Technology transfer or local invention ? A water collecting system in the northern arabian desert

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Des refuges aux oasis :
vivre en milieu aride de la Préhistoire à aujourd'hui
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Technology transfer or local invention? A water collecting system in the northern arabian desert

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Résumé
Les aménagements hydrauliques sont essentiels à la survie dans un environnement marginal désertique comme l'Arabie du Nord. Le but de cet article est d'étudier la gestion de l'eau en marge de l'oasis historique de Dûmat al-Jandal, située au nord du Nafûd. Nous nous proposons de reconstituer la fonction d'un système hydraulique de collecte d'eau de pluie récemment découvert, à travers une synthèse architecturale, un court examen de la céramique et en interrogeant les données géologiques du site. Nous comparons également ce système de collecte avec ceux développés dans d'autres oasis d'Arabie afin de comprendre ses origines et ses influences. Il est ainsi possible de conclure que les stratégies hydrauliques les plus proches du système hydraulique à l'étude se trouvent en Arabie du Nord-Ouest, où les Nabatéens surent intégrer des stratégies locales.
Mots clés : Dûmat al-Jandal, oasis, survie dans le désert, structure hydraulique, canaux semi-enterrés, citerne, époque nabatéenne

Abstract
Water management is essential for survival in marginal environments such as the North Arabian desert. The present study examines strategies of water management near Dûmat al-Jandal, a major oasis at the edge of the Nafud. Through a synthesis of architectural, ceramic and geological data sets, we attempt to reconstruct the purpose and function of a water collecting system recently discovered in the desert margin of the oasis. We then compare this system with those found in other Arabian oases to understand the

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origins and influences on the present system. We conclude that the closest comparable strategies of water management can be found in Northwestern Arabia, where Nabataean systems blended with local strategies.
Keywords: Dûmat al-Jandal, Oasis, Subsistance in Desert, Hydraulic Structure, Semi-Buried Channel, Cister, Nabataean Period

Introduction

The desert, by definition, is one of the least suitable environments for human occupation ; it comprises a vast and desolate space with negligible water resources.[1] Abundant permanent water can only be found oases, and these provide the sole opportunity for permanent human settlement, the development of organized agriculture, and associated social practices.

While not entirely incorrect, the foregone claims could be regarded as overly simplistic or incomplete. Mobile pastoral populations have always lived on the margins of oases, developing lifeways in arid or hyper-arid areas (Dbiyat [al-] and Mouton, 2009). Like caravaners, they successfully exploited water points and wells (Potts, 1988) – which can be found even in the largest deserts (*e.g.* Nafūd) if one has an intimate knowledge of the region – or small pools of rainwater created naturally in low areas (Qā‘). In both cases, the development of areas using cisterns, retaining walls or canals made the harvesting of scarce water resources possible. In

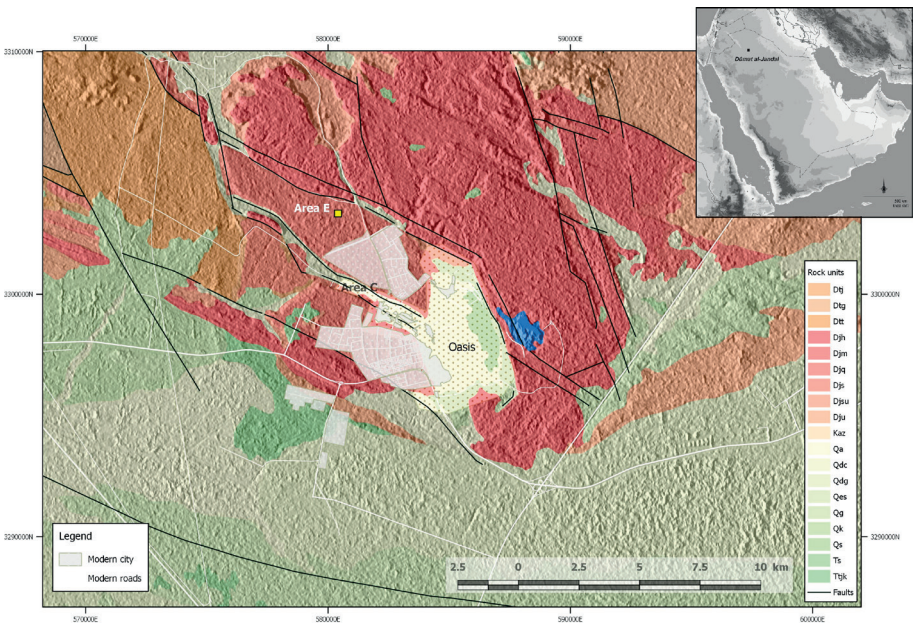

Fig. 1. *Map of the region west of Dûmat al-Jandal in northwestern Arabia, ©MADAJ, G. Charloux, after* Wallace et alii, *1997".*

1. http://www.cnrtl.fr/definition/désert.

Arabia, these installations, rarely described in the literature, date back as early as the mid-Holocene, when the climate was arid, and are still used today.

The aim of this article is to present a double installation, recently discovered on a desert plateau near the oasis of Dûmat al-Jandal in northern Arabia, and to compare and discuss its features in relation to contemporary technological traditions.

Context and method

The oasis of Dûmat al-Jandal is located in al-Jawf province – "the depression" in Arabic – roughly 37 km southwest of the provincial capital Sakâkâ (fig. 1). Known in the neo-Assyrian annals by the name of "Adummatu", human occupation of this oasis stretches back to the prehistoric period (Munoz *et alii*, forthcoming; Charloux, 2018; see also Hilbert *et alii*, 2015), although most of the ancient archaeological remains date to classical and Islamic times. Losing its influence in medieval periods, the oasis in recent years has experienced a revival of activity and its population today approaches 34,000 inhabitants. The ancient historical areas of the oasis have been the subject of a joint Italian-French-Saudi archaeological mission since 2010.[2]

The hydraulic structures considered here are located 2 km west of the oasis (sector E, ca. 640 m above sea level). Their remote location has contributed to the

Fig. 2. *The northern installation at the end of the excavation, looking southward ©MADAJ, R. Schwerdtner (DJ2017a0491).*

2. The mission is directed by Guillaume Charloux (CNRS, UMR8167 Orient et Méditerranée) and Romolo Loreto (University Orientale, Napoli). The authors wish to thank the Saudi Commission for Tourism and National Heritage (SCTH), as well as Dr. Abdullah al-Zahrani, Thamer al-Malki and Ahmed al-Qaeed for their daily support.

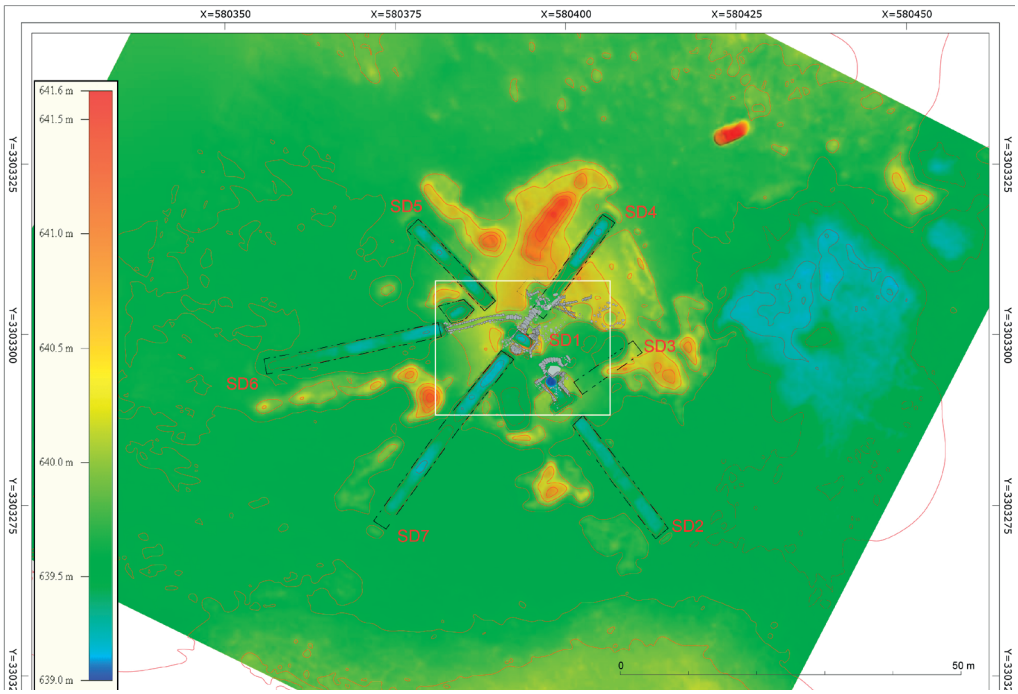

Fig. 3. *Numerical Terrain Model and aerial photogrametry of the archaeological area at the end of the excavation, ©MADAJ, R. Schwerdtner.*

preservation of these installations over time, despite looting and extensive urban construction on the plateau (fig. 2). These hydraulic structures, however, will soon be destroyed as the residential areas of As-Sabilah and As-Safah continue to extend towards the northwest. Modern neighborhoods have already grown more than 3 km in this direction since 2009. The creation of a grid of modern plots and roads was accompanied by the installation of a water tower 670 m south of the sector under study in 2015.

Sector E is located on a plateau with a relatively flat surface about 10km long and 3km wide and oriented NW-SE, within *Al Wadi Graben*. The ancient structures were built in a shallow depression in the Qaṣr Member (Jawf Formation) dating back to the Early Devonian. This geological formation is composed of a "layish-grayish-brown, gray, and yellowish-gray, argillaceous and silty, thinly bedded fossiliferous and bioclastic limestone and interbedded gray and greenish-gray shale" (Wallace *et alii*, 1997). It is therefore a non-aquifer formation with an impermeable cover, which can however conceal aquiferous sandstone veins and supplant non-aquifer formations (Shaiba Member) or much deeper aquifers (Tawil formation), as it is the case in the oasis (Charloux *et alii*, 2017: fig. 13).

The two semi-buried structures discussed here were previously identified by Kh. Muaikel (Muaikel, 1994). Apparent on the surface not far from undated circular stone circles (Arbach *et alii*, 2016: 94-95), they had been the subjects of illegal digging. Noting the urgency of an in-depth study during a survey in 2011, the

Fig. 4. *Plan of the northern and southern installations, ©MADAJ, C. Marquaire.*

archaeological study of this area took place in 2016 and 2017.[3] The excavation perimeter was based on the topography of the site and the extent of the remains (fig. 3). Six large trenches (named SD2-7) were dug until the bedrock with a backhoe, defining a 60m diameter right-of-way around two large basins (L3006 and L3007, SD1).

Description of the remains

The hydrological semi-buried installation is composed of two sub-rectangular basins (L3006 in the north and L3007 in the south) 4.5 m apart, north-west/south-east oriented and in dry limestone masonry (fig. 4). These structures were almost completely filled by a homogenous layer of yellow indurated sand blown from the desert by the wind, except for some thin layers of shale.[4]

Northern installation

Basin L3006, 4.72m long and 3.62m wide, reaches a height of 1.25 m. Only the internal face of the basin was cleared. It is characterized by non-isodomic masonry and relatively irregular stones cut in length.

3. We rapidly recognized a stone with rope marks near the structures, confirming the hydraulic nature of the installation before the excavations.
4. Modern waste has been found not only in basins L3006 and L3007, but also in canals L3023 and L3018, which are still covered.

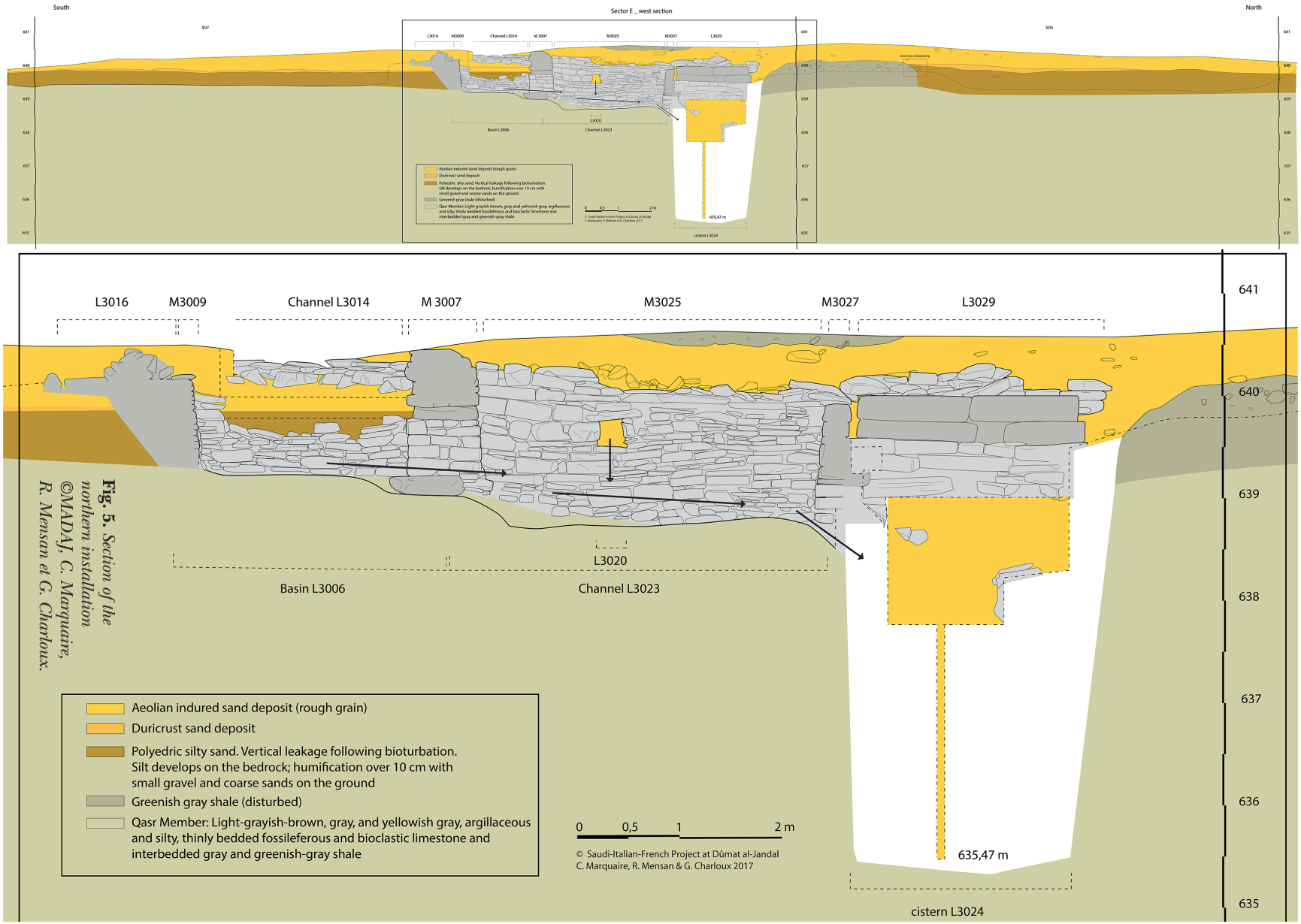

Fig. 5. *Section of the northern installation ©MADAJ, C. Marquaire, R. Mensan et G. Charloux.*

A semi-apsidal structure (L3016) preserved only two stone courses high and contiguous with the south wall of the L3006 basin, could have played the role of a buttress or have been a kind of curbstone to facilitate access to water.

The southeastern corner of the basin is open (L3028) : this opening is part of the original construction, intended to permit the runoff of water from the outside to the inside of the basin.[5]

There is an extension on the eastern part of its northern wall : alcove L3004. It adjoins a small decantation basin (L3026), of which only a few stones remain.

The alcove has a stair (L3020) on its northern part which provides access to the principal basin. This arrangement must have been planned to facilitate the cleaning and repairs of the installation.

On this northern wall, but in its western part, a channel (L3023) covered by large slabs created a junction between the basin and cistern L3024. Rectilinear and oriented southwest/northeast, this channel measures 4.20 m in length. Completely excavated, it showed a significant dip at its northern junction with the cistern, where the bedrock declines sharply (fig. 5). This junction was formed in the masonry of the wall that closes the channel in its northern part : the opening could be closed by a large stone of almost 50 cm in height laid vertically.

Horizontal slabs covered the cistern (L3024) at the time of its discovery. Owing to the risk of collapse and danger to the workmen, the cistern was only partially excavated, revealing its corbelled dry stone masonry.

The size of the stones used for the construction of the cistern superstructure, up to 1.30 m long, 70 cm wide and 15 cm thick, is much larger than that used for the walls of the installation. It is on the other hand rather close to that of the covering slabs of the channel.

Core drilling in the cistern reached the altitude 635.47 m (about 4.5 m under the surface) ; it is, however, impossible to know if it corresponds with the bottom of the structure. It is certain, however, that it had been dug into the bedrock, which emerges in the canals and basins (fig. 4), and that digging persisted until

Fig. 6. *The cistern and channel L3023 of the northern installation MADAJ, C. Marquaire, DJ2017a0062B.*

5. A marly layer creating a slope from the outside to the inside of the basin.

Fig. 7. *The slab and the filter at the west end of channel L3014, ©MADAJ, R. Mensan.*

reaching a layer of greenish gray shale, as evidenced by backfill deposited north of the structure.

To the west of cistern L3024, a "platform" M3020 was exhumed. Only preserved one course of stones high, and associated with a small wall, it is founded at the same level as the covering slabs of the cistern.

At the northeast of cistern L3024, several irregular narrow stone walls preserved one to two courses high were excavated. These walls are superimposed on each other, indicating that they were constructed during multiple stages. They post-date the construction of the hydrological installation but were probably used at the same time.

A straight channel (L3014), oriented southwest/northeast and still partially covered by slabs on its northern part, joined the main channel (L3023). It is 14 m long and has a slope of about 1.5 % from west to east. This channel collected rainwater in the Qā', towards the cistern via channel L3023 (and opening L3030). Its western end is marked by a stone laid vertically and pierced by six rectangular central perforations. These crude perforations could not have acted as an optimum water filter but were probably intended to prevent obstruction of the channel by unwanted waste (*e.g.* by branches or stones).

In the case of the northern installation, the section (fig. 5) shows that the central arrangement (basin L3006, channel L3023 and cistern L3024) was dug in the bedrock by removal of naturally detached limestone blocks. The nature of the geological formation certainly made difficult regular digging of the structure's faces, which were therefore reinforced by stone masonry.

The emerging part of the masonry, above the surface, served to consolidate the upper part of the remains in the paleosol – a very compacted, brown, polyhedral sandy loam which had accumulated in the center of the depression, before the implementation of the structure – and wind sands accumulated over time. Channel L3014 was installed in the paleosol and sandy substrate at its western end and dug into the bedrock at its eastern end (L3023).

The cover of the channels and cisterns was probably not a strategy to counter evaporation due to this arid context, but rather acted to prevent aeolian silting, especially since the structure was without water part of the year.

Southern installation

The central basin (L3007) measures about 4.85 m long and 3.02 m wide. Its walls are preserved at 1.10 m high max (fig. 3, fig. 4). Its ground has a downward slope to the west (639.45 m to the southeast and 639.11 m to the northwest).

Here again, there is an alcove in the northeast wall of the basin and a channel (L3021) installed further west. In front of this alcove, on the other side of the basin, a small tank (L3022) was probably used for decantation, like L3026 in the northern installation. This tank was built at the junction between the two western walls of the basin, which are completely disconnected. Its bottom, located 0.70 m (asl 639.79 m) above that of the nearby basin (L3007), revealed a layer of very compact sand.

At the southeastern end of the basin, several small standing stones forming another rectangular tank were found. These tanks were perhaps used to filter the water. Water was then drained from the Qā‘ towards the cistern (L3019, not excavated) via the basin and through a covered channel (L3018) about 5 m long. The channel is characterized by a bent axis, oriented firstly southeast/northwest then northeast. Its southern opening measuring 0.22 m wide and 0.60 m deep is in all respects similar to those of channel L3023 in the northern installation.

Discussion

Use and function of the structure

The architects of this hydraulic system made good use of the natural topography: the northern and southern installations in sector E were built at the heart of a depression (Qā‘), where water was naturally led towards the channels, basins and associated cisterns. The two structures seem to have worked in a complementary way, both recovering water from different areas. The northern structure is fed from the west and the south, while the southern one gets water from the southern and eastern sides. Indeed, most of the rainwater comes from the southwestern area of the Qā‘. The installation could therefore recover most of the flow without being open to the north.

This observation, however, does not fully explain the lack of hydraulic development in a small depression located 30 m west of the structure, and about 0.30 m

lower than the canals and the rock surface (fig. 3). Does this suggest that the depression had another function? Was this small depression covered with sand in former times? Or did walls or ditches, now vanished, originally block the area conducting water towards the hydraulic structure?

These issues lead to the broader question of the diachronic evolution of the landscape and of the two excavated hydraulic structures. They are very similar in construction and therefore do not seem to have been built very far apart in time. No construction connects the two systems on the surface, and the sedimentary deposits in the interval do not show any relative stratigraphy. However, the construction of a double installation raises many questions: was a single structure not sufficient to manage the water runoff? Was it a problem of storage capacity? Or did the silting of the sector require the construction of another structure, and the displacement of the cistern? Was the creation of channel L3014 contemporary with the rest of the northern installation or was it added later, in order to fetch a low zone of water stagnation far to the west? We have no definite answer to offer on these points yet. However, the complementarity use of structures at a given moment seems to confirm at least one phase of contemporaneity.

In the hyper-arid region of Jawf, rainfall is scarce and irregular (less than 50 mm/year) and occurs mainly in winter and spring as intensive, short-lived episodes.[6] This can explain the development of effective rainwater collecting strategies. The goal of this installation remains nonetheless debatable.[7] Although the geomorphological study finds no trace of agriculture in the area, the role of the small circular walls north of the complex is uncertain. Instead of agricultural activity, we may suggest some watering use in narrow walled spaces. Herds could also have found sparse undomesticated desert plants in the Qā'. The installation was a station for animals from caravans and herds to drink, or even for the transport of water to nearby inhabited areas. It is perhaps significant that, even today, shepherds lead their sheep to this point every day, maybe echoing an ancient practice.

Dating

The architectural characteristics of the hydraulic installation – namely a relatively elaborate construction involving basins, water channels, a six-hole filter and covered cisterns – indicate that it dates back to historical periods, although it probably predates the rise of Islam, on account of the absence of large rectangular or circular *birkeh* or specific hydraulic lime.[8] The ceramic evidence seems to corroborate this dating as well.

6. During the 2017 campaign (March), sector E was totally flooded after one night of rain.
7. In this case, we think that the hypothesis of a refuge for inhabitants of the oasis is not compelling because of the location of the structure on a flat desert limestone plateau.
8. The excavation of the cistern was too dangerous: it was therefore impossible to determine details of cutting techniques. It is therefore also impossible to determine the chronological range of the installation, nor can we delimit chronological phases and periods of reuse. No OSL, or C^{14} dating was carried out during the project.

The surface layer and the exposure of the installations yielded a small assemblage of 103 pottery sherds, most of which lacked any diagnostic features. Only 54 of them were collected in or under aeolian deposits within the archaeological remains. Most sherds are dense and well-baked, in a rather fine orange ware,

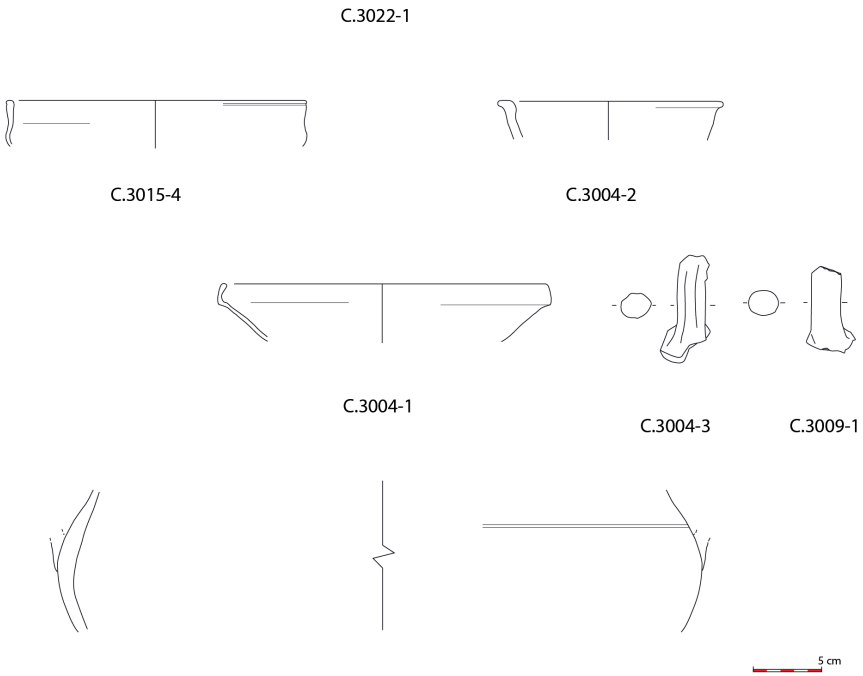

Fig. 8. *Pottery assemblage found in sector E, ©MADAJ, G. Charloux (C.3013-1).*

with fine mineral grit (P2A) typical of Nabataean productions, and sometimes covered with a thick beige-white slip or more rarely with a red slip. One example is a very fine unpainted "eggshell" dish with an incurved rim (fig. 8, C.3004-1). It is entirely covered by a red slip, onto which a thick white slip was added on the outer rim. This is a well-known shape in Nabataean contexts (Schmid, 2000 : abb. 49-51, gr. 6-7 ; Negev, 1986 : 79, n° 614-617), notably in the *triclinium* at Dûmat al-Jandal (Charloux, Bouchaud *et alii*, 2016 : fig. 6f). Another small bowl whose everted rim is underlined by a horizontal incision (fig. 8, C.3022-1) – as well as a vessel sherd – reminds unpainted Nabataean table ware shapes (Schmid, 2000 : abb. 179). Several other sherds belong to a globular jar in the same fabric (P2A), dense but thicker, with an orange surface and grey core (P3 ; fig. 8, C.3015-1). It was found in a layer of indurated sediment north of L3006. Handle C3009-1 (fig. 8) could have come from a jar of this type. Thirteen sherds from a single local cooking pot (thick orange-beige paste with large white limestone grit : P3 ; fig. 8, C.3013-1) attributed to the classical period came from a layer of very indurated sand at the bottom of channel L3014.

At the same time, we noticed a significant quantity of sherds made of a rather powdery white marl ware (P1) encountered in Hellenistic and Nabataean contexts in the oasis and certainly of local provenience. It includes a bowl with a thin and sinuous profile exhibiting a horizontal incision on the outer rim (fig. 8, C.3015-4) ; its face is covered with a residual white-beige slip. This bowl may imitate some pottery shapes with painted rims from Petra (Schmid, 2000 : abb. 194-196, 359 [phases 1-2]). There are also a bowl with thicker walls and a slightly everted rim (fig. 8, C.3004-2 ; compare with Schmid, 2000 : abb. 68, 129, 170) and a jar handle (fig. 8, C.3004-3).

To sum up, table, storage and cooking wares were found in small quantity in sector E. They were produced in two different fabrics : one typical fine orange "Nabataean" ware, probably produced in the Jawf region but of exogenous tradition, and the other white marl ware, a possibly contemporary production but mainly of local tradition. In view of the successive looting and the nature of the fillings of the structure, this ceramic assemblage seems homogeneous, although it can only provide *a silencio* dating for the main period of use of the hydraulic structure, *i.e.* around the 1st century AD. At that time, we know that Dumat experienced a dense growth of Nabataean occupation (Savignac, Starcky, 1957 ; Loreto, 2013 ; Charloux *et alii*, 2016), as well as of the surrounding environs (Muaikel *et alii*, 1994 ; Charloux *et alii*, 2018 ; Charloux, 2018). This also coincides with a period of intense transarabian trade (Schmid, 2004 ; Charloux *et alii*, 2014 : 204-208).

Persistence of water collecting systems in a desert environment

Desert populations adopted specialized livelihood strategies to survive in inhospitable environments since the first phases of Holocene aridification. Rainwater collecting and storage systems, like cisterns, were naturally the most common strategy in such environments.

However, other hydraulic strategies are encountered in this landscape. Dams, which are commonly found in Arabia (Charbonnier, Schiettecatte, 2013), were in use, as were retaining walls, for example at Dûmat al-Jandal (Charloux, 2018) or qanat networks (Charloux *et alii*, 2017).

— The advent of desert hydraulic systems is generally difficult to establish, in particular because of the lack of detailed documentation of these structures and publications. Several water collecting structures can be dated with certainty to the Neolithic period, *i.e.* the Middle Holocene aridification phase (Dinies *et alii*, 2016) : Qulbān Banī Murrah (130km southeast of al-Jafr) (Gebel, 2013 : 113, n. 8 ; Gebel, Mahasneh, 2013 : 131, n. 19) and Rasif (north of Sakākah) (Gebel, 2016) [9] are "typical sites" for pastoral cultures in northwestern Arabia that developed this storing runoff water technique as early as the 5th millennium BC. Installed in shallow depressions, these structures developed with dams forming artificial watering areas. Rainwater was channelled and naturally drained and stored thanks to the slope in the ground. These sites also included channel systems connected to wells. The rainwater collecting principle is therefore similar to the installations from sector E of Dûmat al-Jandal, despite different means. We can also notice that a similar strategy associating dams and a cistern-like feature is dated from the PPNB in the Jafr Basin, at the southeastern edge of the Transjordanian plateau (Fujii, 2010). This cistern-like feature is a semi-subterranean structure without covering composed of three rooms. Only one of these rooms is well masonry with five buttress walls. The principle of runoff water draining is the same but it is less sophisticated because of the evaporation of the water in this large "cistern-like" feature and the absence of channels.

— A well (SU 5995) was excavated in area E at Tayma (in the central part of the site), near building E-b1 used from Hellenistic (Lihyanite) to Late Roman (after the 2nd-3rd centuries AD) periods[10]. Its construction seems to date back to the Nabataean/Early Roman period (1st century AD : Hausleiter A. *et alii*, forthcoming a : pl. 0.14, 0.18 ; Hausleiter A. *et alii*, forthcoming b : table 2), according to pottery and stratigraphic examination as well as comparison of masonry with a well at Mada'in Salih. The duration of its use is more difficult to establish, but does not seem to bypass the Late Roman period as shown by the material in its upper fill[11]. The well is enclosed by a rectangular double wall and connected to E-b1 building with a channel 15 m long. The junction between the channel and the well was fitted out in the wall of the well and is surmounted by an architrave whose dimensions – 1 m high and 0.60 m wide – allowed easy

9. We can cite Rajajil, but the well seen by Zarins in 1979 (Zarins, 1979) is still not found.
10. A cistern (SU 3373) dug into the bedrock, with masoned stairs and channels covered with slabs, was also recently found north of Early Iron Age building O-b1 (Hausleiter A. *et alii*, forthcoming b : &2.1 ; comm. A. Intilia & F. Tourtet, dated 9th-12th cent BC according to them. Thanks for this information. Icaane 11, 4th April 2018).
11. The lower fill would date back to the Nabataean/Early Roman period according to the authors (& 3.4), see also Lora, 2017.

maintenance. The module of the stone blocks as well as the corbelled construction technique and the dry stone masonry are similar to the installations of Dûmat al-Jandal. However, its use – water drained from the well via a channel – as well as its role, no doubt cultic, differs radically.

— Riy'a Qiriyah is another interesting site which was reported during the 1980s surveys along the pilgrim roads (Gilmors *et alii*, 1983). It is located on a low terrace at the base of Jebel Qiriyah in southeastern Arabia, and has a large rectangular birkeh (46 m × 46.65 m). The basalt walls were completely covered with plaster. In the centre, a square infrastructure was built and has openings similar to the channels connected to basins L3006 and L3007. In addition, its western wall was consolidated with a circular buttress of 0.65 m in diameter on its outer side comparable with L3016. This installation, probably later than that of Dûmat al-Jandal, was not precisely dated, but the similarities seem to confirm the longevity of these technical processes in Arabian desert environments.

Nabataean hydraulic technology and local tradition in northwestern Arabia

The Nabataeans' skill in hydraulic engineering is well-known thanks to Diodorus Siculus (XIX, 94, 2-9). Their hydraulic structures were vital in arid contexts, and insured them political independence and autonomy. Diodorus Siculus informs us that the Nabataeans built cisterns – only they knew the location of – outside the cities and provided with tiny orifices hidden from enemies. Archaeology has shed more light on this practice. The Nabataeans developed ingenious water resource management systems; they constructed dams against wadis, dug channels, and constructed basins and cisterns to collect and conserve water (Muheisen *et alii*, 2009; Muheisen *et alii*, 1988).

This type of water management scheme is recurring, particularly in Petra, where the catchment system is developed both locally and on a large scale (Nehmé, Villeneuve, 1999; Ortloff, 2005; Muheisen *et alii*, 2009) to channel runoff and spring water. The 'local' level uses channels dug in the bedrock leading water to cisterns, which were often pear-shaped and generally covered with masonry arches supporting slabs. A settling basin is often associated, joining the canal and the cistern (*e.g.* in the Jabal Ithlib in Madâ'in Sâlih : Dentzer, 2008; Nehmé *et alii* 2010). But here again, these installations are constructed in mountainous areas and their function is often religious.

In the wadi Ramm and in the vicinity of Petra, hydraulic infrastructures for collecting rainwater are also numerous (Muheisen *et alii*, 2009). However, the channels, connected to unmasoned settling basins and cisterns located on outcrops, are used in a distinct topographical context. The use of a corbelled technique is however frequent for the cistern cover. The structures consisting of channels, settling basins and slab-covered cisterns, like in Dûmat al-Jandal, are thus numerous in the Nabataean sphere.

The principle of drainage is however older in Transjordan. On the Umm al-Biyara at Petra, many cisterns at the top of outcrops are attributed to the Edomite

period, and are perhaps even more ancient according to Gentelle (2009: 133).[12] The Nabataeans seem to have adapted a technique they had known for a long time.

At Dûmat al-Jandal, the massive use of masonry in sector E deviates completely from the transjordanian pattern, so it is difficult to posit the diffusion of this technology to northern Arabia. Moreover, the dimensions of the installation as well as its relatively simple use are factors that suggest its construction did not require a central supervising authority – unlike other hydraulic strategies.[13]

In this case, is it:

— A technological adaptation to a specific and local hydrological context? It is well known that the Nabataeans adapted their techniques according to the particular context of each region. For example, in the Negev, terraced farming – probably practiced to bring water to the agricultural areas near farms located in hyper-arid areas south of Beer Sheva – relied on the collected runoff water, according to a regional practice documented since the Neolithic (Bruins, 2012). It is the same at Petra, where terraced farming was practiced in the Nabataean period. There, the runoff water was canalized (Muheisen *et alii*, 2009; Ortloff, 2005; Nehmé, Villeneuve, 1999) and the soil erosion was prevented by walls (Gentelle, 2003).

— Or rather, as we believe, a local practice of building hydraulic systems, the oldest traces of which date back to the Mid-Holocene and which we see in Tayma during the Iron Age. According to this scenario, the builders of our hydraulic system would have been inspired by a pre-existing practice. From this point of view, it is interesting to note the divergence between this installation (sector E) located in the margins of the oasis and those implanted in its heart (water retention walls, qanâts). By its nature, we think that it was a watering area, a sort of niche or refuge along long-distance regional and commercial routes, put in place by a population clearly linked with the Nabataean cultural sphere. Considering its position in the desert and its ephemeral type of use, we would privilege pastoral/nomadic peoples, but other solutions cannot be ruled out.

In conclusion, the discovery of this system of collecting rainwater in a small natural depression, type Qā', makes it possible to highlight on the one hand a long practice of subsistence and of human adaptation in a desert environment, and on the other hand, perhaps, a regional specificity whose geographical extent will have to be established with the multiplication of publications on this type of hydraulic structure.

12. We know of some examples of cisterns built at the top of mountains, for instance in South Arabia. Near Shabwa, the *neqaba* (name of these cisterns) are cut in sandstone and, despite their small openings, have a huge storage capacity. A small wall erected all around the cisterns brings the water into them. (Pirenne, 1990).

13. In Petra, the construction of this type of hydraulic structure could be undertaken by one or more families, for example (Nehmé, Villeneuve, 1999).

Dûmat al-Jandal was in fact controlled by a Nabataean authority in the 1st century AD. Nevertheless, there remains no conclusive evidence that the pastoral nomadic (and sedentary) peoples of the Southern Jawf – who produced a large number of graffiti in Ancient North Arabian alphabets (Norris, 2018) – considered themselves as Nabataean, although they were very close culturally. From the perspective of water management, the strategies and technology employed at the oasis were regional.

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