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Characterization study of the Albian reservoir of southern Algeria

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Abstract - *Deep oil and hydraulic drillings that have reached the Albian aquifer also called the Intercalary Continental aquifer testify that this is an important reserve of thermal water that constitutes the main geothermal resource in southern Algeria. The main purpose of this study is to define the structural characteristics of the Albian reservoir of southern Algeria such as localisation and structure, depth, thickness, and piezometric level. For this purpose, we have realized characterization maps using data from petroleum drillings of Sonatrach (National Society for the Research, Production, Transportation, Processing and Marketing of Hydrocarbons) and hydraulic boreholes of ANRH (National Agency for Water Resources) of Algeria.*

Résumé - *Les forages hydrauliques et pétroliers profonds qui ont atteint l'aquifère de l'Albien appelé aussi le Continental Intercalaire, témoignent qu'il s'agit d'une importante réserve d'eau thermale qui constitue la principale ressource géothermique au Sud de l'Algérie. Le but principal de cette étude est de définir les caractéristiques du réservoir Albien du Sud de l'Algérie telles que la localisation et la structure, la profondeur, l'épaisseur et le niveau piézométrique. Pour cela, nous avons réalisé des cartes de caractérisation en utilisant les données de puits de pétrole de la Sonatrach (Société Nationale pour la Recherche, la Production, le Transport, la Transformation, et la Commercialisation des Hydrocarbures) et de forages hydrauliques de l'ANRH (Agence Nationale des Ressources Hydrauliques) de l'Algérie.*

Keywords: Characterization - Albian - Réservoir - Drilling data - Petroleum well - Hydraulic borehole - Structural map - Algeria.

1. INTRODUCTION

Southern Algeria has been the subject of numerous geological and hydro-geological studies that have defined the main characteristics of the Albian aquifer [2-5]. The Albian aquifer is defined by continental Mesozoic Cretaceous formations situated between the Cenomanian and Neocomian, which consist of sand and sandstone inter-bedded with clay (figure 1).

The base consists of primary Paleozoic land that is made very rough by the Hercynian orogeny. The roof is formed mostly by the upper Cretaceous deposits constituted by Cenomanian and Turonian clay. The Albian geothermal aquifer is a fossil layer that is weakly loaded, compared with its volume. The main recharge of the tank dates back to the rainy period of the Quaternary.

The current groundwater recharge is mainly done by the infiltration of runoff water of rivers descending from the mountains of the Saharan Atlas in the north, the mountains of Dahar of eastern Tunisia, and the rivers of western Tademaït. During exceptionally wet years, a low recharge of the reservoir is supplied by rainfall infiltrations in outcrop zones of the Great Western Erg.

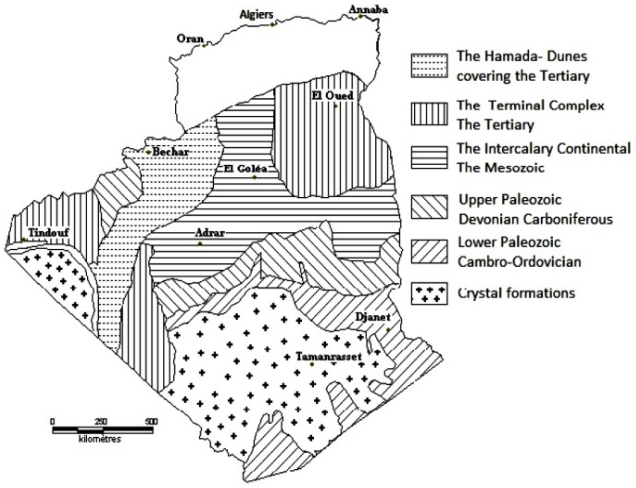

Fig. 1: Hydro-geological map of the Algerian Sahara [6]

2. METHODOLOGY

In order to achieve the characterization maps needed, data acquisition and processing are the most important steps.

2.1 Data acquisition

The total number of hydraulic drilling consulted is 118. The drillings were made during the period from 1953 to 1987. The crossings depths reached are ranging from 100 m to 2900 m. The maximum depth is 2937 m, reached by the ABS-1 drilling conducted in 1970 in the Nafta region.

Table 1: Selected hydraulic drilling data of southern Algeria [1]

Drilling	Region	Year	Depth	Piezometric level
H011-541	El Oued	1981	1615	230
J0010-583	Ouargla	1974	1122	244
J0011-8	Ouargla	1257	1272	379.3
H006-59	Laghouat	1968	210	134
G009-122	Biskra	1982	1640	110
I009-55	Ghardaïa	1973	640	403
0004-18	Adrar	1959	407.1	-

Table 2: Selected data on oil converted to water drilling data of southern Algeria [1]

Well	Longitude (E/W)	Latitude (N/S)	Depth (m)
RYB-1	09°20'33"E	30°46'08"	810
MAO-101	07°06'32"W	28°53'50"	433
EG-102	09°03'45"E	32°01'45"	532
GLA-1	05°11'51"E	31°57'59"	939
RDJ-1	04°01'52"W	34°17'32"	1157
DET-1	05°23'37"E	33°01'13"	1111
ZM-1	07°33'40"E	29°12'02"	654.5

2.2 Data processing

The geographical coordinates of water points of study area (figure 2) are found in different projection systems such as Lambert, UTM, and Sexagesimal systems. The

coordinate system used in the mapping is in the geographic decimal system (decimal degree).

In order to standardize all drilling coordinates, we have used Coord4.exe and Geodata.exe software's. After homogenization of all drilling coordinates in the geographical decimal system, the data are transferred to Surfer and MapInfo software's for achieving the maps (location and structure, depth and piezometric levels).

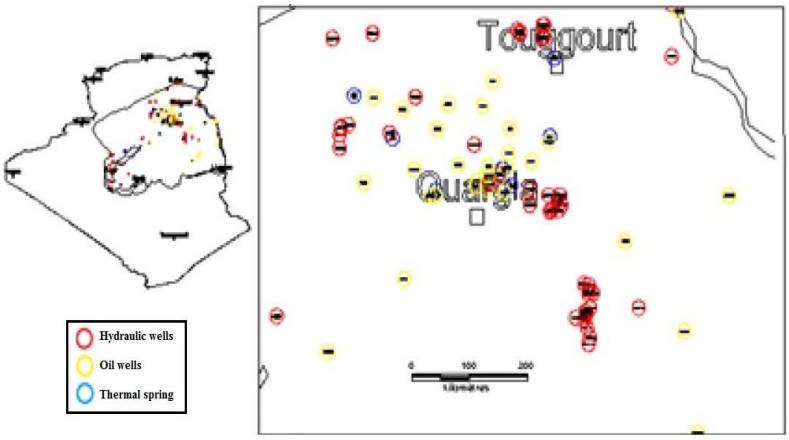

Fig. 2: Geographic distribution of water points having reached the Albian aquifer in the study area [9]

3. RESULTS AND DISCUSSION

As part of the studies conducted by UNESCO for the promotion of arid regions [7, 8] and [10, 12], the geometry of the Albian reservoir (geographical limits, depth, extension, thickness, etc.) was defined by the seismic method.

The mapping carried out in these studies represents the reference documents about the structural characterization of Albian reservoir. However, the digital versions of these cards do not exist yet. The results obtained through this study are given in the form of maps and Table (figures 3-5; **Table 3**) representing the structural characterization of the Albian aquifer in Algeria.

3.1 Location

The figure 3 below represents the location of the Albian aquifer of southern Algeria and the water points used for this study (oil and hydraulic wells, hot springs). It appears that the Albian reservoir in Algeria is limited by:

. The Saharan Atlas line (from Biskra to Bechar) in the north,
. The line (Bechar-Adrar-Reggane) in the west,
. The line (In Salah-In Amenas) in the south, and
. The Algerian-Tunisian and Algerian-Libyan borders in the east.

The figure 4 below represents the depth map of the Albian aquifer of southern Algeria.

The image also shows clearly that the Albian aquifer outcrops in the southwest part in Adrar and In Salah, and is captive to the north-eastern part.

The tablecloth plunges to over 500 metres in the central part of the basin, where it starts becoming deeper towards the northeast until the northern Atlasic flexure.

The maximum depth recorded is over 2.000 m in Ouargla, Touggourt, and Biskra.

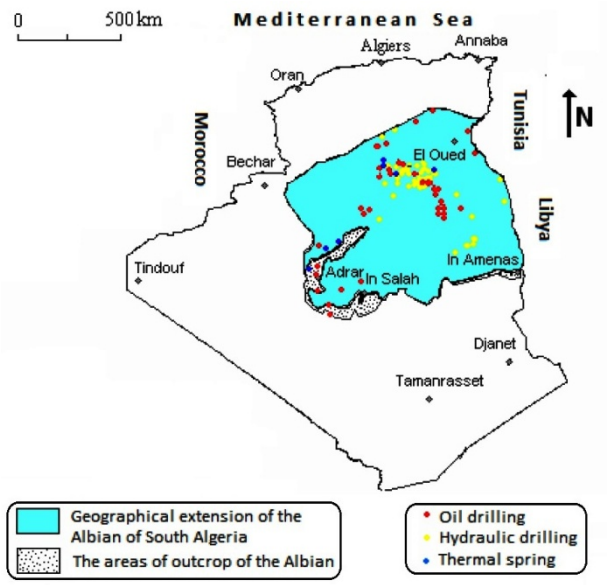

Fig. 3: Location, structure and water points of the Albian aquifer, South Algeria

The entire northeast area of the basin is limited by the iso-depth curve (500 m), which represents more than 40 per cent of the total surface of the reservoir; the depths reached are over 1,000 m. In this area, the geothermal groundwater is the most interesting since it is deep enough to provide sufficient heat to the water.

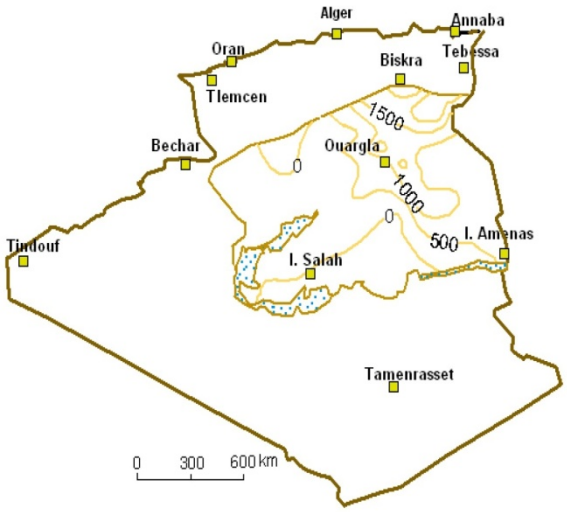

Fig. 4: The Albian depth map of South Algeria [9].

3.3 Reservoir thickness

The many hydraulic wells that have crossed all secondary geological formations and the Albian aquifer allowed us to establish the average thicknesses of the Albian tablecloth on different regions of south Algeria.

These thicknesses are given in **Table 3**.

Table 3: The thickness of the Albian aquifer in some cities of southern Algeria

Regions	Thickness (m)
Touggourt	500
El Oued	500
Ouargla	700
Ghardaia	800
El Golea	600
Adrar	200
In Salah	300

From **Table 4**, it appears that the albian aquifer has an average thickness of 600 m (El Golea). The maximum thickness is encountered in the region of Adrar (200 m) and the minimum thickness in the region of Ghardaia (800 m).

3.4 Piezometric level

The piezometric map of the Albian aquifer of southern Algeria is shown in figure 5. The map highlights three distinct piezometric anomaly zones:

. The first one, in the piedmont of the Saharan Atlas (piezometric level 200m),

. The second one, in the northeast part, in the lower Sahara basin (piezometric level 300), and

. The third one, in the east of the basin (piezometric level 300).

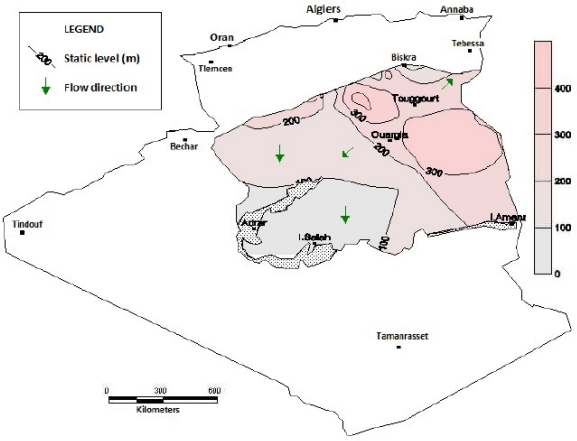

Fig. 5: The Albian piezometric level map of South Algeria [9]

These anomalies correspond well with water-accumulation zones of the basin, and the three directions of flows highlighted in figure 4 (southwest, south, northeast) match well with the flow directions described in the bibliography.

Indeed, authors who have studied the Albian aquifer indicate that the continuity of permeable Cretaceous formations allowed the transport and regularization of infiltrated water from high to low areas. From the Saharan Atlas, the water flows according to two main directions: A portion flows to the south and southwest towards the outlets that line the Tuat-Gourara and Tidikelt, and also to the evaporative areas of the Great Western Erg. Another part flows to the northeast, near the Tunisian coastal zone.

4. CONCLUSION

The Albian reservoir is located in the septentrional Sahara. In Algeria, it covers an area of over 650,000 km^2 and has an average thickness ranging from hundred metres to approximately 800 meters.

The Albian aquifer is a fossil groundwater because the bulk of its recharge dates back to the rainy period of the Quaternary. Nowadays, the recharge of this reservoir is very small compared to its volume (268 million m^3/year) and is carried out from rivers descending from the Saharan Atlas, and infiltration of rainfall in the Great Western Erg and outcrop zones. As a result of its low recharge, the Albian reservoir faces a risk of imbalance in case of overuse.

The depth of the Albian increases from the southwest to the northeast, where the tank reached maximum depths of over 2,500 m. On the southwest part, the aquifer is shallow and outcrops in the regions of Adrar and In Salah. The artesian flow is stronger in the centre and maximum in the region of El Oued in the central part of the basin.

The water flows according to two main directions: A portion flows to the south and southwest towards, another part flows to the northeast, near the Tunisian coastal zone.

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