Studying the origin of the foggara in the Western Algerian Sahara: an overview for the advanced search
A. Dahmen and T. Kassab

ABSTRACT
After more than a century, studies on the origin of the foggara the Western Algerian Sahara remain open. The reasons are related to disconnected approaches and a lack of focus on the subject as a main search aim. Hence, there is a need for a retrospective synthesis on what could be figured out from the different studies on the question in order to suggest a new search perspective. An overview of the sources shows an ascending development through reporting, critical and interpretative approaches. The comparative study figures out some synthetic aspects which feebly suggest a local invention process even with some preliminary arguments. The origin of the foggara often seems of secondary interest. The origin is checked, at least, through apparent foggara characteristics so that the studies seem less systematic. Additionally, an interest in the intangible aspects and comparative studies is missing. The study concludes that there is a need to conduct multidisciplinary fieldwork investigation in the regions surrounding the Tademaït plateau. This has to be conducted on the most ancient foggaras, checking systematically the characteristics of both tangible and intangible aspects. An additional comparative study should eventually check the similarities with the recent findings in the ancient Garamantian Fezzan.

Key words | foggara, foggara origin, ifli, intangible heritage, Western Sahara

INTRODUCTION
The foggara is a well-known traditional hydraulic system especially in the arid zones of various places around the world. More recent sources suggest that its earliest presence should be related to the 2nd millennium BC in north-east Iran (Fattahi 2015). The technique consists of catching groundwater through a gently inclined tunnel, ventilated by successive shafts, so that water outlets to the surface to irrigate the downstream soil. Given the central role of the technique in foggara-based agriculture zones, advancing knowledge about its genesis seems of particular interest for the comprehension of the history of the settled arid zones. Additionally, the results will indicate to what extent the resilience capacity of the hydraulic structures has coped with the effects of climate change after the last Pluvial starting from the 20th century BC (Rognon 1994).

The foggara is found in various areas in North Africa from Egypt to the Canaries in the Atlantic Ocean (Figure 1). There are several foggara-based regions like Kharga in Egypt or around Marrakesh in Morocco (Chartinières 1919). Some other regions are more likely foggara-sparse areas where the technique punctuates other hydraulic systems. This is the case in the Tunisian Djerid or in the Algerian Saoura valley. Their most ancient presence seems to be in Egypt around the 5th century BC (Wulff 1968), while the more recent is around Marrakesh related to the 11th century (Lô 1953–1954).

The first Kharga foggaras are attributed to the Achemenian Empire (Semsar Yazdi & Labbaf Khaneiki 2010). It is also known that the Moroccan foggara, called khettara, is from a transfer process. However, there is no tangible
evidence about the origin of the foggara in the Western Sahara. The oldest foggara in North Africa is attested as a transfer from the Iranian region. This may suggest that the technique has been developed from the East to the West. However, the Moroccan case indicates that the process might have had various developments.

In Algeria, the foggara-based agriculture zone is situated in the Western Sahara. It is situated at the south side of the Great Western Erg and mostly around the Tademaït plateau (Figure 2) in the regions of Gurara, Tuat, and Tidikelt, which are described as the most concentrated foggara zone outside Iran (Bisson 1989; Kobori 1989). This underlines how central the technique could have been in the Western Saharan life. It has enabled Berber and Arab settlements for more than a millennium. It has enhanced the Saharan trade between the Mediterranean cities and the African city kingdoms of the so-called Bilad-es-Sudan.

Due to their particular features, and mostly the hydro-geological conditions, there are at least four kinds of foggara. The most common is the Tademaït foggara, tapping on the fossil aquifer called the Continental Intercalary or more commonly the Albian. This foggara is exclusively representative of the three regions of Gurara, Tuat and Tidikelt. The Erg foggara is situated on the southern limits of the Great Western Erg. It taps on the Erg aquifer fed from the southern slopes of the Saharan Atlas. This second kind may also cover the foggaras tapping on the foothills such as in Beni-Ounif at the south side of the Great Moroccan Atlas. The third kind is the valley foggara catching the riverbed water flow such as in some areas along the Saoura Valley or in the Hoggar region in the Central Sahara. The last one is the source foggara which gathers various water sources such as in Beni-Abbes near the Saoura Valley. This is also the case in Bouchagroun and Badès in the south of the Aurès Mountains at the eastern side of the Tellian Atlas. The four kinds could also cover the chegga system, a network of small foggaras such as in the region surrounding the Hodna lake near Msila. The chegga is mostly initiated from dried-up water sources; but it can belong to the various cited kinds.

According to various sources, the Tademaït foggara seems to be the oldest. Its common foggara profile is a gallery tapping in the water table of the fossil aquifer. The successive escarpments dropping to the salty depression called the sebkha allow the gallery to outlet to the surface irrigating the soil situated downward. The drainage process works naturally towards the sebkha (Figure 3).

The origin of the foggara in the Western Algerian Sahara has interested scholars in recent centuries. The first attested source belongs to a Saharan scholar from the 18th century, Ahmad ben Yussuf at-Tinilani (1593–1667), quoted by Martin (1908). Obviously, since the French colonisation of
the region in 1902, the technique has been of particular interest (Niéger 1904; Watin 1905; Martin 1908, 1923). More accurate studies came three decades later (Gautier 1930, 1933; Cornet 1952; Lô 1953–1954; Bisson 1957). After independence, additional studies manifested more interest (Capot-Rey & Damade 1962; de Planhol 1968; English 1968; Echallier 1972, 1973; Mammeri et al. 1973; Goblot 1979; Granier 1980; Bellil 2000; Bisson 2003; Wilson & Mattingly 2003; Wilson 2009). More recent sources belonging to the Desert Migrations Project (2007–2011) indicate an earlier dating, up to the 2nd century BC (Wilson 2009), of the Garamantian foggaras in the Libyan Fezzan (Mattingly et al. 2010).

However, the Foggara origin question remains open. Obviously, clarifying the question is crucial to advance knowledge about the history and development of Saharan Berber settlements through their capacity to adapt elementary hydraulic structures up to the foggara technique. Hence, there is a need to make a synthesis of what could be figured out from the different studies in order to underline the weak points and suggest a new search perspective.

Figure 2 | Map of the Algerian Sahara with its hydrographic network. The foggara complex corresponds to the south-west limits of the fossil aquifer called the Continental Intercalary. Source: Dahmen (2015).
Several different origins have been attributed to the foggara. Some sources suggest Roman, Jewish, Arab, or Persian origins. Some sources consider an external origin indisputable (Goblot 1979; di Angeli & Finocchi 2010). However, other sources insist on a genuine invention process (Cornet 1952; Bisson 2003), while more recent works are willing to consider the technique invention process as polycentric and related to various periods (Boucharlat 2015). Nevertheless, the hypothesis of an exogenous origin is still more supported given the particular foggara spread after demographic increase as Arab tribes arrived in the region starting from the 11th century. An overview of the main literature, and the way this addresses the issue, shows an evolution in three major approaches which could be identified as: the reporting approach, the critical approach, and the interpretative approach.

The reporting approach

This is the earliest approach motivated by a lack of reliable information on the region. Except for some comments that sometimes occur, it simply reports from the statements or records collected from the local tradition or the limited ancient written sources. Even though the first-known written manuscripts go back to the 12th century (Bouterfa 2005), those reporting about the foggara start from the 17th century. Quoted by Martin (1908), At-Tinilani seems to be the earliest; he reports that the foggara was transferred by the Jewish people who arrived in the region in 4322 (Jewish calendar), which corresponds to 562 AD.

Reporting from other local sources, Watin (1905) attributes the first foggaras to some travellers being tired and left by caravans, at various times, close to a well in the Reggane region, 150 km south of Adrar. Consequently, thirst was the main reason to lead them to explore the region and dig wells. The convenience and abundance of water stimulated their imagination to connect the wells through a gallery. Then the water joined up and followed the gradient of a slope and emerged to the surface. A similar description is also given by Niéger (1904). Watin reports a second tradition which refers the creation of Tamentit villages to the Jews who had come to Tuat by the 5th century. However, he does not indicate if they may have introduced the foggara technique.

The critical approach

This approach is more critical of the sources in order to check more efficiently their veracity. It tends to oppose the former sources with additional general observations on the foggara. The studies often belong to a further discipline such as geography, archaeology, anthropology, or sociology. Martin (1908), even if he underlines the exaggerations of the At-Tinilani report, justifies the introduction of the technique by a climatic drying process during the first millennium AD. Some other sources insist on a particular climate change affecting the hydraulic systems. Due to the large presence of the salted depressions, sebkhas, through the Maghreb, and the use of...
uncovered galleries around the ancient settlements in the region, Marouf (1980) suggests that the region used to be a lake system enabling ground hydraulic networks. The drying-up process would have caused the use of the artesian system pre-dating the foggara system. However, the theory is strongly disproved by Bisson (2003). Based on several works synthesised by Rognon (1994) and confirmed by Côte (2014), he shows that these depressions could not be previous water lakes.

Gautier (1908) mentions the Eastern origin as being quite evident. However, he notices that Algerian foggaras were not the aim of a preconceived plan, but were a result of centuries of progressive trial-and-error processes. He underlines the disproportion between the huge work and the insufficiency of those who achieved it.

Lô (1953–1954) supports a foggara transfer in the Tidikelt region as the technique could not be mastered by nomadic tribes. He also notes that the digging process of the gallery starts downstream from a dried-up source.

English (1968) allots qanat introduction in the Maghreb to a second cycle of major diffusion from the Iranian area during the 7th and 8th centuries following the spread of Islam. Moreover, foggaras would be those of Jews or Judaised Zenata Berbers fleeing from Cyrenaica during Trajan’s persecution in 118 AD. However, he gives no evidence about the existence of the foggara in northern Libya.

Echallier (1972, 1973), Mammeri et al. (1973) and Bellil (1999, 2000) conducted studies in the Gurara region. The area is described as more evidently keeping its genuine characteristics. The studies involve various disciplines, respectively archaeology, anthropology, and sociology. They confirm the primacy of Berber settlements and draw up the evolutionary forms from semi-nomadic life to sedentary (Table 1). All three sources seem to prefer the Arab transfer hypothesis.

Goblot (1979) used to be described as one of the most prominent scholars in qanat studies. He clearly supports the Eastern transfer, referring to three French authors: Watin (1905), Martin (1908, 1923), and Gautier (1908, 1923). He points out a satisfying common point in favour of an external transfer of the technique; hence he accepts this ‘consensus’ as a historical fact. Additionally, he refutes any means of local invention, arguing that the qanat must necessarily arise from mining expertise.

Smaili (2011), a local scholar, strongly believes that the foggara would be of local invention by the Zenata Berber tribes. Referring to Herodote (1850), who quoted the Nasamons trip describing many desert regions populated of salt-stone-built villages during the 5th century BC, the author concludes that the Sahara seems to have been settled almost since that date. Hence, he concludes that it was certainly supplied by foggaras as the sole possible technique enabling enough water for drinking and irrigating continuously.

The interpretative approach

In this approach, there is more focus on the foggara itself. Its visible characteristics are studied in relation to the related environment. Obviously, there is a particular interest in checking what can be figured out from interdisciplinary

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Population</th>
<th>Name</th>
<th>Place</th>
<th>Hydraulics</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Small raised fortress with central court and a well</td>
<td>Semi-nomadic breeders</td>
<td>Awmah</td>
<td>Between Uled-Aissa &amp; Ajdir</td>
<td>Well</td>
</tr>
<tr>
<td>T2</td>
<td>Small fortress raised with caves cut in the base</td>
<td>Judaic communities</td>
<td>Taerhi</td>
<td>Between Wajda &amp; Timimoun</td>
<td>Chegga, small dams</td>
</tr>
<tr>
<td>T3</td>
<td>Fortress, small constructions staged with caves in the bottom, terrace and covered way and enclosing wall often with a ditch and houses outside the enclosure</td>
<td>Various lineages</td>
<td>Agham</td>
<td>Generalised</td>
<td>Chegga, foggaras</td>
</tr>
<tr>
<td>T4</td>
<td>(T3) surrounded by external houses with several doors and house rampart, mosque and place with covered area</td>
<td>Several lineages, model around a Zawiya eventually</td>
<td>Ksar (village)</td>
<td>Generalised</td>
<td>Foggaras</td>
</tr>
<tr>
<td>T5</td>
<td>(T4) in bigger size</td>
<td>Several lineages</td>
<td>Big Ksar</td>
<td>Charwin, Uled-Saïd, Timimoun</td>
<td>Foggaras</td>
</tr>
</tbody>
</table>
interpretation. Studies mostly result from site investigations with more reliable analysis. Cornet (1952) conducted a hydrological study with more focus on the Gurara region. He concluded that foggaras were first developed from a dried-up source in an elementary form called a chegga, a trench in Arabic, which he describes as an ‘embryonic foggara’.

Capot-Rey, who conducted a study in the Tuat region, noticed that water in the oldest foggaras of Tamentit is shared by duration, not by volume (Capot-Rey & Damade 1962). He concluded that they may belong to the Zenata Berbers even if he accepts a possible transfer. Starting from similar investigations, Bisson (1957) and de Planhol (1968) confirm the Zenata origin. Additionally, half a century later, Bisson (2005) continues to refute any transfer hypothesis.

Granier (1980), who conducted a geographical study on the Gurara region, has focused on the origin of the foggara through a part of its management characteristics. He points to the base-24 numeration used in the foggara water division as a proof that the foggara system pre-dates the Arab penetration, given that the Arabs use decimal numeration.

More recently, Wilson (2006, 2009) underlined a possible transfer in ancient North Africa based on the conclusions of the Fezzan Project (1997–2000) directed by David Mattingly (Mattingly et al. 2003). He underlined some similar foggara characteristics with the Western Algerian Sahara. It mostly concerns physical characteristics, social organisation, and foggara building and maintenance. In addition, the two regions use the same name to identify the system. He suggests a transfer from the Fezzan since the early centuries AD as a consequence of the change operating in trans-Saharan trade from the Garamantian network to the Western Sahara.

DISCUSSION

The three approaches seem to draw a significant evolution. They start from a very basic level, consisting of simply reporting what appears as first-hand information from the autochthons, in a more accurate way. This is clearly shown through the timing evolution (Figure 4). The reporting approach ends with the short early period following the colonisation of the Western Sahara. The critical approach follows just after. The year 1908 seems to be a moment of inflection. This is due to the early launched studies on Western Sahara hydrogeology.

The interpretative approach starts at the beginning of the second half of the 20th century. The second-approach studies end by the 1980s except for the Smaili contribution (Smaili 2011); the interpretative-approach studies, however, seem to continue more obviously into the 21st century.

Synthesis

Apart from the tentative discussion given by the earlier work of Martin (1908), the reporting approach sources do not show a need to discuss what they report. The two later approaches present accurate analysis and give more discussion about previous studies; some authors confirm a previous thesis, as does Bisson (1957, 2005) for Cornet (1952), whereas others refute hypotheses supported by predecessors, like Goblot (1979) with de Planhol (1968), or like Wilson (2009) with Martin (1908), English (1968) and Goblot (1979).

Furthermore, the interpretative approach presents more substantial arguments and more focus on the foggara features. Researchers Cornet, Capot-Rey, de Planhol, and Bisson have conducted local investigations. Excepting Capot-Rey, who softly accepts a possible transfer, all others support a local invention process (Table 2). Wilson underlines the Fezzan Project results which refer the origin of the foggara to the 2nd century BC. Further dating operations have pushed the limit two centuries earlier. However, the fieldwork is limited to the Libyan Fezzan and the transfer thesis needs more site investigation.

Findings

A transversal lecture suggests some key features which can already be noticed. The foggara technique is attested before the Arab tribe’s arrival. It corresponds more to the
Berbers in both Libya and Algeria where the water system takes the Arabic name: foggarā. While the Libyan foggarā belongs at least to the 2nd century BC, the Algerian foggarā belongs to the Berbers who settled in the region before the 10th century, presumably during the early centuries AD. Even if the artesian sources’ anteriority is attested, the foggarā technique seems to be the major means enabling nomads and semi-nomads to change massively to being sedentary. Furthermore, due to the important effort needed to build up a foggara, the technique might have required a gathering process between the primary separate lineages inherited from the nomadic and semi-nomadic periods (Bellil 1973).

In both the Gurara and Tidikelt regions (Cornet 1952; Lô 1953–1954), foggarā building starts more generally downward without reference to a mother well upward. However, in the Tuat region, a mother well called ayn-el-foggara, literally the foggarā source, seems to be witnessed by the practitioners (Grandguillaume 1973).

Foggara water sharing is mostly by volume. The flow is divided so that every shareholder can receive water daily and continuously. Some older foggaras seem to have water sharing by duration such as in the case of Tamentit. The major part of the hydraulic systems share water by duration. This is the case in the Algerian Sahara, and presumably in the whole Maghreb. The sole use of sharing by volume concerns river floods, as in the Ziban region around Biskra or in the Mzab valley. There is no evidence regarding the sharing system in the old Libyan Fezzan; this would be essential for checking transfer possibilities.

Some foggaras in the Gurara and Tidikelt regions seem to start from a dried-up source (Cornet 1952; Lô 1953–1954). In the early 20th century, the French administration dug some artesian wells around In-Salah in the Tidikelt region. The artesian sources were attested up to the southern Gurara in Uled-Mahmoud (Martin 1908). This fact confirms that artesian sources pre-date the spread of the foggara technique. Furthermore, the trial-and-error process is noticed by two sources from both the critical and interpretative approaches (Gautier 1972, 1958).

In the Gurara region, several foggaras present, in their downstream gallery, a feature similar to the chegga system. The chegga exists more exclusively in the north, such as in the Ziban region (Flamand 1908), and around the Hodna Lake in Msila region, where it would be of the Berber Ibadits (Despois 1953); it would be related to the cimbra developed by the Berbers in Spain (Bazzana & Meulmeester 2009). As an elementary technique, the chegga could be achieved independently everywhere without the need to suppose how the invention was diffused. However, the rise of the technique after the artesian water sources could possibly occur either as a transfer or a local invention process.

### Table 2 | The foggara origin sources related to the Algerian Western Sahara, classified following the major three approaches explained above

<table>
<thead>
<tr>
<th>Approaches</th>
<th>Authors</th>
<th>Field/Discipline</th>
<th>Conclusion about foggara origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reporting approach</td>
<td>Niéger (1904)</td>
<td>History</td>
<td>Invention by gathering water wells by a gallery</td>
</tr>
<tr>
<td></td>
<td>Watin (1905)</td>
<td>History</td>
<td>Jew/Berber transfer from Cyrenaica</td>
</tr>
<tr>
<td></td>
<td>Martin (1908, 1923)</td>
<td>History</td>
<td></td>
</tr>
<tr>
<td>Critical approach</td>
<td>Gautier (1908, 1923)</td>
<td>Geography</td>
<td>Trial-and-error process</td>
</tr>
<tr>
<td></td>
<td>Lô (1953–1954)</td>
<td>Hydrology</td>
<td>Evolution from a water source</td>
</tr>
<tr>
<td></td>
<td>English (1968)</td>
<td>History</td>
<td>2nd historical transfer cycle from Iran</td>
</tr>
<tr>
<td></td>
<td>Echallier (1975)</td>
<td>Archaeology</td>
<td>Introduced by Arab tribes</td>
</tr>
<tr>
<td></td>
<td>Mammeri et al. (1973)</td>
<td>Anthropology</td>
<td>Introduced by Arab tribes</td>
</tr>
<tr>
<td></td>
<td>Goblot (1979)</td>
<td>History</td>
<td>Transfer from Iranian qanat</td>
</tr>
<tr>
<td></td>
<td>Granier (1980)</td>
<td>Geography</td>
<td>Pre-Arabic origins</td>
</tr>
<tr>
<td></td>
<td>Bellil (2000)</td>
<td>Sociology</td>
<td>Allotted to lineage gathering process</td>
</tr>
<tr>
<td></td>
<td>Smaili (2011)</td>
<td>History</td>
<td>Zenata invention from 5th century BC</td>
</tr>
<tr>
<td>Interpretative approach</td>
<td>Cornet (1952)</td>
<td>Hydrology</td>
<td>Evolution starting from a chegga</td>
</tr>
<tr>
<td></td>
<td>Capot-Rey &amp; Damade (1962)</td>
<td>Geography</td>
<td>Pre-Islamic evolution from a water source</td>
</tr>
<tr>
<td></td>
<td>Bisson (2003)</td>
<td>Geography</td>
<td>Evolution starting from a chegga</td>
</tr>
<tr>
<td></td>
<td>Wilson (2009)</td>
<td>Archaeology</td>
<td>Transfer from the Libyan Fazzan</td>
</tr>
</tbody>
</table>

The table underlines the major conclusions on the origin of the foggara.
PROBLEM

Among all the cited sources, the origin of the foggara seems of secondary interest. At least, there is a focus on the apparent characteristics of the foggara. However, given its secondary status, the characteristics analysis seems not to be systematic and we can therefore underline some missing points.

The foggara is the Arabic name corresponding to the Berber name, ifli or efeli, largely in use presently in the Berber territories around the Tademait plateau, in the Hoggar, and in the Moroccan Tafilalet (Gast 1998). Given the collapse of the technique in the Fezzan since the mid-first millennium AD, there is no evidence of a Berber name even if some foggara shafts clearly keep some Berber inscriptions (Barnett & Mattingly 2003; Mattingly et al. 2010). The geography of the names and toponyms is of particular interest to deepen the question of the origin of the foggara. Moreover, there is a need for more interest in old language use and more generally about the intangible aspects. Indeed, as limited as they are, the studies on the oral tradition in the Gurara conducted by Bellil (1999, 2000) suggest how useful a focus on the intangible aspects of the foggara could be.

The strongest arguments related to the foggara origin issue are those concerning the foggara itself. The arguments found are only partly gathered and the results seem inconclusive. The Libyan studies have approached the question in a limited way; the investigation in the galleries was limited since all of the underground part was choked with sand.

Another critical aspect is related to the fact that the Algerian foggaras are in use, although in continuous decline. A live heritage is always a source of concern for the dating process. This indicates the critical need to consider the various aspects globally.

CONCLUSION

To fully clarify the question, the origin of the foggara has to be central and of first interest in future research studies. An in-depth site investigation about the characteristics aiming to clarify the foggara genesis is of first interest. Although limited, the Fezzan Project seems to be a relevant way to investigate the origin of the foggara in the Western Sahara. However, there is a serious need for a comparative fieldwork study opposing the Berber foggara zones in the Western Sahara and the Hoggar, to the Garamantian Libyan foggaras. A multidisciplinary study gathering scholars from anthropology, archaeology, sociology, cultural heritage, architecture and town planning has to be implemented on a fieldwork investigation. In particular, more focus on archaeological investigating may enable more details through the use of new dating processes, as for the Miam qanat in north-east Iran (Fattahi 2015). The interest has to cover the oldest foggaras for both tangible and intangible aspects. This may especially be of interest in the Gurara region due to its genuine aspects in relation to the Berber past.

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REFERENCES


Martin, A. G. P. 1923 Quatre siècles d’histoire marocaine au Sahara de 1504 à 1912 (Four Centuries of Moroccan History in the Sahara from 1504 to 1912). Alcan, Paris, France.


Smaili, M. 2011 (Foggara genesis and development in Tuat). In: *Colloque international sur la Foggara (Cifog), Adrar (Algeria)*, 9–11 April 2011.


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