



## **THE FOGGARAS OF IN SALAH (ALGERIA): THE FORGOTTEN HERITAGE**

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### **ABSTRACT**

In this article we treat for the first time the foggaras of the region of In Salah. The mission in the region and surveys near the ksourienne population showed that the In Salah foggaras are dug in the southern outskirts of the Tadmaït plateau to capture the waters of the Albian aquifer which is approaches the ground. The distribution of the water of the foggaras obeys of the volumetric law. Farmers receive their water units at the same time; the irrigation shall proceed in parallel.

Because of economic and environmental problems, these traditional techniques are regressing and may disappear in the short term. On a number of 104 foggaras dug in the oasis: In Salah, In Ghar Foggaret Ezzoua, Foggaret El Arab Sahela Foukania, Sahela Tahtania, Igostene, Hainoune and El Barka, there are only 30 foggaras in service, but with a discharge very low. To save what remains of the hydraulic heritage, a rehabilitation plan is required in the short term.

**Keywords:** Foggara - In Salah - Oasis - Tablecloth – Intercalary Continental.

### **INTRODUCTION**

In Salah, one of the most arid regions on the planet. Given the low annual rainfall in the region (60 mm/year), surface water is scarce on the ground. For cons, under ground is abounded groundwater. The oasis of In Salah sat a one of

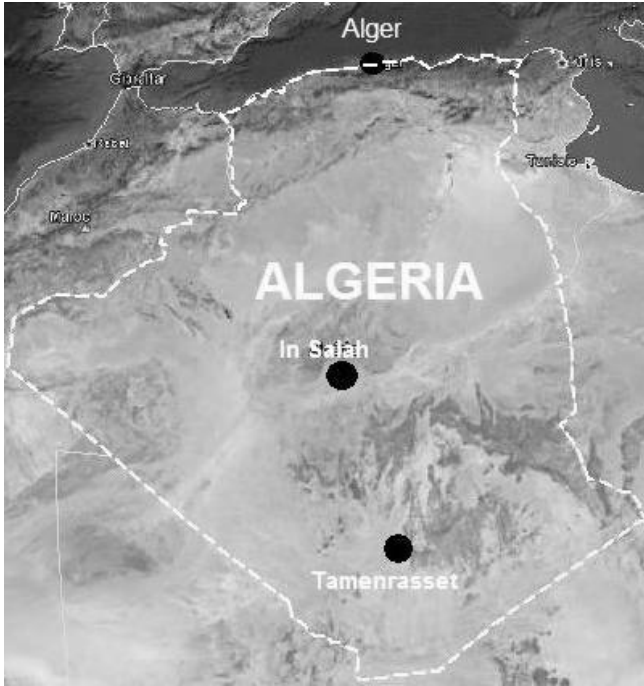
the large tablecloth of the globe, it is the Continental Intercalary. For over 10 centuries, the farmers used artesian wells to supply the ksours and develop the agriculture. With the disappearance of artesian phenomenon, the farmers have used hydraulic techniques for acquisition of groundwater; they are called the foggaras.

The Albian aquifer approaches the soil surface in the Tadmait plate, which permits to join in creating tunnels of foggaras. It is admitted that this hydraulic technique is born in ancient Persia there are more than 3000 years under the name of qanat (Ghorbani, 2007; Kazemi, 2004). Become a universal technique, the qanat has spread to over 30 countries around the world (Hofman, 2007). It is through these foggaras that the oases have been developed in the Algerian Sahara, especially in the oasis of Adrar (Abidi and Remini, 2011), Timimoun (Remini et al, 2011), Ahaggar (Remini and Achour, 2013) and Mزاب (Remini et al., 2013). With these 1400 foggaras, the Adrar region is considered the country of foggaras. Numerous studies on the history, sociology and hydraulics were performed on the foggaras of Adrar and Timimoun. By cons, there is no scientific work on the foggaras of Ain Salah, which has prompted us to make this contribution.

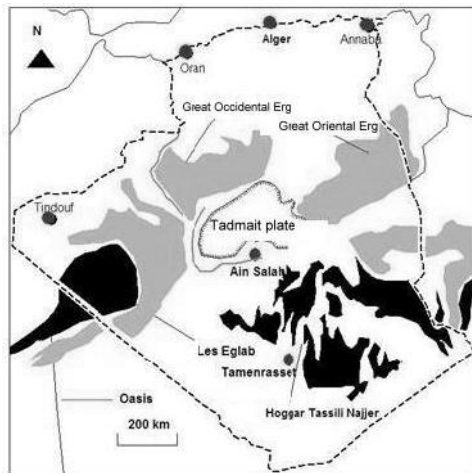
## **PRESENTATION AND CHARACTERISTICS OF THE STUDY AREA**

The region of Ain Salah is located in the center of the Sahara. It is located at 1000 km south of the capital Algiers and at 600 km north of Tamanrasset (Figure 1). Ain Salah is a hyper arid region; it is considered one of the hottest regions of the Sahara. The In Salah region contains nine oases: In Salah, In Ghar, Foggaret Ezzoua, Foggaret El Arab, Sahela Foukania, Sahela Tahtania, Igostene, Hainoune and El Barka.

The oases are developed over several centuries thanks to the two existing groundwater in the region. It comes groundwater and the Continental Intercalary. Two traditional techniques have been developed: the well to draw water of the groundwater and the foggaras to exploit the waters of the Continental Intercalary aquifer which approach the soil on the periphery of the Tadmait plate. Moreover, the oases of central Sahara form an arc of green circle on the east side of Tadmait plate (Figur 2 a and b).



**Figure 1:** Location of the study area



a)

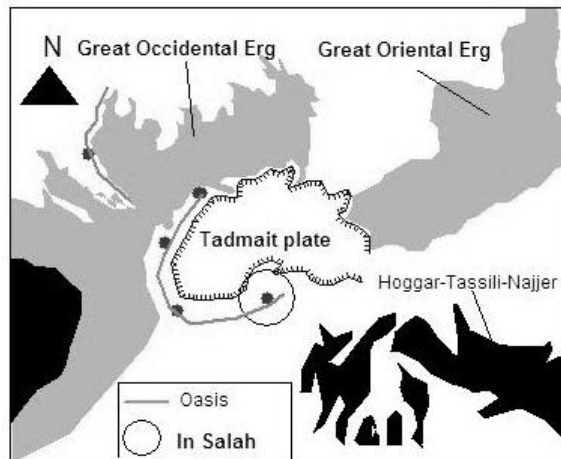
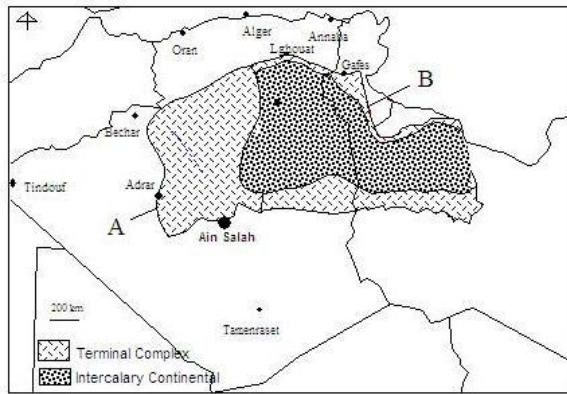


Figure 2 : Localization of oases at foggaras around the Tadmaït plate

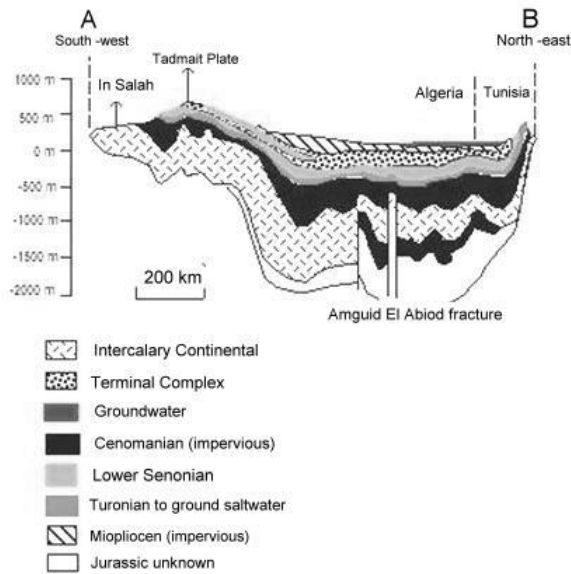
## RESULTS AND DISCUSSION

### Water resources of the In Salah region

Due to the rarity of rainfall in the In Salah region, it is rather the groundwater reserves are principally the basis of formation of oasis. There are two types of aquifers: groundwater and Continental Intercalary. Knowing that the Tadmaït plate is considered such as the reservoir of foggaras of regions of Adrar, Timimoun and In Salah, since in the under ground of Tadmaït plate exists the water of the Continental Intercalary (Figure 3 a and ). It is considered as to one of the largest of the tablecloth in world occupying an area of 600,000 km<sup>2</sup> and containing 60 trillion m<sup>3</sup> of water. For comparison, this volume is equivalent to 12,000 times the capacity of Algerian dams (Remini, 2007). Continental Intercalary Basin was defined between 1940 and 1960 (Dubost, 2002). It consists of different permeable formations Saharan underground filled with water during rainy periods of the Quaternary, contains a quantity of water equal in theory to a hypothetical continuous flow of 1000 m<sup>3</sup>/s during 20 centuries (Dob, 2003, Guido, 2005 and Ansari, 2005).



a)



b)

**Figure 3:** Intercalary Continental and Terminal Complex aquifers  
(Design Remini, Source Unesco 1972 Castany, 1982)

### **Foggaras In Salah**

Undoubtedly the foggaras of Touat and Gourara are the most studied. Various studies have been made since the fifties. We can cite the work of Cornet (1952), Grandguillaume (1973), Kobori (1982) Goblot (1979), Remini and Achour (2008, 2012 and 2013). Five inventories of foggaras were conducted in 1909, 1960, 1974, 1998 and 2012. Few studies have been conducted on the foggaras of Tidikelt particularly those of Aoulef. We can cite the work of Capitaine Lo

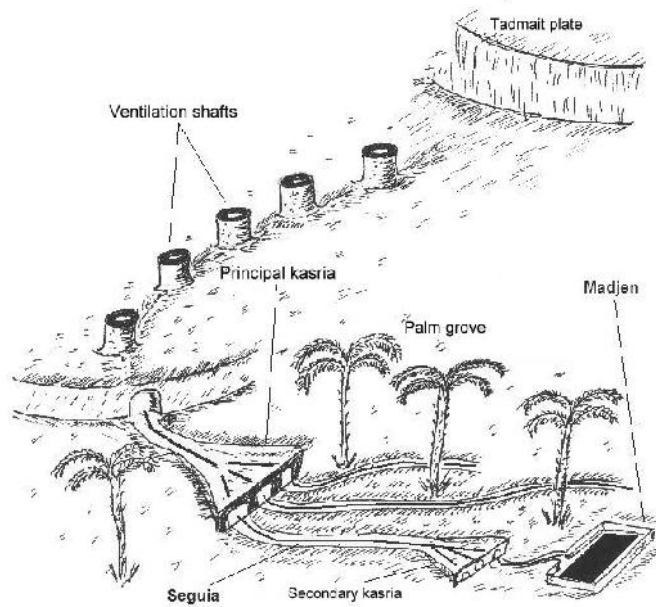
(1953, 1954) and Kobori (1969). Now, Aoulef belongs to the wilaya of Adrar according to the latest clipping of wilayas. The foggaras of In Salah have many similarities with those of Adrar and Timimoun in two parts: capture and distribution. Dug south of the Tadmait plate, the foggaras of In Salah were not inventoried. On site of foggaras, we identified about 100 foggaras spread over oases: In Salah, In Ghar Foggaret Ezzoua, Foggaret El Arab Sahela Foukania, Sahela Tahtania, Igostene, Hainoune and El Barka (Table 1). These values are approximate, since there are of foggaras that have been abandoned and it is not even a trace.

**Table 1 :** Foggaras of In Salah region (approximate Data)

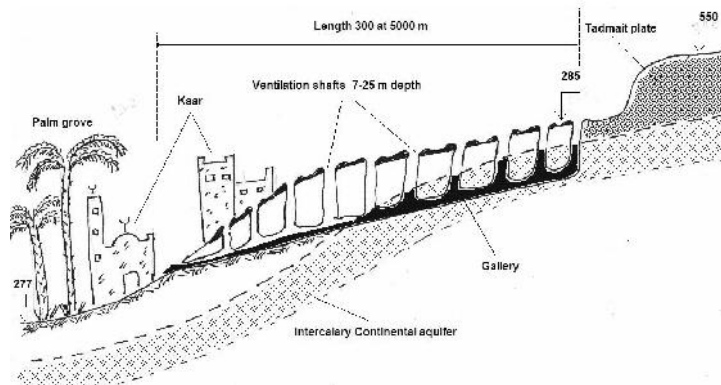
Oasis	Total foggaras	Operating foggaras	foggaras dry
In Salah	25	08	17
In Ghar	20	10	10
Foggaret Ezzoua	15	07	08
Foggaret El Arab	08	00	08
Sahela Foukania	10	02	08
Sahela Tahtania	09	02	07
Igostene	06	00	06
Hainoune	05	01	04
El Barka	06	00	06
Total	104	30	74

Over 100 foggaras were dug in the oases of In Salah region. Today there are only about 30 in service. This number is approximate and should be lowered for socio-economic reasons. Direction North-east to south-west, the In Salah foggaras capture the waters of Continental Intercalary through underground tunnels with a maximum length not exceeding 5 km. The galleries are equipped with maintenance and aeration well separated from each other by an average distance of 13 m (Figure 4 a and ). On a slope ranging from 0.003 to 0.006, the galleries have two parts: drainage and transportation. We can estimate the total length of the galleries of foggaras at 100 km and the number of wells in 7500. As foggaras of Adrar and Timimoun, those of In Salah are equipped with a main kasria just outside the gallery (Figure 5). It is the centerpiece of the foggaras system. It is from this triangular basin equipped with a distributor that makes the sharing of water between the owners. The existence of kasriates in all distribution networks of water of foggaras of In Salah shows that the sharing of water is volumetric, the irrigation of gardens occurs at the same time (Figure 6). This confirms that the foggaras in the In Salah region comes of Adrar and Timimoun. The volumetric method is more advantageous compared to the hourly method practiced in the oasis of Ahaggar (Remini and Achour, 2013) and of Moghrar (Remini, 2011), it can be irrigated at the same time all the

parcels. It is said that the irrigation of the gardens is parallel. This type of distribution (volume) requires the existence of individual Madjens to store its share of water. In addition to the main kasria, volumetric network has secondary, tertiary and multiple kasriates.



a) Overview of foggaras of In Salah



b) Longitudinal section of foggaras of In Salah

**Figure 4 :** Simplified diagram of foggaras of In Salah



**Figure 5 :** Kasia of the foggaras of Ezzoua (In Salah)



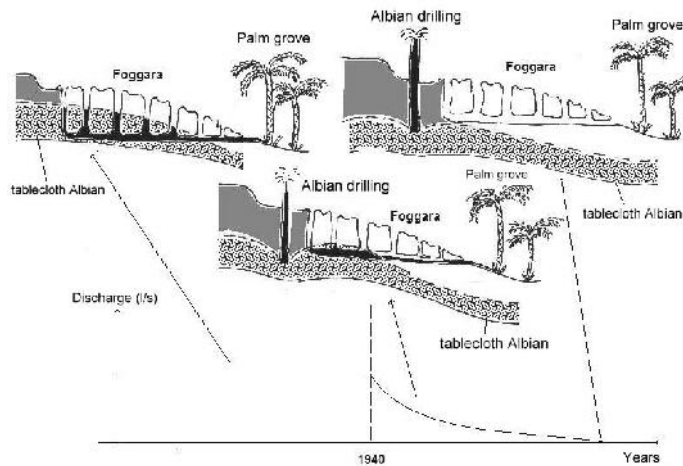
**Figure 6 :** In Salah garden irrigated by foggaras

### **Degradation foggaras In Salah**

Socioeconomic and environmental problems are causing the decline of the hydraulic heritage. These problems include: the collapse of wells and galleries due to the urban development. Homes and roads have been made over the galleries. From a social, the inheritance is the problem that has contributed to



the degradation of foggaras. The contribution of the groundwater wells capturing the Continental Intercalary in the In Salah region in the early forties has contributed significantly to lowering of the water, which caused the drying up of several foggaras. The discharge of foggaras of In Salah has evolved in two phases. In the first phase the discharge of foggaras remains constant over time if it is assumed that there was no collapse or maintenance. The low discharge captured by the foggaras does not disrupt the groundwater level of the Albian aquifer. The contribution of the drilling early forties has led the lowering of the water and consequently the discharge of foggaras recorded a decline in time to the total drying foggaras (Figure 7). Due to its efficiency, the use of pumps for groundwater exploitation has become generalized in all the oasis of In Salah. Farmers quickly abandoned the old system to the detriment of the new system on the basis of its performance and autonomy of irrigation.



**Figure 7 :** Evolution of the discharge of foggaras of In Salah

## CONCLUSION

Effectively the foggaras of In Salah is a forgotten heritage since it was abandoned by scientists and hydraulic services. If the foggaras of Adrar and Timimoun have been the subject of several publications, those of In Salah are not processed. More than a hundred foggaras were dug in the oases on the southern outskirts of the Tadmaït plate. Today, it remains in service only thirty foggaras for socio-economic and environmental problems. The contribution of new techniques (drillings and pumps) in the In Salah region has contributed to the decline the foggaras. With this rhythm we risk losing the rest of foggaras at short term. The rehabilitation of these foggaras becomes an indispensable operation to save the hydraulic heritage.

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