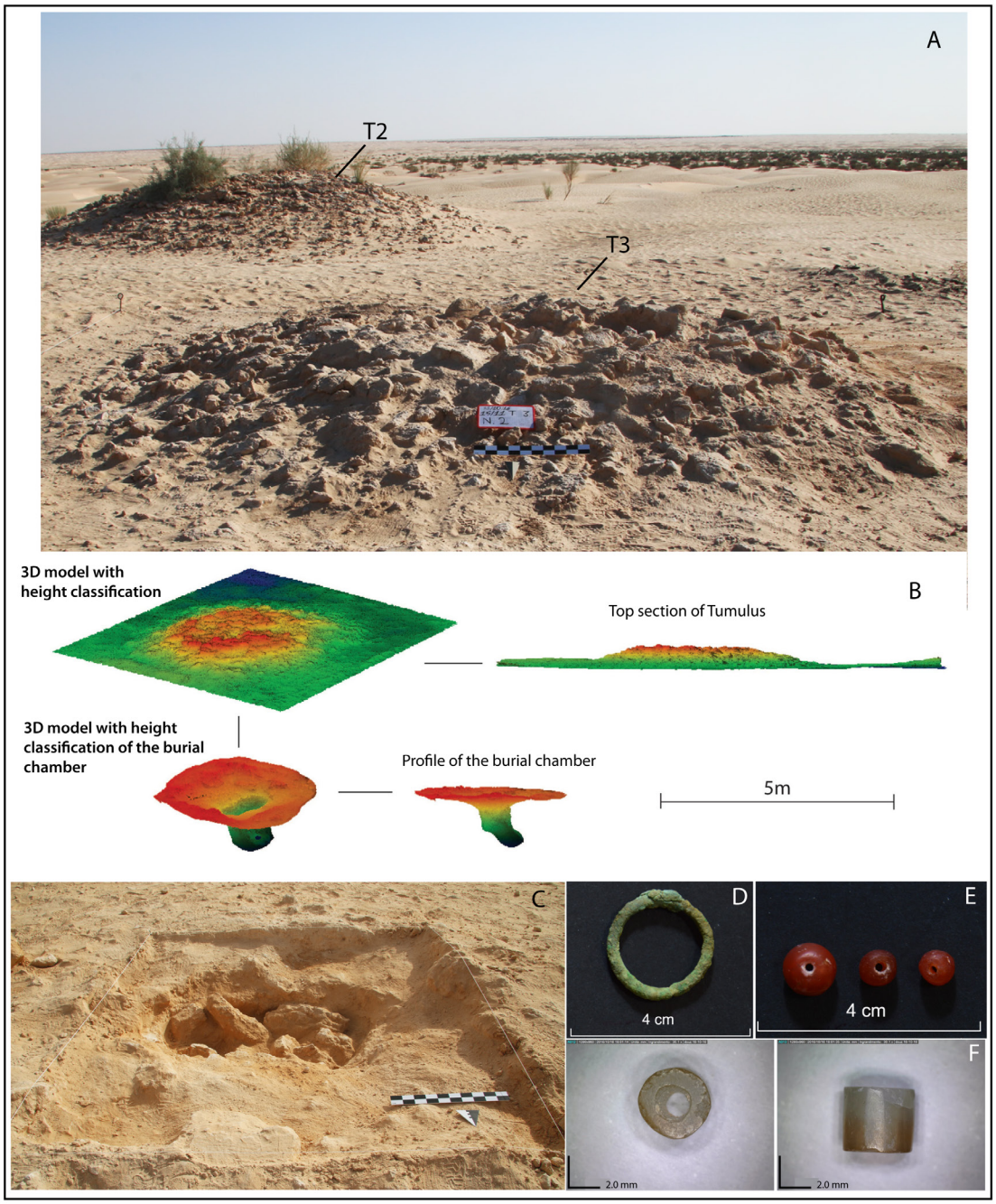

Fig. 12. Ben Chroud (Site 15/11). A) Tumuli 15/11 T2 and T3; B) 3D photogrammetric model of T3 and of its burial chamber; C) Detail of the closure of T3 burial chamber; D-E-F) Grave goods found in T3 (D: Copper ring; E: Perforated glass paste globular beads; F: Perforated glass paste tubular bead).

17/16 T1

The structure 17/16 T1 is a quadrangular monument of about 2.5 m per side (Fig. 11 E, F), with a central platform of medium-large stones (Tab. 3). This type of structure is commonly referred to as "Fatima Tent"[1]. The removal of the first layer of stones immediately brought to light the gypsum crust bank, where no artificial cuts were identified. Archaeological materials were absent.

[1] Milburn (1993).

4.2.2 *The Necropolis of Ben Chroud (Site 15/11)*

The number of structures and the overall apparent good state of preservation of this site led to the excavation of two structures (T3 and T5), both of tumulus-type but of different sizes.

15/11 T3

Tumulus T3 is a dome-shaped structure 3 m in diameter and 0.7 m high (Fig. 12 A). The stratigraphic sequence consists of several layers of stones unevenly arranged above the burial chamber, which was cut in the gypsum crust bank (Fig. 12 B). The chamber revealed a sub rectangular shape (1.4 m in length, 0.6 m in width and 1 m in depth) and uncoated raw walls: it was filled with stones and fine aeolian sand (Fig. 12 C). Ornamental glass paste beads and a copper ring were found within the filling of the chamber (Fig. 12 D-F). No skeletal remains were found. On the basis of the few grave goods, mostly personal ornaments, the structure can be dated to 3rd-5th century AD.

15/11 T5

Tumulus T5 is dome- shaped, 6 m in diameter and 0.8 m high (Fig. 13 A). Due to the size of the structure, we excavated a sample area (3x2 m) in its central portion. As in Tumulus T3, different layers of unevenly arranged stones were found, covering a sub-rectangular burial

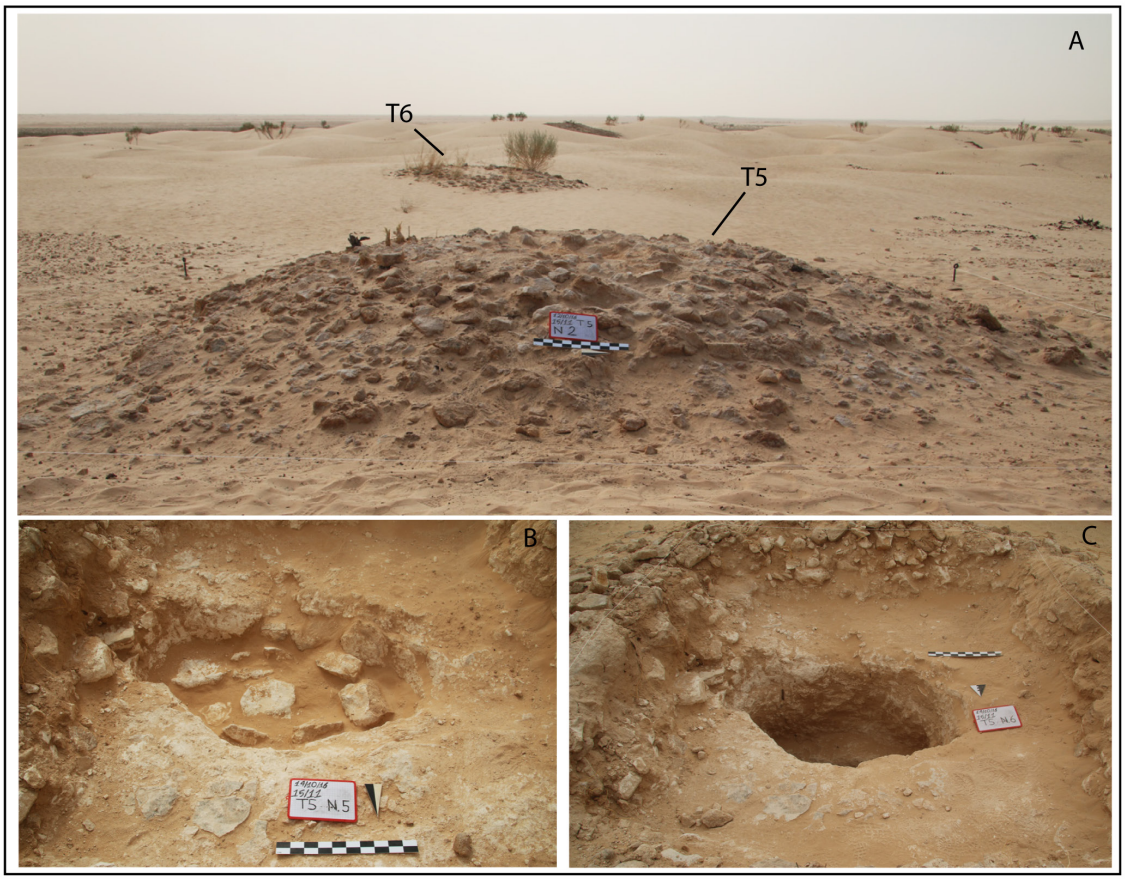

Fig. 13. Ben Chroud (Site 15/11). A) Site 15/11 T5 with T6 in the background; B) Detail of the closure of the burial chamber T5 and C) the burial chamber at the end of excavation.

Tab. 5 – Number and incidence of stone monuments by transect according to architectural typology.

Type	GeoUnit I								GeoUnit II		GeoUnit III		Total	
	Tr. 1		Tr. 2		Tr. 3		Tr. 4		Tr. 5		Tr. 6			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Bazina	1	11	-	-	-	-	-	-	-	-	-	-	1	2
Corbeille	1	11	-	-	-	-	-	-	-	-	-	-	1	2
U-Structure	-	-	-	-	-	-	-	-	1	3			1	2
Platform	1	11	-	-	-	-	-	-			1	7	2	3
Tumulus	3	33	2	50	2	100	1	100	27	84	14	93	49	78
MR(*Ruines Megalithiques)*	3	33	2	50	-	-	-	-	4	13	-	-	9	14
Total	9	100	4	100	2	100	1	100	32	100	15	100	63	100

chamber (1.5 m in length, 0.9 m in width and 1.15 m in depth), that was cut in the gypsum crust bank (Fig. 13 B-C). The chamber was empty, likely looted in ancient times.

5. Discussion

Megalithic structures, mainly tumuli, are common in all the geomorphological units identified, with high densities recorded in the region close to the Chott el Jérid basin. Although our excavations only rarely found evidence of human burials, it is possible that many of the monuments were built for funerary purposes.

In the area of Wadi Lazalim (Geomorphological Unit II, Transect 5) we mapped 28 monuments, with only 3 published in historical cartography. A similar situation can be observed in Geomorphological Unit III (Transect 6), with 15 mapped structures not previously known. Although most of the tumuli appear to have been looted in ancient times, the state of preservation of the monuments allowed their typological classification (Tabs. 2-5). Tumuli are the most common architectural typology, making up about 80% of the dataset. Nevertheless, the mountain areas seem to present a greater variability of types, with bazinas, corbeilles and platform type structures having been identified in Transect 1 (Tab. 5). The six structures excavated (4 in the Wadi Lazalim area and 2 in the necropolis of Ben Chroud) provided some information on the monuments' function and on some aspects of the funerary practices. The stratigraphic investigation revealed the existence of monuments with different organization, from structures with burial chamber cut in the bedrock, to stone mounds without any chamber. The tumuli 15/11 T3, 15/11 T5 and 17/3 T1, all plundered *ab antiquo*, show similar architectural features: the structure is made of an accumulation of mainly medium-sized stones arranged in a conical or domed fashion covering a more or less shallow burial pit cut in the bedrock. On the basis of pottery features found in the structures, their last use could be dated to the 4th-5th century AD, an age consistent with surface materials[24].

The excavated monuments of our study area are different from those studied by F. Paris and colleagues in the necropolis of El Menaguib, in the Jeffara area. But for a stone tumulus of prehistoric age, dated between the 4th and 3rd millennium BC, showing a burial chamber excavated in the calcareous bench with raw walls, the other structures were architecturally

[24] Peacock *et al.* (1990).

more complex and dated between the end of the 1st century BC and the 2nd century AD[25]. The excavation of the tumulus in the Nefzaoua region, integrated with the data collected by F. Paris and M. Gakhi in the Jeffara area to the east, shows a certain continuity of funerary behaviour, at least with regard to the morphological aspects of the structures, from the end of the 4th millennium BC until the 5th century AD.

As elsewhere in the Sahara[26], we record here the impossibility to distinguish pre-protohistorical monuments from historical ones on the basis of architectural features only. This circumstance may nevertheless reflect the persistence of social and cultural features deeply rooted in the populations that occupied the region through the centuries. Funerary customs, though time contingent and culture-specific, suit well to mechanism of emulation and memory reiteration and conservation, which to some extent may explain long-lasting traditions. This said, the few chronological data here available point to an intense occupation of the area between the last centuries BC and the first centuries AD. The structures without any archaeological content are difficult to define, functionally and chronologically; however, they could be considered either landmarks or cenotaphs.

Overall, quantity and density of stone monuments indicate a densely populated region. A transit zone on the northern edge of the Sahara, rich of water supplies and arable areas. In addition, it was strategically located along the caravan routes between the Mediterranean coast and the Sahara, which were active until the last centuries[27].

Although poorly preserved and providing few anthropological and archaeological data, the stone monuments of the late protohistory and historical age of the Chott el Jérid region and surrounding areas are a critical component of the Tunisian cultural heritage, in great danger from anthropic pressure and from development activities. A better knowledge, an understanding of their historical meaning and an adequate awareness among local communities and institutions can hopefully allow their preservation and protection.

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[25] Paris, Ghaki (2010).

[26] Clarke, Brooks (2018); di Lernia, Manzi (2002); Gatto *et al.* (2019).

[27] Mattingly *et al.* (2017).

Desktop study, survey and field activities have been conceived and designed by SDL. Fieldwork has been led by JBN, SDL and AM. All the team took part to the survey and excavation of the stone structures. SDL and AM wrote the paper; EL implemented the photogrammetry; MJ advised on pottery and other grave goods; EC and RR made GIS analysis. All Authors contributed equally to the discussion and approved the paper.

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Riassunto /*Abstract*

Riassunto: I monumenti megalitici sono una caratteristica archeologica distintiva del paesaggio sahariano. Partendo da una base piuttosto limitata di lavori editi, e nell'ambito di un programma di ricerca dedicato al Sahara settentrionale, abbiamo avviato nel 2015 un'indagine territoriale sui monumenti in pietra della pre-protostoria e della storia antica della Tunisia meridionale. L'area di studio selezionata è localizzata a est e a sud-est della depressione del Chott el Jérid (governatorato di Kebili). In questo lavoro viene presentata la strategia di ricerca adottata, modulata sulle specifiche caratteristiche locali, quali il pessimo stato di conservazione dei monumenti e la loro incerta cronologia. I nostri risultati, basati sulla combinazione di analisi di telerilevamento, ricognizioni di superficie e scavi di alcuni monumenti, evidenziano una densa occupazione di questa regione del Sahara settentrionale, dove edifici monumentali di possibile funzione funeraria si collocano cronologicamente dalla tarda preistoria fino all'età romana. L'uso persistente dell'area in un arco di tempo molto lungo ne conferma la posizione centrale nelle antiche vie di collegamento transahariane.

Abstract: Megalithic monuments are a distinctive archaeological feature of Saharan landscape, as indicated by different systematic research projects undertaken so far. Starting from a very low baseline of previous archaeological research, and as part of a comprehensive research programme focussed on northern Sahara, we launched in 2015 a territorial investigation of stone monuments of the pre-protohistory and early history of southern Tunisia. To do this, we selected a sample study area east and south-east of the Chott el Jérid depression (Kebili region) where to conduct field research. In this paper we present the research strategy adopted, planned to address some issues such as the poor state of preservation of the monuments or their uncertain chronology, also known from other parts of the Sahara. Our results, based on the combination of remote sensing analysis, field survey and selected excavations, highlight a dense occupation of this area of northern Sahara, where monumental buildings of possible funerary function tentatively trace back to the late pre-protohistory up to the roman age. The persistent use of the area across a long-time span corroborates its pivotal location in ancient trans-Saharan connection routes.

Parole chiave: Sahara; tardo Olocene; strutture megalitiche; archeologia funeraria; telerilevamento; indagine sul campo e scavi

Keywords: Sahara; Late Holocene; Megalithic Structures; Funerary Archaeology; Remote Sensing; Field Survey & Excavations

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