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The ramparts of Khaybar. Multiproxy investigation for reconstructing a Bronze Age walled oasis in Northwest Arabia

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ABSTRACT

The multidisciplinary investigation carried out between 2020 and 2023 by the Khaybar Longue Durée Archaeological Project (CNRS-RCU-AFALULA) demonstrates that the Khaybar Oasis was entirely enclosed by a rampart in pre-Islamic times, like several other large regional walled oases in north-western Arabia (Tayma, Qurayyah, Hait, etc.). The cross-referencing of survey and remote sensing data, architectural examinations and the dating of stratified contexts have revealed a rampart initially some 14.5 km long, generally between 1.70 m and 2.40 m thick, reinforced by 180 bastions. Preserved today over just under half of the original route (41 %, 5.9 km and 74 bastions), this rampart dates back to the Bronze Age, between 2250 and 1950 BCE, and had never been detected before due to the profound reworking of the local desert landscape over time. This crucial discovery confirms the rise of a walled oasis complex in northern Arabia during the Bronze Age, a trend that proved to be central to the creation of indigenous social and political complexity.

1. Introduction

Walled oases are a key component of the archaeological landscape and the socio-political evolution of north-western Arabia through time (Charloux et al., 2021a; Luciani, 2021, Fig. 1). In contrast to looser defensive systems of fortresses, isolated towers or city walls implanted in “open oases” (e.g., Fiema and Villeneuve, 2018 (Hegra); Charloux et al., 2021b (al-Bad), the monumental defensive system of walled oases is characterized by an agricultural and sedentary territory in the desert entirely protected by an external enclosure wall. Studies of the two long-known walled oases of Tayma and Qurayyah had previously shed light on the presence of these monumental enclosure walls, reaching up to around 19 km in length at Tayma (Parr et al., 1970; Abu-Duruk, 1986; Edens and Bawden, 1989; Hausleiter, 2018). The presence of a “new” walled oasis of Khaybar had only been previously suspected by the examination of satellite imagery, and has emerged in the context of a re-evaluation of oasis fortifications in north-western Arabia (Charloux et al., 2021a; Schneider, 2010; Schneider, 2016; Klasen et al., 2011;

Hausleiter, 2018; Hausleiter et al., 2019; Luciani, 2019; Luciani, 2021; Lüthgens et al., 2023; Villeneuve, 2014;). The recent study of satellite images enabled the identification of four walled oases - Khaybar in addition to Huwayyit, Dumat al-Jandal and Hait (and more recently Al-Wadi, Al-Ayn (Dalton et al., 2021), and al-Tibq). These were part of an original regional development process, possibly inspired by the urban trajectory of the southern Levant (Charloux et al., 2021a). This indigenous defensive system seems to characterize the emergence of a process of urbanization and oasis protection in north-western Arabia during the Bronze Age (Charloux et al.). Later, in the Iron Age, this phenomenon persisted, through redevelopment or new constructions, and played a major role in the rise of the caravan kingdoms.

No rampart walls had previously been identified at Khaybar, apart from the famous Islamic-period fortresses located on mesas in the centre of the oasis' great wadis (Charloux et al., 2022; Alshilali, 2019). In addition to the numerous methodological difficulties arising from the dismantled state of the walls, the distances considered, the difficulty of the terrain and, of course, a starting hypothesis based solely on satellite

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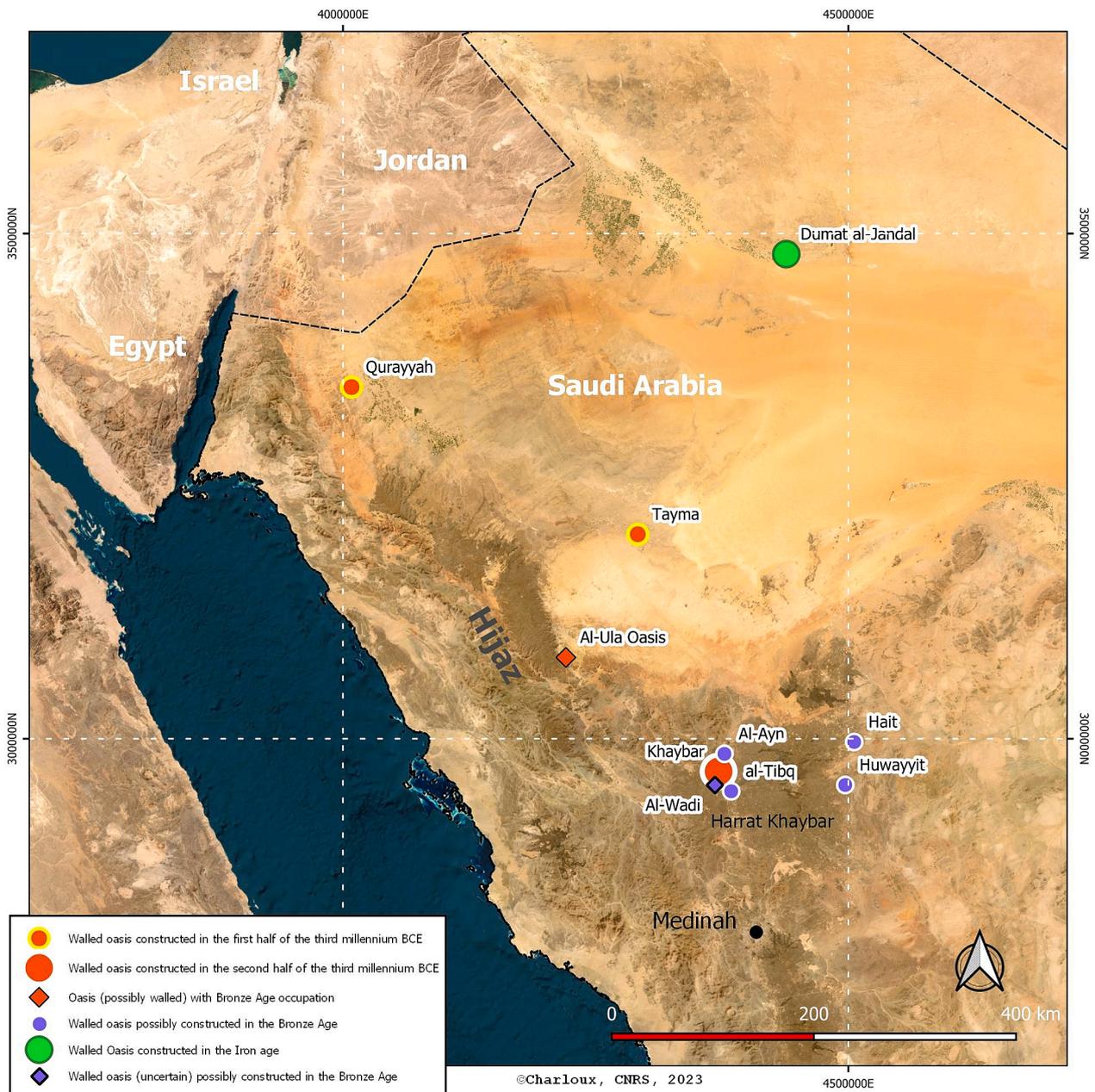


Fig. 1. Location map of the Khaybar walled oasis (red and white circle) and other major sites in north-western Arabia, © G. Charloux, ESRI.

imagery, demonstrating that the oasis was entirely encircled by an outer enclosure constitutes a significant scientific challenge. In the basaltic environment of Khaybar, where plateau sedimentation is very low, archaeological remains have been exposed above ground and superimposed for millennia, creating a lunar landscape dotted with thousands of megalithic archaeological structures from all periods: desert kites, mustatils, funerary avenues and dense necropolises, encampments, forts, plot walls, and so on (Kennedy et al., 2021; Barge et al., 2022; Charloux et al., 2022). Ongoing surveys have counted over 16,000 such structures within the 56 sq. km sample area. The examination of the often dismantled, rearranged and segmented ramparts presented here is established on an empirical, interdisciplinary, systematic and comparative approach. Only such a scientific approach, with several levels of verification, can reconstruct a coherent defensive ensemble in such a dense archaeological landscape. Here, we demonstrate and precisely date the existence of a monumental defensive “belt” at Khaybar in pre-Islamic times. (Figs. 2 and 3; SMI Figs. S1-S12).

2. Methods

2.1. General framework

The study was carried out from October 2020 to March 2023 (six field seasons) as part of the Khaybar Longue Durée Archaeological Project (CNRS-RCU-AFALULA, henceforth Khaybar LDAP). The Khaybar Oasis was an important agricultural centre of the Hijaz in early Islamic period, located midway between Medina and AlUla. Measuring around 8 x 7 km at an average altitude of 670 m, the Khaybar Oasis is located in three alluvial valleys (Wadis al-Suwayr/ Halhal, al-Zaidiyyah, al-Sulamah), forming the Wadi Khaybar to the west. These wadis, where agriculture developed near water sources, cut through the surrounding western basalt plateaus of Harrat Khaybar of Neogene and Quaternary age (Figs. 1 and 4) on which a number of sedentary settlements from various periods are perched. Before the Aerial Archaeology in Kingdom of Saudi Arabia project (AAKSA) from 2018 (e.g., Kennedy et al., 2021,

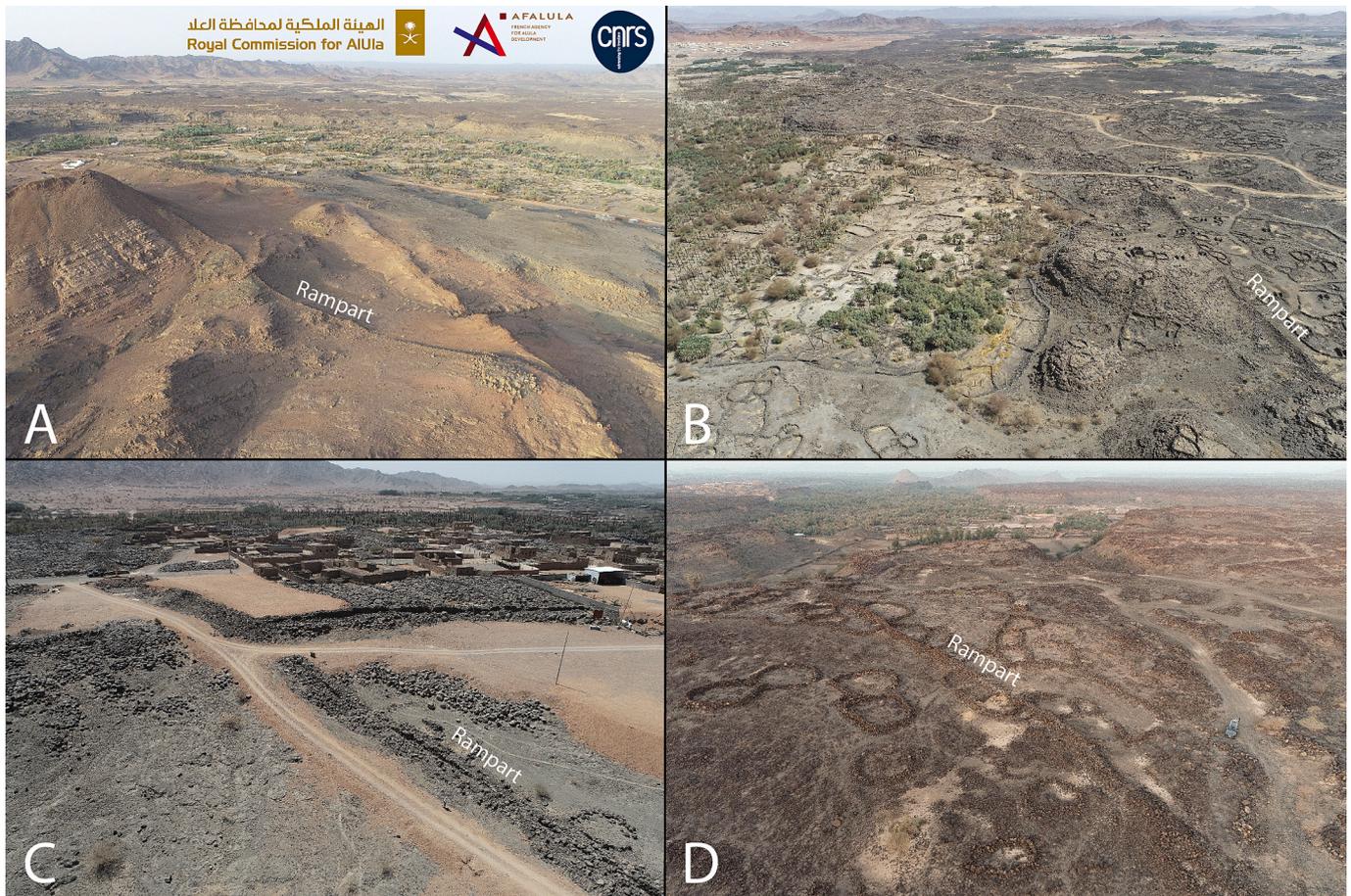


Fig. 2. Aerial views of the dry-stone basement of the outer rampart: A. Segment KH00911 facing south; B. Segment KH01130 facing north; C. Segments KH00904-KH00905 and KH00906 facing south; D. segment KH00922, © Khaybar LDAP, G. Charlot.



Fig. 3. View of the ramparts KH00905-KH00906 and a bastion KH00974 during excavation (see Fig. 9), looking west, © Khaybar LDAP K. Guadagnini.

without forgetting the brief survey of the area in Kennedy et al., 2015) and our own research from 2020 onwards inside the 56 sq. km RCU jurisdiction perimeter (Charlot et al., 2022), no systematic archaeological survey had been carried out in the oasis.

The survey was based on spatial analysis carried out using GIS (©ArcGis Pro Online), combining aerial documentation (orthophotographs and DTM) georeferenced at very high resolution (0.5 to 2 cm/pix and 5 cm/pix) on an up-to-date map base (geology, 1/50,000

topographic maps, world data, etc.) and a database combining the results of the architectural, archaeological and geomorphological surveys and those from the 19 archaeological test pits conducted on the ramparts. Following the initial identification of part of the northern sections of the walled oasis by Google satellite imagery in 2020 (Charlot et al., 2021a), the main stages of the study were the creation of a preliminary map of the wall network, indicating the nature of the walls and the presence of associated remains, followed by cross-referenced architectural, archaeological and remote sensing analyses, the results of which were compared with radiocarbon dating of stratified contexts (SM2).

2.2. Classification criteria

Archaeological exploration revealed the existence of 15 km of hitherto unknown rampart walls, 5.9 km of which are part of an exterior network enclosing the oasis area (Fig. 4; SM2 for an explanation on research stages and selection of walls). The initial survey stages led to the identification of 146 large wall segments as part of the fortification network of the oasis (SM2 Table S1). They are sometimes only a few metres long, as a result of combined anthropic and natural deteriorations, but can extend up to hundreds of metres. In order to illustrate the construction layout, we classified the ramparts into five groups (Gr.A-E) according to three main hierarchical criteria (Fig. 5):

1. Layout

- 'Aligned' walls: wall segments extending without any major discontinuity, with and without bastions, corresponding to the enclosure walls of the oasis (Group or Gr.A-C, D). These walls extend over a length of 12050.25 m.

- 'Isolated' walls (Gr.E). These non-aligned wall segments, or walls

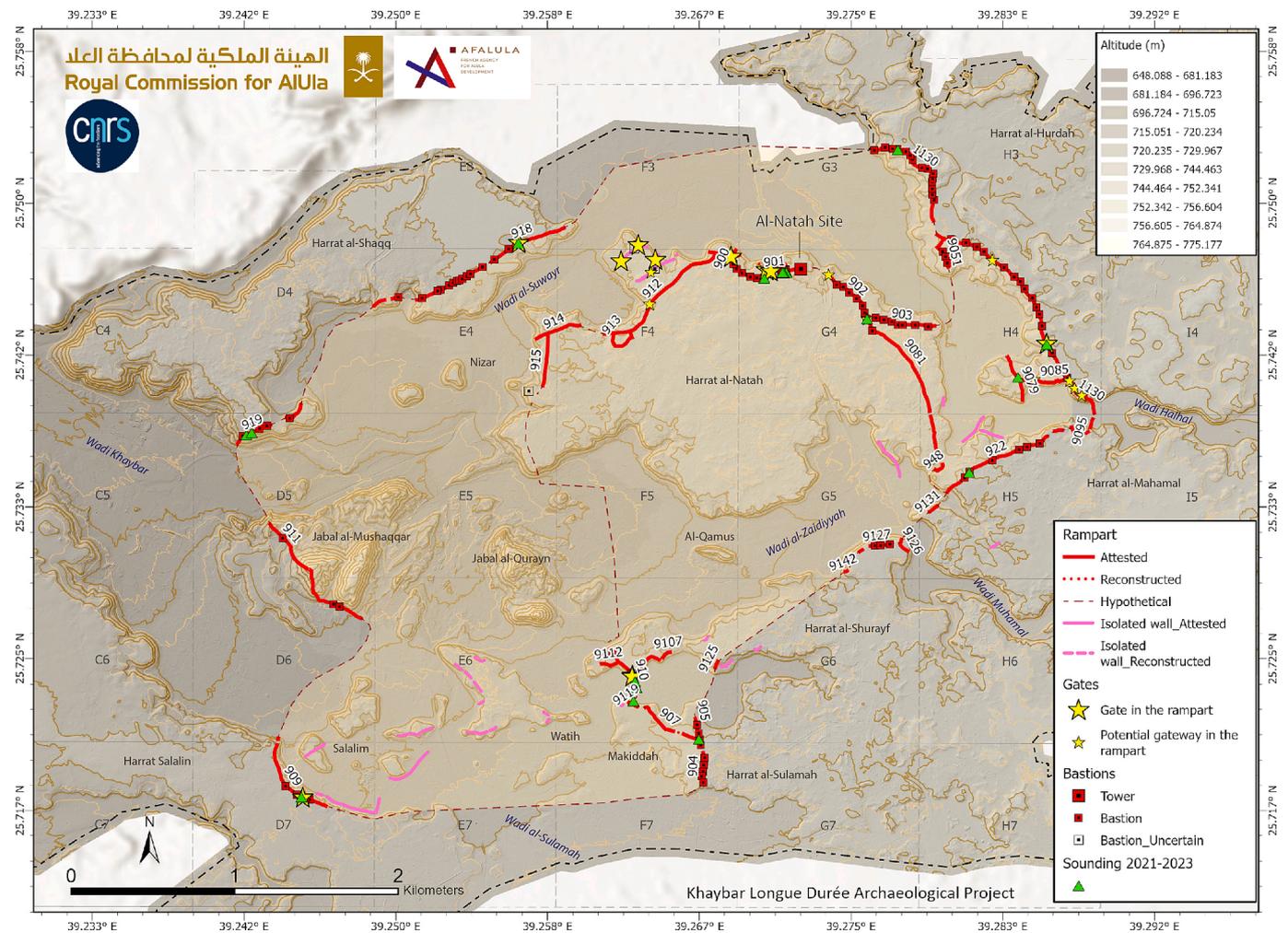


Fig. 4. Map of the main ramparts of Khaybar, with identification of main segment walls and location of bastions and soundings in 2021–2023, © Khaybar LDAP, G. Charloix. Feature numbers KH00000 are written for ease of reading without KHO or KH00.

without an observed extension, and without bastions, are often later additions, and were excluded from our analysis (3272 m).

2. Presence or absence of associated/abutting structures

- Absence (or almost total absence) of bastions (Gr.D [& E]).
- Presence of bastion(s) (Gr.B-C). These segments alone constitute 7193 m – corresponding to 47 % of the total length of the preserved ramparts in Khaybar.

- Presence of bastions and towers (Gr.A) around al-Natah Site only.

3. Type of masonry and wall thickness (Figs. 6 and 7; SM3 Figs. S13–14)

- Gr.A: accretion wall masonry (masonry Typ.e) between 2.4 and 4.5 m.

- Gr.B-C: main masonry type comprising two faces and a rubble-filled core, sometimes with wall juxtaposition, between 1.4 and 2.4 m (masonry Typ.b-d mainly, except wall KH00911 on top of Jabal Mushaqqar: 1.1 m).¹

- Gr.D-E: multiple types of masonry (between 0.5 and 4 m, mainly masonry Typ.a-b and others not mentioned).

¹ The similarity of the layout and the low variability in the thickness of the walls suggest that they were built or used at the same time, but this remains to be proven.

3. Results: The outer enclosure wall of Khaybar

By mapping the walls, determining their hierarchy and interpreting the position of the bastions on the ramparts, it is possible to distinguish two main sets of enclosures in Khaybar (Fig. 8): the inner enclosure walls (Gr.A, B and D), which are briefly discussed in SM4, easily differentiated from the outer enclosure wall (Gr.C), the subject of the present study.

3.1. Architecture and layout of the outer wall

The outer enclosure wall completely surrounding the oasis is the main line of ramparts at Khaybar (SM1 Figs. S1–S12). Its preserved perimeter is 5912.78 m, estimated to represent 41 % of the original layout of about 14.5 km, for an enclosed area of approximately 1180 ha. The wall segments are generally interrupted by later routes, modern destruction (new facilities, houses, gardens, etc.), and wadis. In some cases, this makes it difficult, even unsure, to reconstruct the routes over long distances, for example, in the southern part, where no trace of a rampart has been found between ramparts KH00904 and KH00909 in the Wadi al-Sulamah, which has been heavily impacted by erosion and modern development (Fig. 4). This is also the case to the north between segments KH00918 and KH01130, where a rectilinear trace almost 850 m long is still clearly visible on aerial images, but with no preserved masonry in the field.

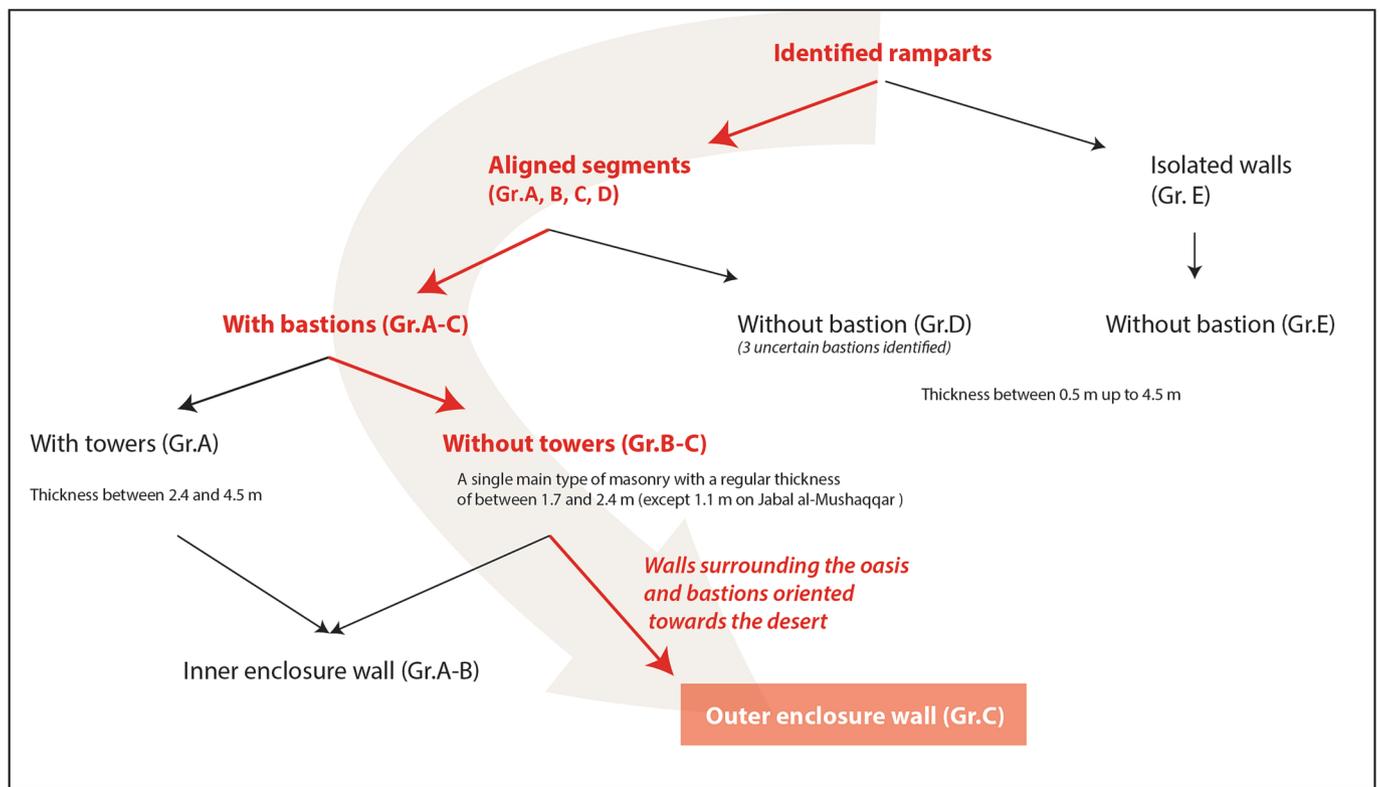


Fig. 5. Methodological framework for the classification of the groups of ramparts in the oasis, © Khaybar LDAP, G. Charloux.

Seventy-four bastions are still positioned on the exterior face of this outer rampart, always facing towards the desert and never towards the interior of the oasis. This observation is a strong argument for demonstrating the coherence of this enclosure and its construction during a single stage (but with later additions or reconstructions).

Another argument is that the segments of the outer rampart (Gr.C) are also very similar from a technological viewpoint. The vast majority are rubble-filled, double-faced dry-stone walls, mostly between 1.8 m and 2.4 m thick. Occasional aggregations of walls are used for reinforcement. The walls were built by separate unbonded segments—impossible to establish length at this stage—and partly by the juxtaposition of walls (accretion), consistent with well-known processes in the region (Charloux et al., 2021a: 21–23). In the homogeneous group, wall KH00911 on the slopes and summits of Jabal Mushaqqar, built in rhyolite from the latter, is much thinner than other walls (1.1 m) and was built with elementary dry-stone masonry (masonry Type a), which can be explained by its high position along a ridge on the top of a rhyolite mountain (Fig. 6C; SM1 Figs. S2–S3). For construction purposes, stones were not only extracted from the neighbouring ground, but pre-existing structures were also used as quarries, and recycled as building stones.

We observe that the lines of the outer enclosure walls most often follow the contours of the plateaus. They cut into valleys in the past to connect distant aligned walls, but at the narrowest possible locations. The layout of walls is systematically curvilinear, with a construction opportunism based on the best use of the variations of the topography. The ramparts are located 250 m away from the cliff at most and on average 120 m from it. The aim of leaving this distance was to avoid topographic irregularities, and to allow for the relatively linear and flat development of the walls (average altitude az.720–740 m, except for KH00911). It also makes the wadi accessible, minimises the area to be protected on the plateau, and optimizes visibility over the desert and oasis, without encroaching on agricultural zones. Several gates

(posterns?) were observed, but nonetheless, at this stage of research, the reconstruction of the whole rampart does not enable us to identify oasis circulation networks and the adjacent desert zones.

It is difficult to determine the original wall height, especially as only the stone masonry is still standing, whereas the top of the wall in stone or mudbrick – as possibly shown by mudbrick traces found on Gr.A (Charloux et al.) – has entirely disappeared. The optimal conservation of stone walls (3 m) was observed at Makidah. As no walk walls (if they once existed) have been reached in any of the segments, we could perhaps add at least 2 m of mud brick elevation (just over guard height, if any), for a total estimated height of 5 m for Gr.C, although this height remains hypothetical. In Tayma, the preserved elevation is higher than 6 m (possibly even higher than 14 m in the central core) (Schneider, 2016: 349), and in Dumat al-Jandal, wall height was estimated at around 6.5 m, but with an identified wall walk (Charloux et al., 2021a).

3.2. Dating the outer wall

The high degree of erosion of the basaltic surfaces due to aeolian weathering and annual runoff, as well as the absence of contemporaneous settlements connected to the outer walls, results in a lack of archaeologically datable sediments related to the enclosure wall. However, it has now been dated by a cluster of concordant data, owing to the discovery of radiocarbon dating elements and relative chronology.

First of all, the lines of the protohistoric funerary avenues of pendant tombs dated to the mid-to late third millennium (Dalton et al., 2021; Kennedy et al., 2021) were overbuilt or had their masonry reused or sectioned by builders of the inner and outer enclosures, which constitutes the early limit of the phenomenon around 2600–2200 BCE (e.g., SM5 Figure S15). Wall blocks and the reuse of wall lines in recent times, notably the stone circles/marabid (Philby, 1957; Charloux et al., 2022), establish the later limit in the 19th–20th century (Figure 2B,D).

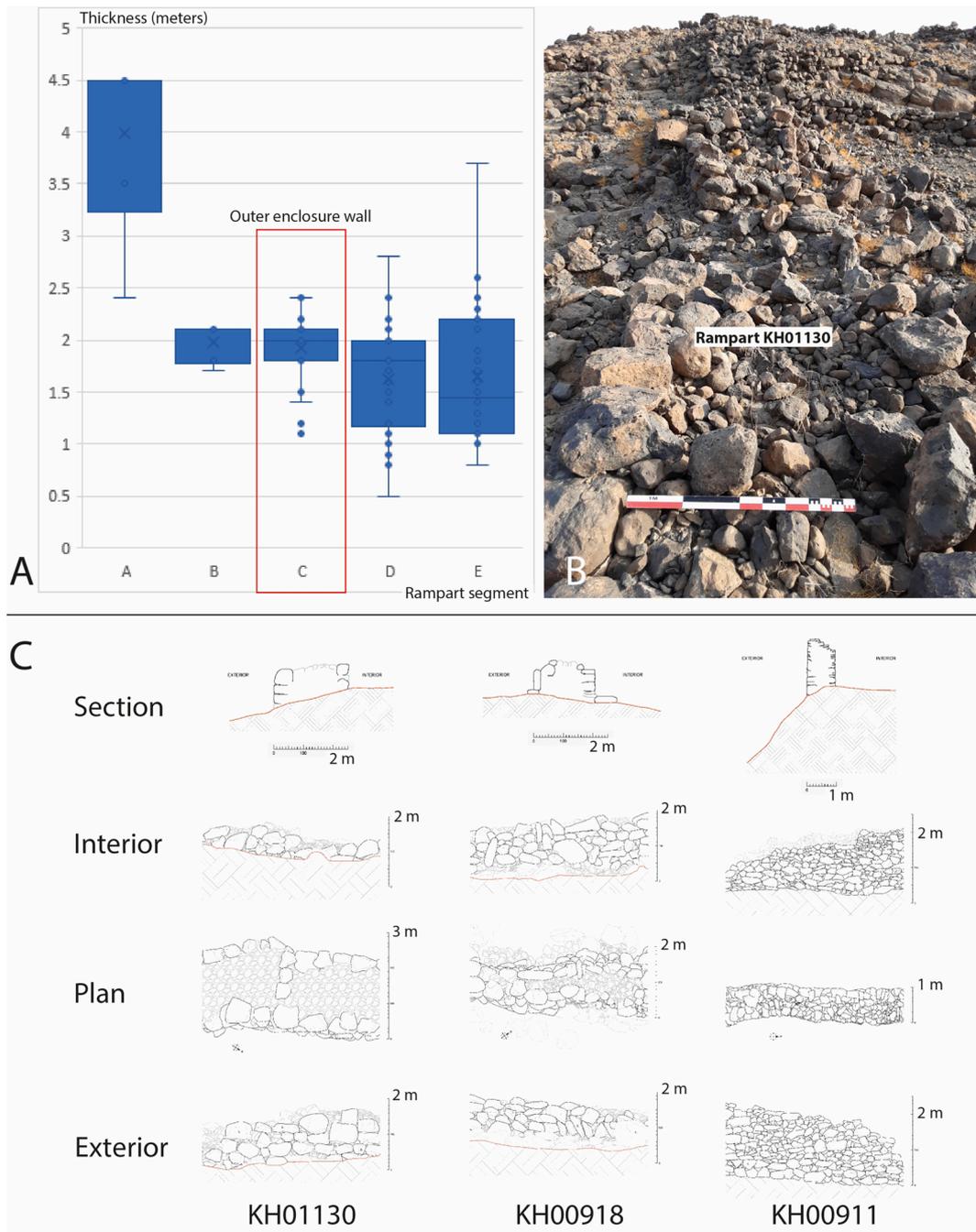


Fig. 6. Study of the masonry of the ramparts. A. Variability of the range of thickness of each rampart group; B. View of the currently preserved masonry of the outer enclosure wall (rampart KH01130) facing north; C. Example of architectural study conducted on outer enclosure wall segments showing inner masonry variability, © Khaybar LDAP, G. Charloux. T. Terrasse.

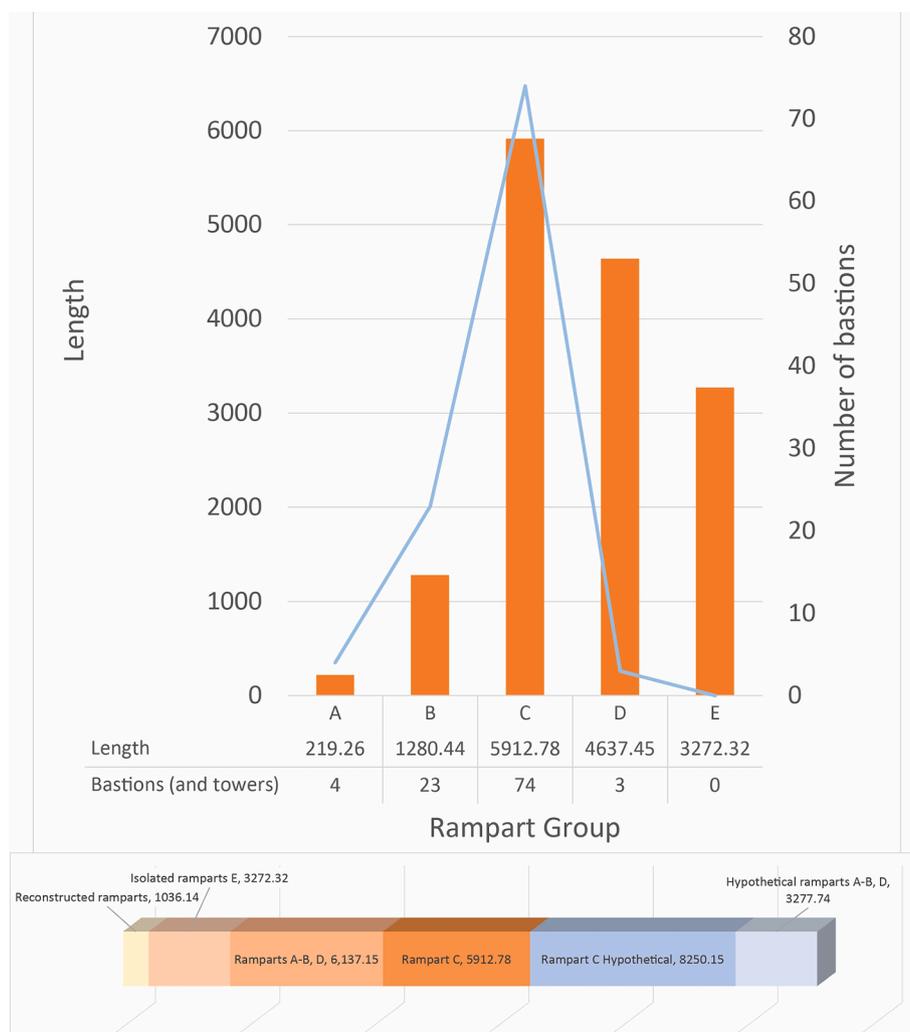


Fig. 7. Diagrams showing the hierarchy and organization of walls inside the oasis (length in meters; blue line for the number of bastions), © Khaybar LDAP, G. Charloux.

Then, within this broad time frame, the most reliable chronological markers were established by radiocarbon dating eight charcoal samples taken from five test pits located on segments of the outer rampart: KH00905, KH00919, KH9039, KH00965 and KH01130 (Table 1; Figs. 8, 9 and 10; SM5). The earliest date for the construction of the rampart is based on the dating of charcoals sampled beneath it, i.e., prior to or contemporary with its construction (terminus post quem TPQ): layer KH00906.006 beneath rampart KH00905 (Fig. 9) and charcoal in layer KH09039.004 beneath an overhang of gate KH09039 of rampart KH01130 (Fig. 10). Samples KH00906.005 and KH00919.006 come from layers abutting the rampart or in the immediate vicinity of its foundation, and also yield a TPQ for the construction (or first use) of the ramparts. Sample KH09066.005 from the stone fill of the bastion also indicates a TPQ for the construction of this structure built against rampart KH01130 and is indicative rather than actually connected to the rampart itself, but supports the idea of a single coherent project including the bastions (SM5 Fig. S17). Charcoal samples KH00905.006, KH00965.004 and KH09039.009, in the gateways or against the upper part of rampart KH00905, testify to a terminus ante quem for their construction around 1980 BCE, and a probable period of use of the ramparts before its collapse (Figs. 9, 10; SM5 Fig. S15).

Considering the dates obtained (Table 1; Fig. 11), rampart segment KH00905 was built after 2279 BCE at the earliest, and before between 1878 and 1626 BCE. This date seems to be supported by the post-2139 BCE construction of rampart KH01130, indicated by sample

KH09039.004, although the gate may have been added some time after the construction of the rampart. The terminus ante quem of rampart KH00918 between 2201 and 1980 BCE is confirmed by sample KH00965.004. Passages through gate KH09039 of rampart KH01130 are still attested between 1741 and 1542 BCE.

All these highly consistent dates derive from test pits located at significant distances from one another (Fig. 8). Considering the hypothesis that the rampart was built in a single operation - it is unlikely that such an operation to encircle the oasis would have been halted for centuries before being resumed - the outer rampart was built in the Bronze Age, between around 2250/2150 and 1950 BCE. Its period of use probably lasted at least four centuries, until around 1626–1542 BCE, based on the dating of charcoal samples coming from a pathway in gate KH09039 and a fireplace KH00905.006 against rampart KH00905, below stone collapse. This chronological range corresponds well to the surface pottery sherds lying around the ramparts (and a few rare specimens from test pits), generally associated with the turn of the second millennium BCE (Shabo and Charloux, 2023, Fig. 11). Another argument for this chronological range comes from the contemporary occupation of the Bronze Age town of al-Natah at Khaybar in the Late third millennium and the first half of the second millennium BCE, not discussed here (Charloux et al.).

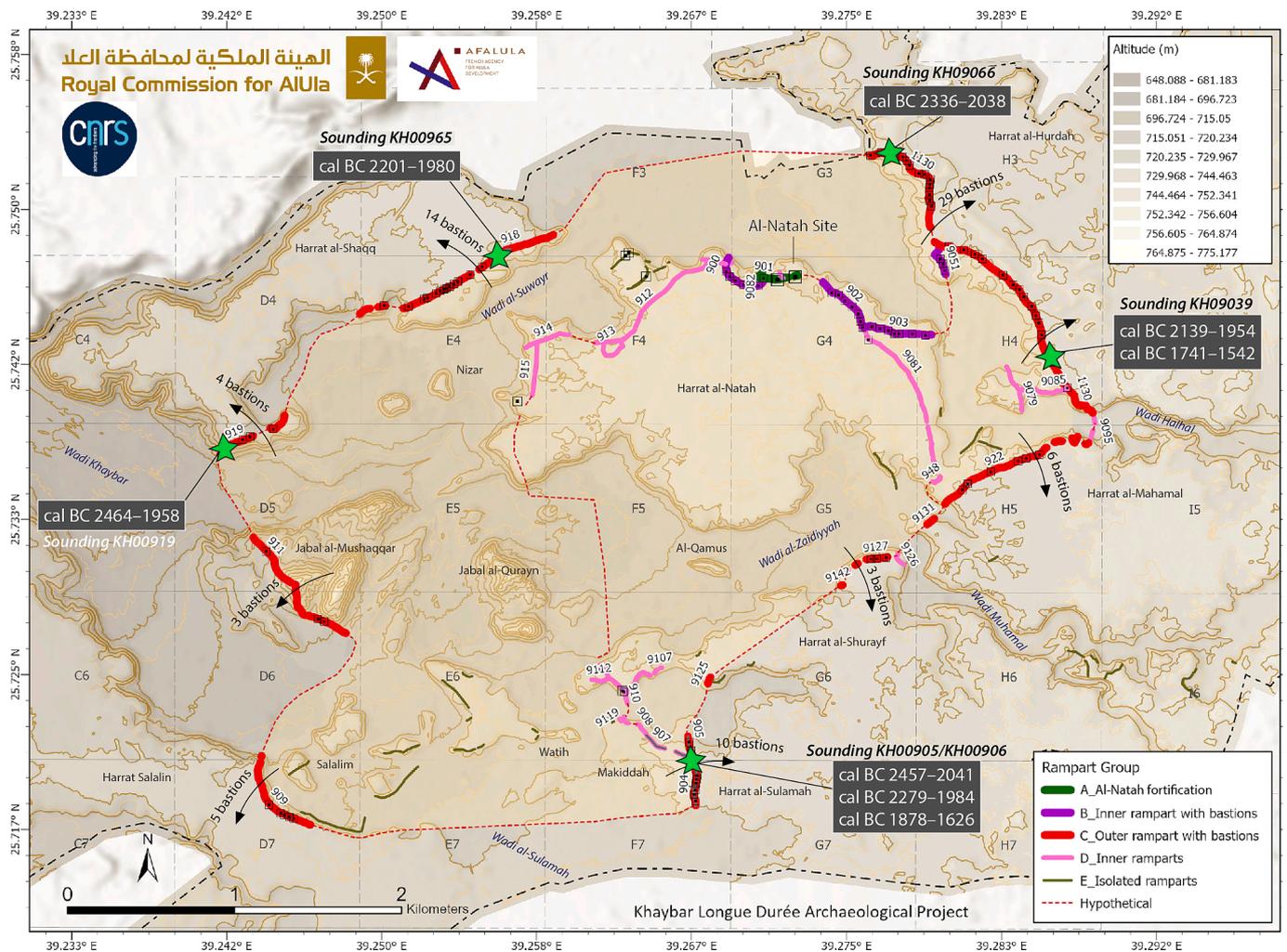


Fig. 8. Map of the “rampart” groups and, in particular the outer enclosure wall in red (Gr.C), with dating results from soundings, in the oasis of Khaybar, © Khaybar LDAP, G. Charloix.

4. Discussion

The study of the outer rampart network in Khaybar makes it possible to delimit the territory of the Khaybar Oasis as it was materialized in the Bronze Age around 2000 BCE. It is exceptional both in terms of its size - one of the two largest in Arabia - and in terms of the technical and collective efforts, as well as for its implications for understanding long-term development related to urbanization processes.

Recently, we evoked three main reasons to explain such monumental architectural investment in an oasis environment, the so-called ‘walled oasis’ phenomenon (Charloix et al., 2021a). The first, and the most evident, was the need for physical protection against mobile groups of populations from the desert, potentially carrying out raids on oasis settlements (Gawlikowski, 1986: 52; Burckhardt, 1829: 323) (and possibly armies in later periods, see Charloix et al., 2021a: 29–30). This was a well-known danger for sedentary populations during pre-Islamic and Islamic times, but not documented in Bronze Age contexts in North Arabia up until now (despite the presence of the so-called “warrior burials”, evidencing social differentiation around 2000 BCE, Hausleiter et al., 2018; Greenberg, 2019: 197–200 for the Southern Levant). The second, more specific reason relates to the daily struggle against natural erosion, in particular silting up, salinization of agricultural soils and violent destructions by flash floods in the wadis (Schneider, 2010: 20–22; Wellbrock et al., 2018, 2019; Charloix et al., 2021a,b). Although it was not observed in Bronze Age Khaybar, the rampart segments, which were located in the wadis and therefore

destroyed by natural events, could support this argument. The last reason was the resolve to inscribe a mark of control in the landscape and to ostentatiously demarcate the oasis territory. In this way, this specific territory was identified with a local authority, in order to impress visitors and desert groups. It was about delimiting a living space, a rural settlement, and separating it from a desert area. The monumental construction of the rampart in the Bronze Age thus strengthened group cohesion while acting as a territorial marker and defining social identity (e.g., de Miroshedji, 2018: 137 in the Southern Levant). For these reasons, the construction of the fortification does not appear to be totally rational when considered solely in protective terms, as from a strategic and defensive perspective; it is imperfect in places (Charloix et al., 2021a: 8; for comparison with the Southern Levant: Nicolle, 1999: 77; Ashkenazi, 2019). The walled enclosure in the oasis is therefore reminiscent of other types of symbolic barriers delimiting a territory in the Near East, such as the contemporaneous “Very Long Wall of Syria”, but also of other monumental fortifications for passive defense (Geyer et al., 2010; Nunn, 2009).

The impressive dimensions of the outer enclosure walls and the scale of the workforce required to build it indicate that the rampart construction necessitated centralized management by a local political entity. For later periods, we previously envisaged a substantial workforce controlled by a powerful entity (Charloix et al., 2021a), but the evaluation of the human resources required to build the enclosure walls in the Bronze Age seems to suggest a different scenario. As a rough guide, the construction of the outer rampart, estimated to be 5 m high, would

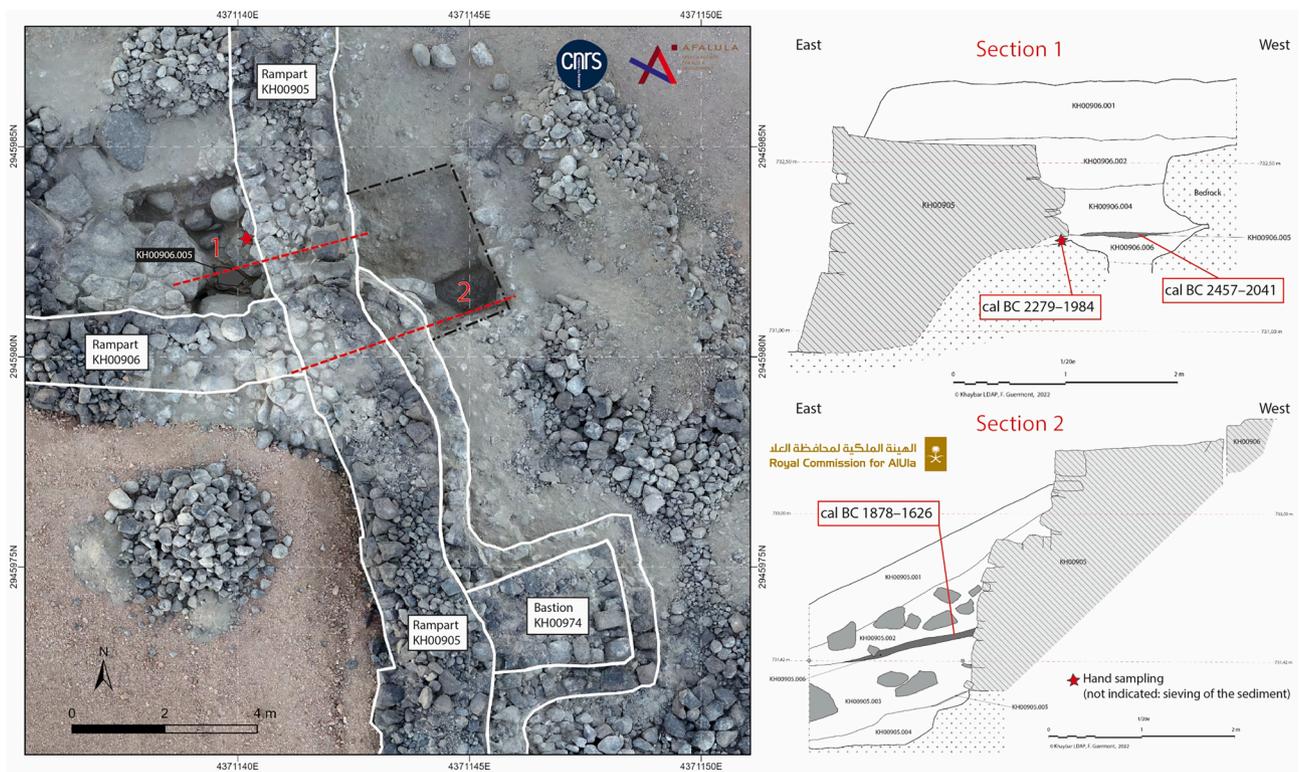


Fig. 9. Location of dating samples on rampart KH00905 (plan on orthophotography and sections). Section 1: KH00906.002 and KH00906.004 are filling layers above ash area KH00906.005 on top of construction floor KH00906.006; Section 2: KH00905.002 is a collapse layer above a thin ash dump above fills KH00905.003 and KH00905.005 above possible construction floor KH00905.004, © Khaybar LDAP, G. Charloux, F. Guermont and K. Guadagnini.

have required a volume of around 164,000 m³ of stones and/or bricks, representing some 170,000 working days (SM6 Tables S2–3). By way of illustration, a community of just 500 people from the nearby settlement (Charloux et al.), only half of whom (250) would have been actively involved in building the rampart for six months per year, could thus complete the outer rampart in just four years, and only two years for half of the community working full-time. This puts the scale of the operation into perspective. Given the relatively low level of planning and preparation required (empirical choice of the enclosure route, simple and systematic construction method, locally available materials, unsophisticated tools, etc.), a small local community would seem sufficient in terms of numbers to plan and raise the outer enclosure wall. This observation should not minimize the importance of this collective and monumental phenomenon, but on the contrary, is a rich source of information.

First of all, let us consider the people who built the ramparts. Although this is not the primary subject of this paper, an interesting avenue of research would be to compare walled oases with the creation process of other fortified settlements on the desert margins of Southern Syria and Jordan in the Bronze Age by indigenous groups (Müller-Neuhof et al., 2013; Nicolle and Braemer, 2021). As a working hypothesis, we might indeed suggest that the outer rampart of Khaybar was built by local pastoralist nomadic populations (from the northwest of the peninsula), that would have gathered together and then settled in the Khaybar Oasis in the Early Bronze IV (Intermediate Bronze Age) (according to the chronology of the Southern Levant, see Greenberg, 2019). This gathering episode would be testified by the construction of the monumental funerary avenues between multiple oases in this region, including Khaybar and Hait, during the mid-to late third millennium BCE (Dalton et al., 2021). The collective practice of building a gigantic rampart network is not unrelated to the process of edifying funerary avenues, in terms of the amount of collective work carried out, in the technics used for both construction types and in the transformation of a

landscape and the materialization of a cultural identity. It could be therefore conceivable that funerary avenues were the first stage in this transformation from a nomadic to a more sedentary way of life over several centuries. Mobile pastoralist groups would have settled in the Khaybar Oasis in a strategic area with a good water supply, ostentatiously demarcating their living and cultural space, in keeping with the principles of plot demarcation for agriculture and grazing. While this indigenous development possibly looked to defend areas of agricultural and water resources from outside (even if amalgams of sedentary and pastoralist lifestyles remain possible), the outer rampart certainly indicates a social and territorial marker. The hierarchical or heterarchical control of social organization and the means of production required to build the outer rampart would have been consolidated during these stages of construction and lifestyle change towards a sedentary lifestyle (for at least part of the population). We could envisage that this lifestyle mutation could be one of the consequences of the aridification of the 4.2 BP climate event, although little is known of the paleoenvironmental context in North-West Arabia (Bar-Matthews and Ayalon, 2011; Petraglia et al., 2020). In a possible stage of territorial competition between groups of desert populations, social tension for food and water access could have required group gathering in an ecological niche/refuge and collective adaptation.

The second lesson can be drawn from the dating of the Khaybar ramparts to around 2250–1950 BCE, thus more recent than that of Qurayyah, founded in the first half of the third mill. BCE (Lüthgens et al., 2023) and the vast development of the Tayma fortifications during the second half of the third mill. BCE (Hausleiter, 2018; Hausleiter et al., 2019; Hausleiter and Zur, 2016), but also older than Dumat al-Jandal, built in the Iron Age (Charloux et al., 2021a). This observation is crucial as it confirms a recurring pattern of similar monumental phenomena over the long term. Shedding light on the walled oasis phenomenon, which probably stemmed from the transition of mobile population groups to a sedentary lifestyle, should enhance our

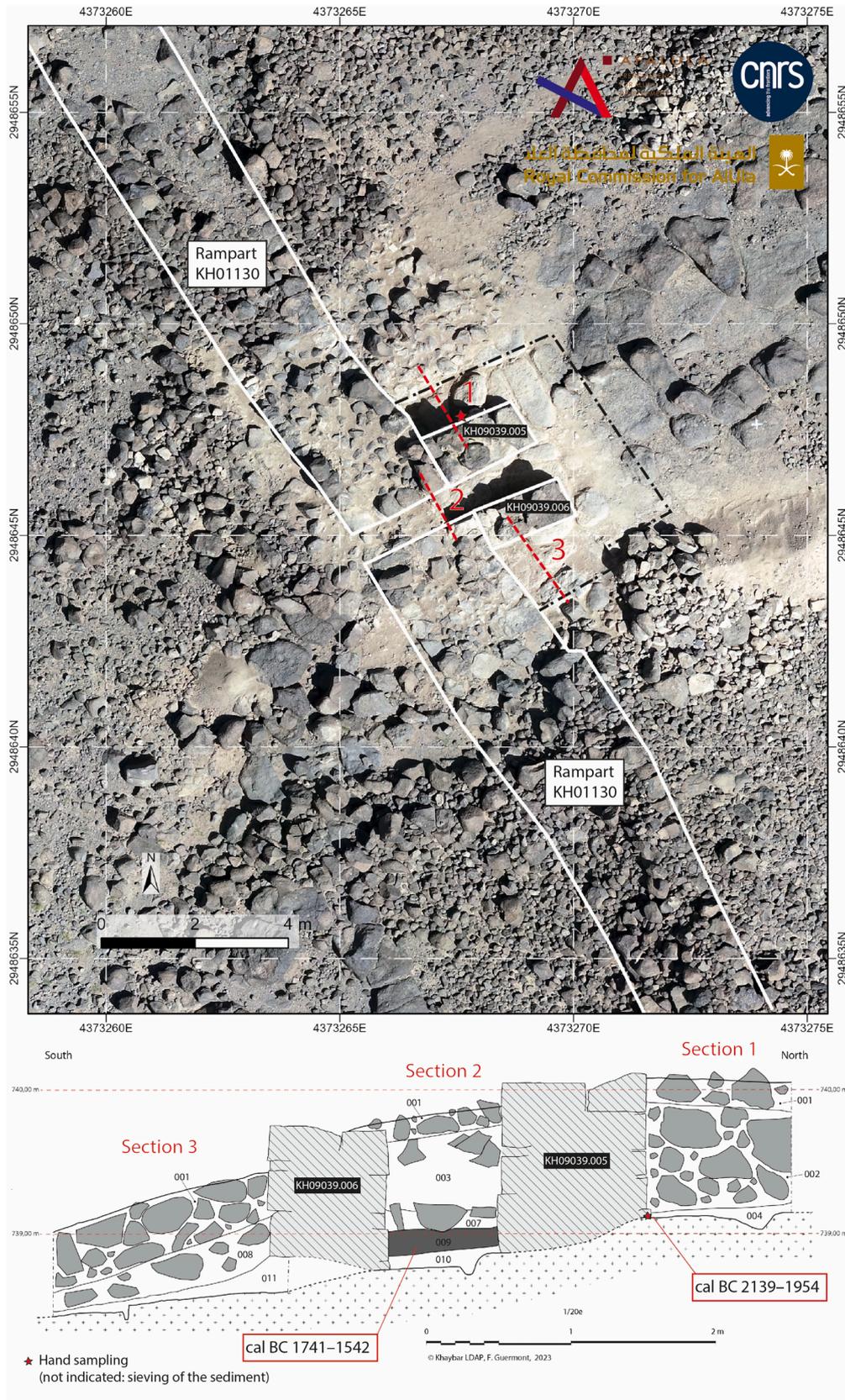


Fig. 10. Test pit in gate KH09039 on rampart KH01130 (plan on orthophotography and section), with location of dated samples. Outside the gate, KH09039.004 is a small layer of brown gravel laying directly on the substratum below the stone collapse. Inside the gate, the collapse was underlain by KH09039.009, an occupation level consisting of grey, coarse sandy sediment with some charcoal and animal bones. Below, a layer of brown gravel (KH09039.010) was laying on the bedrock, © Khaybar LDAP, G. Charloux, F. Guermont, and K. Guadagnini.

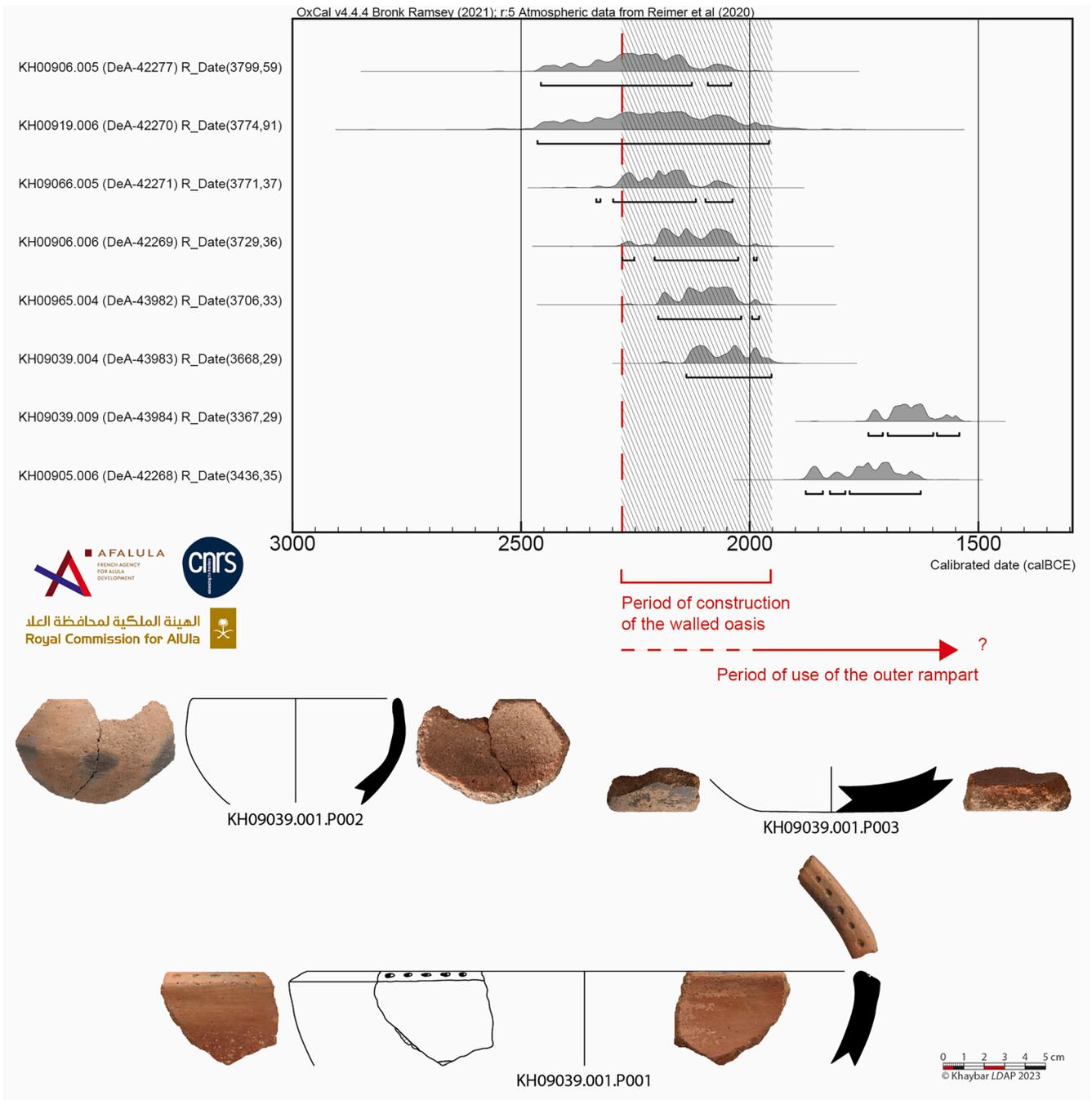


Fig. 11. Top: summarised C14 dating results for the outer rampart of Khaybar, C14 calibration after Reimer et al., 2020 (Bronk Ramsey, 2021); Bottom, diagnostic red burnished sherds from surface layer in sounding KH09039, © Khaybar LDAP, G. Charlot & S. Shabo.

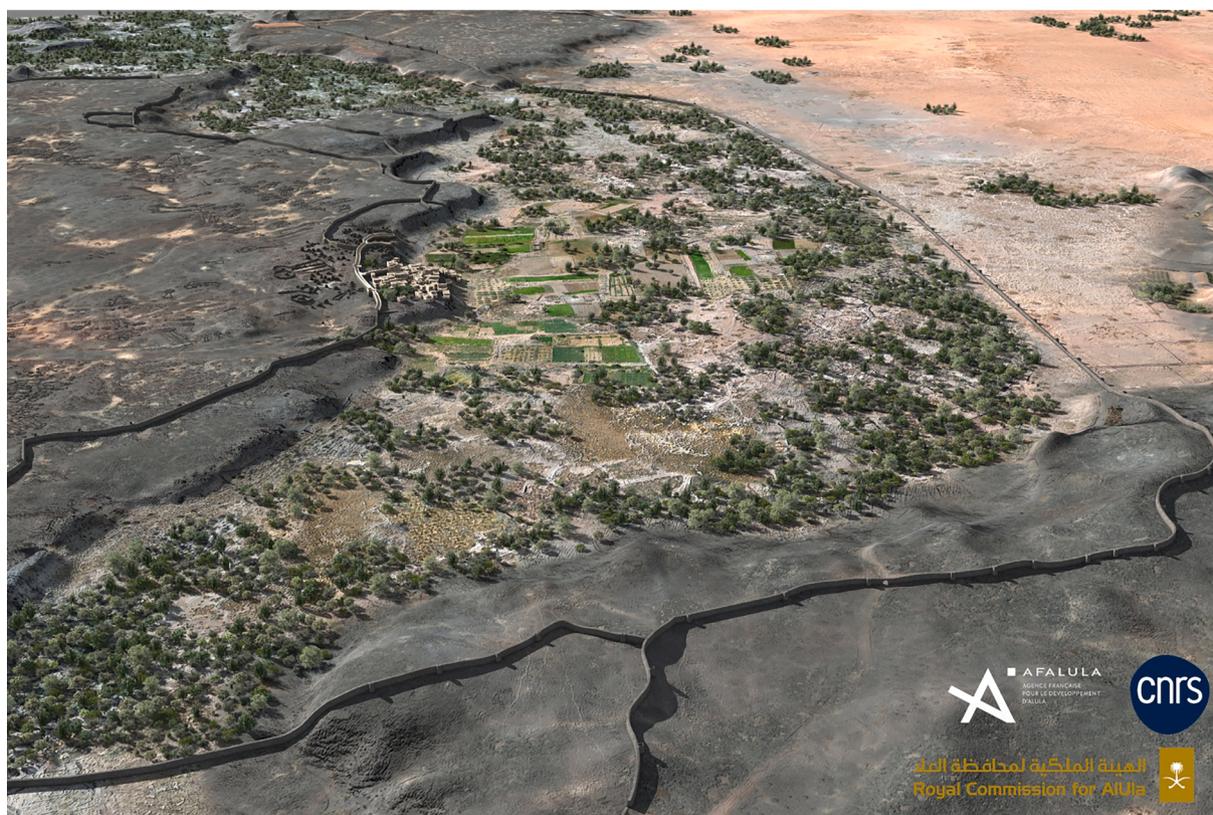


Fig. 12. Reconstruction view of the northern part of walled oasis of Khaybar around 2000 BCE. Pending the results of definitive archaeobotanical analyses, the plant cover at this stage is based on the identified species listed in Table 1 (acacia, tamarisk, amaranth, cereals), © Khaybar LDAP, M. Bussy & G. Charloux.

Table 1

Identification and C14 dating of samples from test pits on the outer rampart of the oasis (Reimer et al., 2020; Bronk Ramsey, 2021), © ECO-Seed, E. Chambraud and C. Bouchaud (MNHN, French National Museum of Natural History).

Sounding	Sample	Lab. ID	Sample Nature	Identification MNHN	Age (not calibrated)	±	95.4 (2 sigma)
KH00905-KH00906	KH00905.006	DeA-42268	Charcoal	<i>Tamarix</i> sp. (Tamarisk)	3436	35	cal BCE 1878–1626
	KH00906.005	DeA-42277	Caryopsis (Seed)	<i>Triticum aestivum/durum</i> (Naked wheat)	3799	59	cal BCE 2457–2041
	KH00906.006	DeA-42269	Charcoal	<i>Vachellia</i> sp. (Acacia)	3729	36	cal BCE 2279–1984
KH00919	KH00919.006	DeA-42270	Caryopsis + Wood charcoal	Cerealia + Amaranthaceae	3774	91	cal BCE 2464–1958
KH00965	KH00965.004	DeA-43982	Charcoal	<i>Vachellia</i> sp. (Acacia)	3706	33	cal BCE 2201–1980
KH01130	KH09066.005	DeA-42271	Wood charcoal	<i>Tamarix</i> sp. (Tamarisk)	3771	37	cal BCE 2336–2038
KH09039	KH09039.004	DeA-43983	Wood charcoal	<i>Tamarix</i> sp. (Tamarisk)	3668	29	cal BCE 2139–1954
	KH09039.009	DeA-43984	Wood charcoal	<i>Vachellia</i> sp. (Acacia)	3367	29	cal BCE 1741–1542

Calibration after Reimer et al., 2020.

understanding of the socio-economic development of Arabia from the Bronze Age to the Iron Age at the very least, in different geographical contexts. It should also help bringing to light the "urban" trajectory in this region (Magee, 2014; Luciani, 2021; Charloux et al.).

5. Conclusion

As a result of a series of field surveys and archaeological and architectural investigations, despite the difficulties of the terrain and the very incomplete state of the ramparts, we are now in a position to confirm the hypothesis that Khaybar was an immense walled oasis (Fig. 12), like

other oases in northwest Arabia, such as Tayma and Qurayyah. Dating from the Late third millennium BCE, the ramparts of Khaybar were probably built by indigenous populations as they settled down and ostentatiously demarcated their oasis territory. These ramparts lasted for several centuries before being dismantled or replaced by more recent structures. In addition to the discovery of a unique and securely dated monument, the recognition of the Khaybar walled oasis constitutes a crucial landmark in the architectural and social heritage of north Arabia.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary Material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jasrep.2023.104355>.

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