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Exploitation of albian geothermal water in South Algeria

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Abstract

The Intercalary Continental aquifer generally called Albian aquifer constitutes the main geothermal resource in South Algeria. Additionally it represents the biggest water reserve in the word. Albian aquifer is used since centuries, especially in the areas where it levels like Tidikelt Touat and Gourara. But however in other areas where this aquifer is deep and whose water is hot, the exploitation of the aquifer is rather difficult.
As the only geothermal resource in southern Algeria, the Albian aquifer has a lot of interest from geothermal point of view; therefore good knowledge of the different routes of its exploitations is necessary to facilitate future applications of geothermal in the Saharan regions.
The present article gives an overview about various modes of exploitation of the Intercalary Continental aquifer and the major problems which have occurred during exploitation. Finally is added discussion about the main applications of geothermal energy in South Algeria based on projects completed or in progress.

Keyword: Intercalary Continental - Albian aquifer- Geothermal water- Exploitation.

1. Introduction

The Intercalary Continental aquifer is situated in the South of Algeria, see Fig 1, it covers an area of 650.000 km^2 [1]. Geologically, it consists of the Barremian carbonates and sandstones; the Aptian clay

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and dolomits and the Albian clay and sandstones [2]. The aquifer outcrops in its South-West part (in Adrar and Aîn Salah). The depth of this geological layer increases to Northeast direction; it reaches 2500 m depth at the Northeast periphery such as in Biskra and El Oued regions [1]. The water temperature varies from 30 °C to 80 °C respectively from West to East [1]. The potential of groundwater is evaluated by the mathematical model of Eress study [2] to 2381.5 hm^3 including 627 hm^3 for the Albian aquifer. Due to interest of albian aquifer for geothermal studies, this article contains especially the explanation of different ways of Albian aquifer exploitation and major problems encountered during these operations.

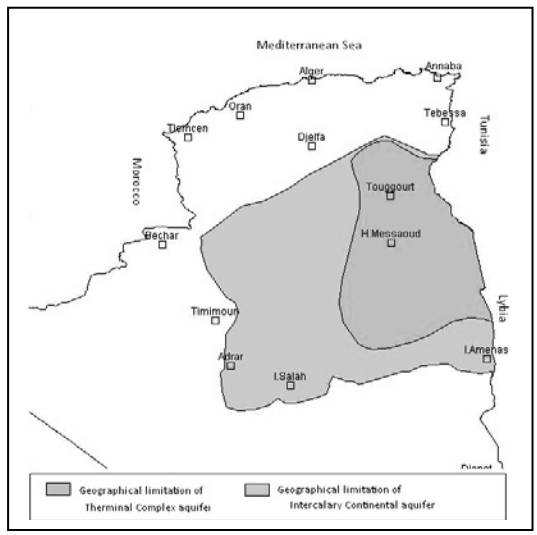

Figure1. Geographical extension of the Albian aquifer in Algeria

2. Exploitation

Between 1986 and 1987, three deep wells which have reached Intercalary Continental aquifer were executed [4]. Since then, The albian water is mainly used for irrigation, which was representing most important part of the water uses and then for drinking and industrial supplies. The exploitation of the albian thermal water in the industry and urban sectors needs the use of a cooler, in Touggourt region a cooler has been built near Ain Sahra province for population water supply. The albian waters arrive to the surface naturally by hot springs or artificially thanks to the foggaras or drillings, see on Fig 2 and Fig 3.

2.1. Structure The foggara

Centuries ago, the operation began with the direct use of water at sources that existed in the South-West part of the aquifer particularly in Tidikelt, Touat and Gourara areas. Since a long time, these hot springs have disappeared, in their place an ingenious technique of water collection has been developed. This technique is called the foggara.

The various searches that are interested in the system of groundwater exploitation converge that the origin of the foggara dates back over 3000 years, and would be born in Persia (Iran country today) and

this technique has followed the long axis of religious propagation of Islam to the great Maghreb countries and then to Spain who brought it in the Americas [5]. The names are different, "Qanats" in Iran, "Ngula" or "Krige" in Tunisia, "Khettara" in Morocco or "Sahridj" in Yemen. The first foggara in the Algerian Sahara have been dug in Tamentit situated at 15 km from Adrar [5], such as the foggara of El Megheir whose construction go back to the ninth century, it is the largest foggara in the region of Timimoun at about 200 km of Adrar.

From 1998 to 2001 the ANRH (Water Resources Agency, Algeria), engaged exploration companions through saharian territory in order to realize the foggaras existing inventory. This is the most reliable statistics existing now [5]. The wilaya of Adrar count 1400 foggaras whose 907 are in perennial (in services) and 493 dry.

Figure2. Foggara in Algerian Sahara,
Source: http://groupedetransport3.forums-actifs.com/t155-les-foggaras-un-patrimoine-en-peril

The collection system consists of an underground tunnel to drain water from the basement and bring it by gravity to the surface of a depression or an Oasis without any expenditure of energy. The water is captured and transferred upstream and downstream to the palm [3]. This gallery whose height is 2 m and several kilometers long is dotted with ventilation shafts. It needs permanent periodic maintenance to remove debris falling from the walls and hinder the flow of water. The genius of the oasis, through the technique of foggara has for centuries been able to make available to the community, without waste and with rationality, the precious liquid is water. The foggara as a physical system compatible with the constraints of fragile ecosystems, it makes a moderate interaction with its environment allowing the slow charging of deep sleep under the uplands of Tademait [5]. However this technique tends to disappear because of the complexity of its implementation and its maintenance. However it will still a historical and cultural world patrimony that governments can develop in tourism [5].

2.2. The drillings

Technological and demographic development has led to increasing needs of water and energy whose consequence was a rapid growth in wells drilled in the Saharan regions. Many drillings are made in the context of oil and water explorations. The boreholes which are deep and reaching the Intercalary Continental layers constitutes a very important database that permitted the realization of various studies on the Albian aquifer. There exist boreholes three types of drillings in the South of Algeria, oil drilling, water drilling and oil drilling converted to water. Statistically, the number of wells whose data were used in the studies of the Albian geothermal tank is near 446 [1], in which 289 are oil drilling, 118 are hydraulic drilling and 39 are oil drilling converted into boreholes.

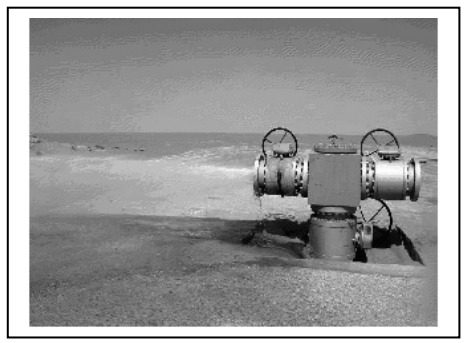

Figure 3. The Albian well, source: www.anrh.dz/souteraine.htm,

2.3. Petroleum wells converted to water boreholes

Several unsuccessful oil exploration conducted by Sonatrach (Petroleum Society of Algeria) through Saharian territory have been converted to water boreholes. The deep drillings that have reached the Albian geological layers have been converted into water wells for irrigation without taking into account the specificities of the Albian aquifer. Knowing that the oil drilling equipment does not conform to standards defined for drilling water, this conversion can cause significant damage on the tablecloth and lead to serious and irreversible situations.

3. Albian water discharge

In the projects of the National Office for the Rural Development Study Bneder [2], a historical flow rate of water discharge from the Albian covering the years 1957-1998 was established. On Table 1 below are summarized flow rates corresponding to different towns of south Algeria between 1960 and 1998.

Using data from Table 1, the graphs in Figure 4 are realized. These graphs show that the exploitation of the Albian water has recorded a continuous increase between 1960 and 1190. On 1990 started the decline in the flow rates recorded. It has been confirmed that this phenomenon is probably related to the overexploitation of the albian water which has certainly caused serious instability of the water table such as the water level drawdown. It is seen on the graphs that regions of Touat - Gourrara and Tidikelt are the main users of albian waters; they represents 44 % of the total exploitation.

Table 1 . History of the Albian flow rates from some areas of South Algeria, Bneder report [2]

Régions	1960	1965	1970	1975	1980	1985	1990	95	1998
Illizi	80	84	84	84	84	100	100	100	100
Biskra	115	109	100	181	154	550	905	790	760
Ouargla	160	385	728	1098	1270	2006	2472	2191	2131
M'zab	983	1149	1049	1423	1844	2569	2820	3103	3103
Oued Rhir	1505	1340	752	1319	1450	2627	3360	3660	3135
Adrar	123	229	346	476	556	1058	5983	7404	7268
Total	2966	3296	3059	4581	5358	8910	15940	17248	16497

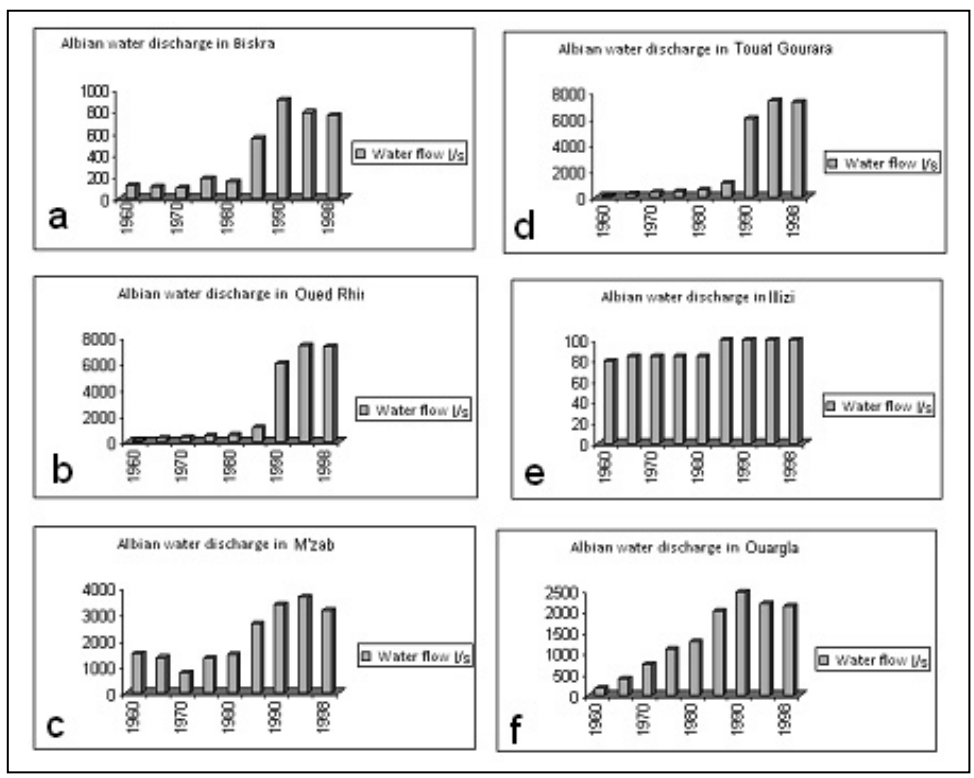

Figure 4. Albien water discharge in some saharian regions:
(a) Biskra; (b) Oued Ghir; (c) M'zab; (d) Touat-Gourara; (e) Illizi; (f) Ouargla.

4. Problems in the exploitation

4.1. Corrosion

Under the effect of high temperature, thermal waters dissolve the minerals that were in the geological layers traversed [6]. While relaxation (pressure drop) or cooling phenomenon happened, minerals such as (calcium sulfate or calcium carbonates) precipitate and form deposits adhering to the walls of pipes. The scaling of pipes (Figure 5) constitutes a serious handicap for the exploitation of thermal waters in saharien provinces. The pipes become more and more unusable over time. The scaling of canalizations imposes a systematic change of pipes and increased energy expenditure. In economic terms the cost of that water is fairly high. In order to fight against scale, there are various ways [6], among which the electromagnetic means or chemical means by the use of calcification inhibitors of ..., etc. In practice, some the experiments that have been already made in the fight against the pipeline scaling, the results have prouved that the chemical means are most convenient; they include the addition of polyphosphates in water.

Figure 5. Scaling of pipes

4.2. Rising water from groundwater

The development of techniques for exploiting deep water with poor management and control of these resources has caused serious imbalances in the Albian aquifer of South Algeria. This imbalance has caused many problems at the surface such as the draining of wetlands, reduction and loss of many hot springs, land subsidence, contamination of water tables and rising waters from groundwater see Fig 6.

Figure 6. Grove irrigated by flooding

These problems are mainly due to overexploitation of groundwater in the Algerian Sahara, Indeed, in the last 25 years the population explosion and urban development have increased the demand for water. This involved drilling wells deeper and deeper for the exploitation of groundwaters from the Intarcalary Continental and Terminal Complex aquifers. Large quantities of water are then removed. After their use, and due to lack of outlets and the subsequent lack of sewage pipes, wastewater rises up to the water tables which becomes supercharged beyond the surface where they forms permanent water pools[7]. This situation has created serious consequences for the environment [7] as asphyxiation of many palms (over 500,000 per year), contamination of groundwater, the foul odor; threat of land collapses; air pollution...Etc.

The phenomenon of upwelling groundwater is a major problem experienced in many parts of the Algerian Sahara. This problem is becoming increasingly serous particularly in El Oued and Ouargla areas. As example, in the region of El-Oued, the inhabitants live mainly from farming and the cultivation of dates. This culture is now threatened by the problem of groundwater upwelling whose result is directly reflected in the groves crops. The statistics shows that thousands of palm trees dies each year from asphyxia, see Fig 7.

To minimize the impact of this environmental problem, it is very urgent to start to implement new simulations with the aim of identifying new areas of water collection, taking into consideration the maintenance of artesian and the maintenance of outfalls; maintaining foggaras with respect of heights pumping eligible and the preservation of water quality near the Chott. On January 2006 two major projects are initiated by Algerian specialists in the aim of improving the sewerage system and the final fight against the rising waters.
The operations involved including the implement the equivalent of 700 km of sewage evacuation and the installation of wastewater treatment plants in the regions of El Oued and Ouargla.

5. Geothermal applications in South Algeria

5.1. Greenhouse heating

In 1990 was realized a first application of geothermal energy in greenhouses heating in the Algerian Sahara (Region of Touggourt and Ouargla). The greenhouses are used for melon and tomato cultivation [8]. The project was directed and supervised by a group of researchers of the Center of Development of Renewable Energies of Algeria. Although this model has yielded good results, however it has not yet widespread. The exploitation of geothermal energy for greenhouses heating is very small compared to the great potential geothermal resources in southern Algeria.

5.2. Aquaculture

Thermal waters play an important role in the aquaculture field, see Fig 7, since they constitutes an ideal culture space for many species of fish. In Algeria, although the potential of thermal water is significant, aquaculture is still in its beginning. In order develop aquaculture; the Algerian government has established a National Plan for Aquaculture Development, which provides incentives subsidies for encouraging private investment [9].

Figure 7. Aquaculture project in the Algerian Sahara

Some projects of fish farming have started producing in South Algeria including the farm of Hassi Ben Hamouda Lefhal (W. Ghardaia), extended over four hectares and producing 490 tons per year [10]; Bouarif farm in Ouargla containing Tilapia broodstocks; aquacultural farm of Hassi Ben Abdellah in Ouargla producing Gambusia and Tilapia species; Moulay farm in Ouargla producing 1 000 tons / year.

6. Conclusion

Intercalary Continental aquifer presents a major geothermal resource in South Algeria. The underground waters which are operated from deep boreholes are mostly used in irrigation, drinking water and industry.

The exploitation of the Albian water has been increasing continuously since 1960 in almost all regions of southern Algeria. This operation is however faced with various problems, the most the scaling and corrosion in pipes and the rising water of groundwater .In order to fight against these problems, Algeria has commissioned experts in various fields to find definitive solutions and implement them as soon as

possible. Recently Algeria will be undertaking works for pilot experiments of geothermal applications on the heating of greenhouses and make facilities to development of fish farming and aquaculture for some varieties of fish or plants.

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