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Study of Geothermal Potential Using GIS in South of Algeria

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Abstract

The region of Adrar is located in the south - western Algeria and covers a total area of 443.8 km², occupied by a population of 432,193 inhabitants. The main activity of the population is agriculture, mainly date palm cultivation occupying a total area of 23,532 ha. The climate of Adrar region is continental desert characterized by a high variation in temperatures exceeding 48°C between July to August and 16°C between December to January. The rainfall is very limited in frequency and volume with an aridity index of 4.6 to 5.0 which corresponds to a typical arid climate.

Geologically Adrar region is located on the edge North Westand is characterized by a Precambrian basement covering stolen sedimentary deposit of Phanerozoic age transgressively. The depression is filled by Touat site Paleozoic deposits (Cambrian to Namurian) of a vast sedimentary basin extending secondary age of the Saharan Atlas to the North of hamada(Tinhirt-Tademaït), the plateau to the South, Touat-Gourara to the West and Gulf of Gabes in the Northeast.

This work outlines a study of the geothermal potential of Adrar region from the borehole data in various sites across the area of 400,000 km²; from the data we developed distribution plots of the data of the various points and boreholes in the region specifying information on available geothermal potential at various depths.

1. INTRODUCTION

The Algerian Sahara is part of the great Sahara, a few millennia ago, this region's flora and fauna were rich and varied. This was the time when prehistoric man scored on cliffs or on the Tassili rock walls of the Saura and Tidikelt, the testimony of the prolific nature. Changes in climate towards desertification were increasingly intense leading man who lived in the Sahara to adapt to new living conditions. Life and survival were related to water. This water essentially was caught in the web of the Continental Intercalary and has been exploited through the system of foggaras. Algeria, with its geographical location (area of high tectonic activity) is considered among the rich countries of thermo mineral waters. While potential of geothermal resources in Northern Algeria are well known but in Southern Algeria no detailed study has yetbeen conducted. The area of study lays in the Algerian South, in the South - Western Algeria in the central part of the Algerian Sahara. The main purpose of this work was the realization of a geothermal database in GIS, and the assessment of geothermal potential in the Adrar region (Southern Algeria).

The Adrar state is located in South-Western Algeria, and extends between the geographical coordinates: longitudes 0°30' E and 0°30'W, latitudes between 26 °and 28°30'N and average altitude of 222m.Geothermal energy is one of the largest sources of renewable energy worldwide. The uses of this energy are numerous. They have direct uses such as fish farming, greenhouse heating and spa and industrial uses such as electricity generation. There are three types of geothermal fields;

• The geothermal fields of recent volcanic areas: This type of deposit is characterized by the existence of a deep magma chamber very hot (1300°C) [9] which is the natural heat source. This magma chamber gives up its heat to the surface geological layers. In this case, the waters are very warm and are more suitable for power generation [1].Among the countries with this type of deposits are New Zealand and Iceland

• Deposits areas of stable continental platform, covered with sedimentary deposits: with this type of deposit there is no heat source in particular depth, but the heat is solely due to the geothermal gradient. In this case the reserves are generally very deep and their exploitation requires the completion of drilling. Such deposits are encountered in France (Paris and Aquitaine basins) and Algeria (the basin of the northern Sahara.)[5]

• The geothermal fields of active continental areas: In this third case, the water resulting from the thermal water flow through cracks and geological discontinuities and arrive at the surface as springs. We find this type of deposit in Algeria, through the various hot springs that flow north.

2. GEOTHERMAL DATA

The geothermal data was characterized by two attributes: descriptive attributes or tabular alphanumeric, incorporating information on temperature, depth, physio-chemical characteristic,geology, water points and boreholes.Spatial attributes related to the geometry of aquifers and the location of boreholes and resources [2].

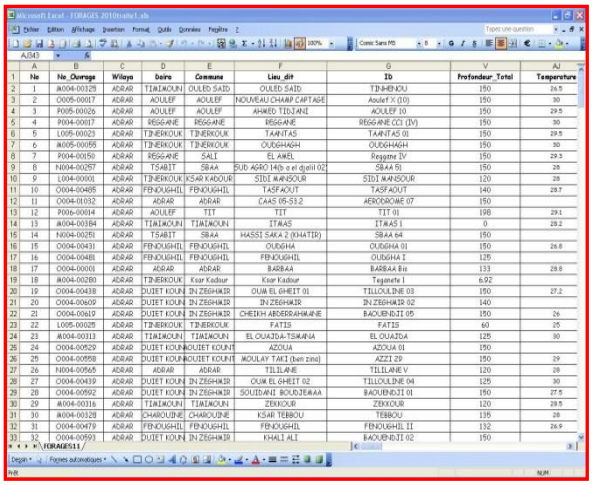
Data was collected from various primary and secondary sources. The National Hydraulic Agency (ANRH) provided data onthe chemical composition of water, topographic and geological maps. Geothermal data on temperature, depth, physical and chemical characteristic, coordinates for the location, geology, water points and boreholes was collected from the field [3].The database allowed us to perform the following tasks:

• View information from any geothermalpoint (depth, temperature, RS, physic-chemical characteristics).

• Compose as raster maps overlaid on topographic map, geologic map or satellite map.

2.1 DATABASE CREATION

To enhance the information collected, in a first step, the data was entered into a Microsoft Excel table. This database is organized in a tabular table contains information on water points, namely: the coordinates, locality, chemistry, and sampling date, Fig 1.



	A	B	C	D	E	F	G	V	AJ
1	No	No_Ouvrage	Wilaya	Daira	Commune	Lieu_dit	ID	Profondeur_Total	Temperature
2	1	I0004-00329	ADRAR	TIMIMOUN	OULED SAID	OULED SAID	TINMENOU	150	26.5
3	2	O005-00017	ADRAR	AOULEF	AOULEF	NOUVEAU CHAMP CAPTAGE	Aoulef X (10)	150	30
4	3	P005-00026	ADRAR	AOULEF	AOULEF	AHMED TIDJANI	AOULEF 10	150	29.5
5	4	P004-00017	ADRAR	REGGANE	REGGANE	REGGANE	REGGANE CC1 (IV)	150	30
6	5	L005-00023	ADRAR	TINERKOUK	TINERKOUK	TAMNTAS	TAMNTAS 01	150	29.5
7	6	I0005-00055	ADRAR	TINERKOUK	TINERKOUK	OUDGHAGH	OUDGHAGH	150	30
8	7	P004-00150	ADRAR	REGGANE	SALI	EL AMEL	Reggane IV	150	29.3
9	8	N004-00257	ADRAR	TSABIT	SBAA	SUD AGRO 14(b p el djalil 02)	SBAA 51	150	28
10	9	L004-00001	ADRAR	TINERKOUK	KSAR KADOUR	SIDI MAHDJOUB	SIDI MAHDJOUB	120	28
11	10	O004-00485	ADRAR	FENOUGHIL	FENOUGHIL	TASFAOUT	TASFAOUT	140	28.7
12	11	O004-01032	ADRAR	ADRAR	ADRAR	CAAS 05-53.2	AERODROME 07	150	
13	12	P006-00014	ADRAR	AOULEF	TIT	TIT	TIT 01	198	29.1
14	13	I0004-00384	ADRAR	TIMIMOUN	TIMIMOUN	ITAAS	ITAAS 1	0	28.2
15	14	N004-00251	ADRAR	TSABIT	SBAA	HASSI SAKA 2 (KHATIR)	SBAA 64	150	
16	15	O004-00431	ADRAR	FENOUGHIL	FENOUGHIL	OUDGHA	OUDGHA 01	150	26.8
17	16	O004-00481	ADRAR	FENOUGHIL	FENOUGHIL	FENOUGHIL	OUDGHA I	125	
18	17	O004-00001	ADRAR	ADRAR	ADRAR	BARBAA	BARBAA Bir	133	28.8
19	18	I0004-00280	ADRAR	TINERKOUK	Ksar Kadour	Ksar Kadour	Teganete I	6.92	
20	19	O004-00438	ADRAR	OUIET KOUN	IN ZEGHMIR	OUM EL GHEIT 01	TILLOULINE 03	150	27.2
21	20	O004-00609	ADRAR	OUIET KOUN	IN ZEGHMIR	IN ZEGHMIR	IN ZEGHMIR 02	140	
22	21	O004-00619	ADRAR	OUIET KOUN	IN ZEGHMIR	CHEIKH ABDERRAHMANE	BAOUENDJI 05	150	26
23	22	L005-00025	ADRAR	TINERKOUK	TINERKOUK	FATIS	FATIS	60	25
24	23	I0004-00313	ADRAR	TIMIMOUN	TIMIMOUN	EL OUAJDA-TSMANA	EL OUAJDA	125	30
25	24	O004-00529	ADRAR	OUIET KOUN	OUIET KOUNT	AZOUA	AZOUA 01	150	
26	25	O004-00558	ADRAR	OUIET KOUN	OUIET KOUNT	MOULAY TAKT (ben zina)	AZZI 29	150	29
27	26	N004-00565	ADRAR	ADRAR	ADRAR	TILILANE	TILILANE V	120	28
28	27	O004-00439	ADRAR	OUIET KOUN	IN ZEGHMIR	OUM EL GHEIT 02	TILLOULINE 04	125	30
29	28	O004-00592	ADRAR	OUIET KOUN	IN ZEGHMIR	SOUIDANI BOUDJEMAA	BAOUENDJI 01	150	27.5
30	29	I0004-00316	ADRAR	TIMIMOUN	TIMIMOUN	ZENKOUR	ZENKOUR	120	28.5
31	30	I0004-00328	ADRAR	CHAROUINE	CHAROUINE	KSAR TEBBOU	TEBBOU	135	28
32	31	O004-00479	ADRAR	FENOUGHIL	FENOUGHIL	FENOUGHIL	FENOUGHIL II	132	26.9
33	32	O004-00593	ADRAR	OUIET KOUN	IN ZEGHMIR	KHALI ALI	BAOUENDJI 02	150	

Fig 1: Geothermal Data base

2.2 ANALYZING OF GEOTHERMAL DATA

The software used to display data is ArcGIS 9.2. This software allows the combination of GIS layers, digitizing,editing and visualization of raster images Fig 2. ArcGIS data are exported in PDF or jpeg format [5].

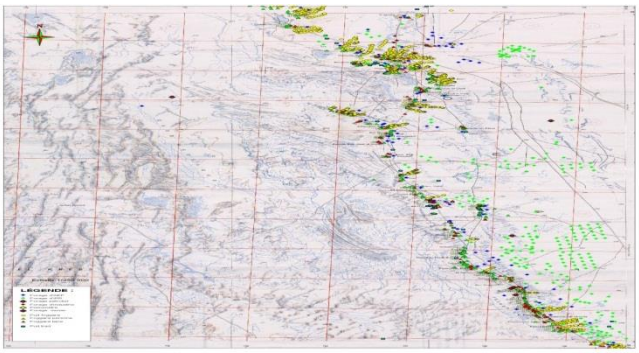


Fig 2: Geothermal points in Adar

The geothermal data for Adrar region was collected at water points from continental infill systems which are operated by traditional harvesting methods (foggaras, Traditional well) with a flow rate of 2 to 35 l/s is drilling a flow rate of 3-60 l/s Tab 1.

Désignation	Forage A.E.P	Forage Irrigation	Forage Industrie	Forage Pétrolier	Forage Minier	Puitstraditionnel	Foggara
Totaux	*277*	*539*	*37*	*46*	*21*	*3355*	*1400*

Table 1: water source point in Adrar

3. MAPPING OF GEOTHERMAL RESOURCES

Mapping of data points in study area was in ArcGIS. Geographical representation of waterholes in the area of study is shown in the following figure.

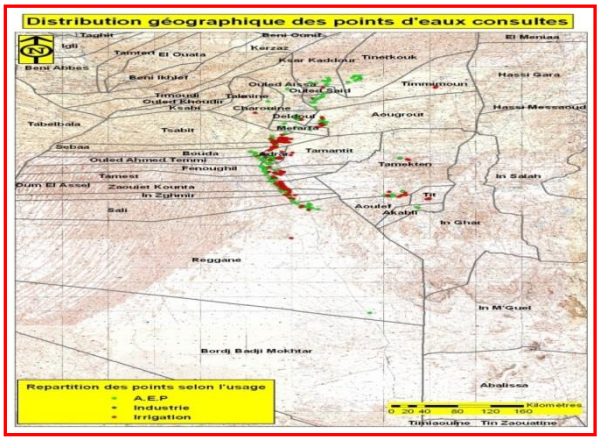


Fig 3: Geological distribution of water points

3.1 GEOTHERMAL POTENTIAL CHARACTERISTICS

In this study, the aquifer continental intercalary is the largest supply of groundwater. This water is the single source in Adrar region and is contained in the sandy horizons sandstone of continental interlayer. The latter is formed by Post-Paleozoic sediments ranging from Triassic to the Albian source and represented by alternating layers of sandstone and Sandy-Clayey levels where permeability is predominant.The substratum of the aquifer is composed of clay formations, Sandy Clay or Carbonate. In the South and Southwest, are unconformable land Paleozoic (Devonian) [6].Coverage of the aquifer of the Continental infill consists mainly of clay formations with evaporates and the Cenomanian Sands of Ergs. To the West and South, the spacer is flush Continental widely in the Tuat, and Gourara-Tidikelt.

The hydrodynamic characteristics of the reservoir are good. The average porosity is 26% and transitivity range from 1 to 6 x 10-3 m2 / s, where the drawdown is a few meters to tens of meters [7].In the Touat site and Tidikelt Western Continental infill of water is drained by lines of depression that identify outcrops of the tank. The natural outlet of the aquifer is the foggaras part of which flows not captured evaporates at the salt flats, the other party escapes to the Taoudenni basin Fig 4.

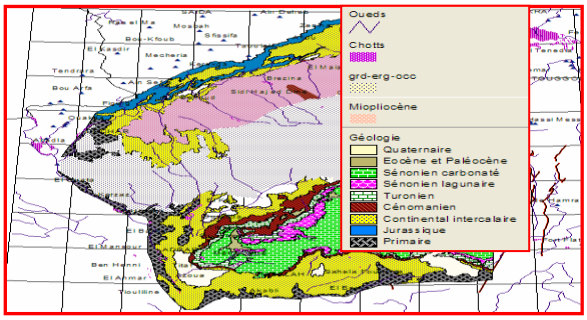


Fig 4: Map of geological outcrop basin

3.2 TEMPERATURE MAP OF GEOTHERMAL FLUID

The data collected from different holes are shown on the map (Fig 5). The temperature varies with depth; the deepest waters that are influenced by the geothermal gradient are the hottest as shown in the temperature map. Temperatures of the ground water increase from West to East. The minimum temperature is located on the Western outskirts which correspond to areas of outcrop water or the temperature is below 28°C.

Temperature data from a total of 145 boreholesin the study area was collected. The maximum temperature value was 32.5°C in the region Meguiden, the minimum value was 24.5°C in the region Charouine. The measured temperatures are classified as follows: 115 wells whose waters are mesothermal 24°C <T <30°C., 30 wells whose waters are orthothermales 30°C <T <40°C.

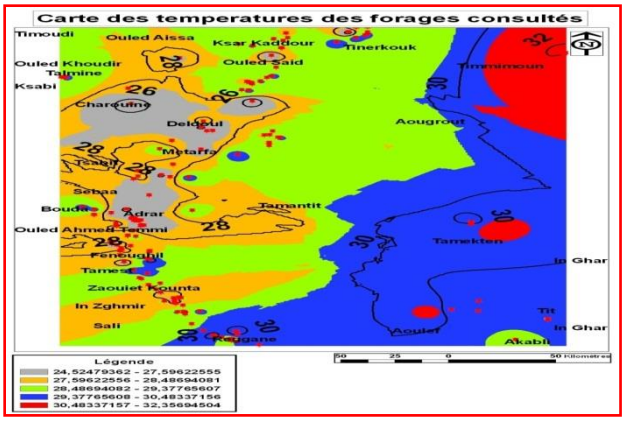


Fig 5: Temperature geothermal Map

The hydrodynamic characteristics of the reservoir are good. The average porosity is 26% and transitivity range from 1 to 6 x 10-3 m2 / s, where the drawdown is a few meters to tens of meters. The depth map shows that the water is free throughout the study area, it can be seen that the maximum depth is about 220m. The central part of the area is characterized by depths between 100 and 150 m so that's the interesting part of the geothermal point of view since it is deep enough to provide heat to the water. The piezometric map shows that there are three flow directions in the study area:

First it flows in the direction NE-SE from the green plateau Tademaït (center of the study area).

The second it flows through the NE-SW direction from a plateau green Tademaït depression Touat and erg Cheche.

The third that flows in the direction NE-N from the plateau region Tademaït green city of Adrar.

The analysis results show that the dry residue salinity geothermal fluid in the Adrar region varies between 400 and 5200 mg / l. and that 15% of water is highly mineralized [8].

The temperature map shows that temperature of geothermal fluid varies with depth, the deepest waters are warmer. We also note that temperatures are rising from westto eastof watercirculation [9] [10].The geothermal fluid in the Adrar region has a neutral pH ranging from 7 to 9 and a geochemical facies sodium chloride to sodium sulfate

4. CONCLUSION

The aim of our work was to study geothermal sources and potential in South Algeria and specialty in Adrar state. We developed a GIS geothermal database of water sources and temperature distribution in the area. The lap of Continental Intercalary is a freshwater tank; most of the water of this resource has been filled during the rainy periods of the Quaternary. The waters of the Continental Intercalary are characterized by: A temperature which exceeds 60°C except where the aquifer is close to the ground surface. In addition to the many hot springs in the North as there are in Southern Algeria and the development of a GIS database will help in managing, updating, analyzing and displaying the available information. The spatial analysis conducted in ArcGIS allowed us to publish thematic maps characterizing the geothermal resources of Adrar state.

The temperature of geothermal fluid in the study area increases towards East of the water source, the minimum temperature is located on Western outskirts which corresponds to areas of outcrop of the aquifer. Thus, the water temperature varies with depth; deepest waters that are influenced by the geothermal gradient are the hottest. Given the temperature of reservoir waters of Albian, the same application of geothermal energy in the Northern Algeria can be realized, particularly in the field of agriculture and the building heating or cooling in summer as the temperature air exceeds 40°C. With the exception of a few experimental applications, geothermal energy has been reserved until now for balneology. The temperature map can be used as a guide for communities to promote applications of geothermal energy such as heating or cooling of urban areas, agriculture and fish farming.

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