ALGERIA COUNTRY UPDATE REPORT

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ABSTRACT

This paper deals with a determination of the main geothermal zones and a preliminary evaluation of the geothermal potential of Algeria.
Three geothermal zones have been delineated according to some geological and thermal considerations.
Three areas have their reservoirs practically known: the Tlemcenian dolomites in the West, the carbonated formations (neritic and Sellaoua series) in the East, especially in the Guelma and Bouhadjar zones and the sandstone-like Alhian reservoir in the Sahara.
The geothermal energy in Algeria is generally of a low enthalpy type.
The heat discharge from the main springs and existing wells is approximated to 642 MWth.

KEYWORDS

Geothermal reservoir. geothermal areas, hrat discharge.

1. INTRODUCTION

The main geothermal studies conducted in Algeria, had as the first objective to find high temperature geothemal reservoirs. However the existence of these reservoirs remains hypothetical.
On the contrary, the existence of low enthalpy reservoirs are more obvious.
Sa geothermal activities have hecn extended to all the territory to evaluate this potential.
The inventory of the thermal springs has been updated leading to the listing of more than 740 springs.
Ca-CI, $Ca\text{-}SO_4$ and $Ca\text{-}HCO_3$ types of water are generally dominating. Most of these waters have TDS varying from 1 g/l to 22 g/l.

The North-East of the country remains the most interesting zone since all conditions suggest the existence of important reservoirs. Unfortunately, our financial situation does not allow us to conduct more detailed studies lo define them.
To this, we can add the large availability of conventional energy. Indeed Algerian energy sources are mainly hydrocarbons exceeding 114 millions tep of which only 23% are used for national consumption.

Despite this, *some* **geothermal** activities are still conducted.
These activities consist of the assessment of the geothermal resources and some specific work such as the modelling of reservoirs, determination of chemical equilibrium and heat flow evaluation.
Some geothermal heating systems have actually been installed in the Sahara for agricultural purposes.

2. GEOLOGICAL FEATURES

Algeria is divided into two main structural units: the folded tellian domain in the North and the saharian platform in the South.
The North of Algeria belongs to the alpine domain. It is characterised by complex geology of overthrusting allochtonous terrains; the geological formations are mainly carbonates and mark.
The last phase of the alpine folding of astian age played an important role in the rejuvenation of the relief and the development of fractures as well as in the apparition of saliferous domes.
Actually the alpine phase affected only the tellian domain where magmatic activities appeared *after* the installation of the over thrusting nappes (Upper Miocene).

The saharian domain has remained a stable zone characterised mainly hy sedimentary basins which constitute the hydrocarbon reservoirs and the geothermal albian nappe. To the South. in the Hoggar region, magmatic activities took place from the Miocene to the Quaternary.

3. GEOTHERMAL AREAS AND RESERVOIRS

The inventory of the thermal springs has hcen updated to show more than 240 sites.
The highest spring temperatures recorded are 66°C for the western area (Hammam Bouhnifia), 80°C for the central area (Hammam El Biban) and 96°C for the eastem area (Hammam Meskhoutine). In the southern area there are some thermal springs with a mean temperature 01 *50°C* (Fig. 1).
Carbonate formations constitute the main geothermal reservoirs in the North of Algeria while in the South, the reservoir is sandstone-like.
Three geothermal areas (Fig. 2), have been located according to the thermal springs distribution and to some geological and geophysical considerations(permeability of terrains and geothermal gradient).

3.1 The Western Area

According to the chemical types of the waters, this western area can be divided into two zones.
A southern one is characterised by homogenous geological formatiom (dolomites and carbonates) and a dominating $Ca\text{-}HCO_3$ type of water.
A northern zone is set on allochtonous terrains. The thermal springs have different chemical types.
The studies of the first zone gave little information about the reservoir and the thermal water origin: Verdeil (1982), Blavoux and *Collignon* (1986) have established a dose relationship between the thermal springs and the sismicity of the area. The isotopic data, particularly ^{13}C and ^{18}O, show that the waters are of a deep origin (Blavoux and Collignon, 1986). Fenet (1975) indicated that the main thermal springs originates from deep "Transverse" faults.
The Plio-Quaternary magmatic rocks in the coastal zone could he related to the thermal waters such as at H. Bouhadjar and H. *Bouhnifia (Fekraoui, 1990).*

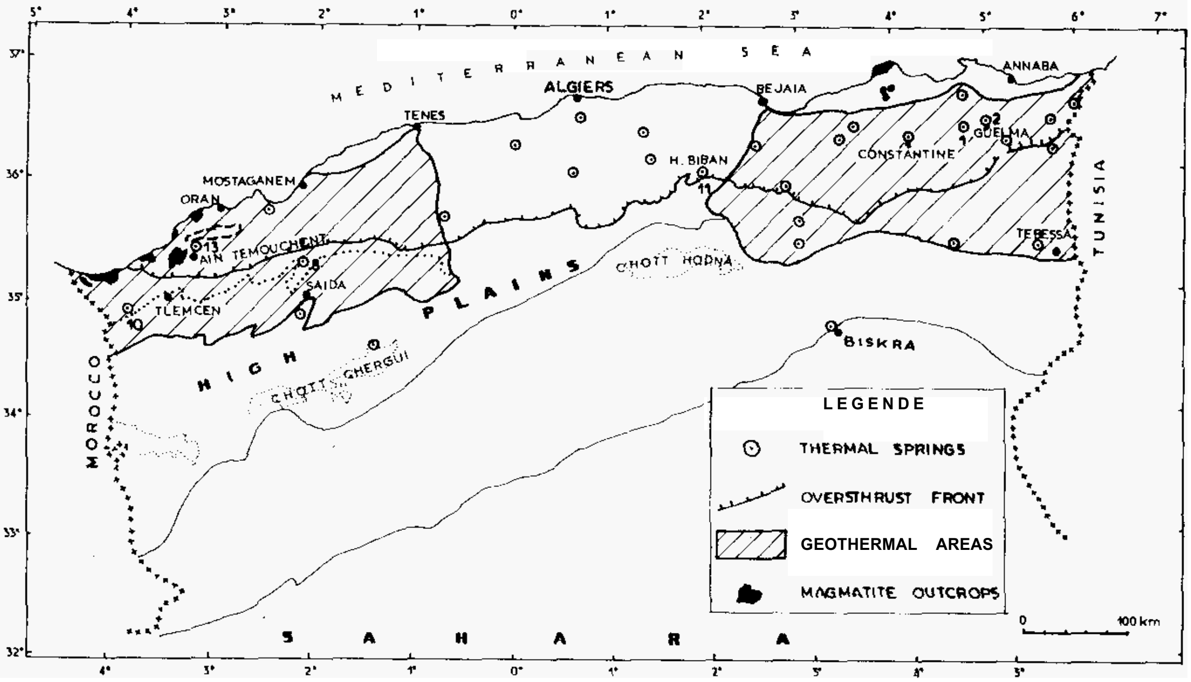

Fig:. 1 MAIN HOT SPRINGS LOCATION

(1_H.MESKHOUTINE 2_H.BERDA 8_H. BOUHNIFIA 10_H. BOUGHRARA 11_H.BIBAN 13_H. BOUHADJAR)

To the South of this wne, the Jurassic "dolomites of Tlemcen" on the Tlemcen-Saïda axis, constitute a shallow reservoir. About fifteen thermal springs whose temperature ranges from 25°C to 47°C and of a bicarbonate water type have been recorded, (Blavoux and Collignon, 1986).

3.2 The North East Area

In the eastern part of the country, the "neritique constantinois" formations and the carbonate part of the tellian nappe form the reservoirs of Guelma and Souhadjar respectively (SONELGAZ, 1982).
This area is characterised by springs of high flow rates i.e. more than 100 l/s for H. Barda spring and by the highest temperature of the country (96°C far H. Meskhoutine spring).
The thermal waters m this area have a chemically dominating facies of chloride and sulphate and have TDS ranging between 1.6 g/l and 2.2 g/l. This area extends to about 15000 km². Two prospect9 have been chosen for more &tailed investigations when g e o t h d reservoirs could exist at different depths (SONELGAZ, 1982).

3.3 The Southern Area

The t h d springs are scarce in this area. The Albian nappe is exploited by wells mainly for domestic and agricultural purposes.
The "Continental Intercalaire" formation which is sandstone-like, constitutes the Albian nappe covering an area of 600.000 km² (Conrad, 1983). This reservoir outcrops m it8 southern part and dips towards the North to reach a depth of 2600 m m the Biskra region. This reservoir is covered by calcareous formations which determine the chemical characteristics of the wafer (CaNa- SO_4Cl type with a mean TDS of 1.5 g/l).

4. HEAT DISCHARGE EVALUATION

In order to have a more precise idea about the possibilities of the energy potential immediately available for direct use, we made a preliminary evaluation of the heat discharge from the main hot springs and from the exploiting wells of the Albian *nappe*, (see Table hereafter).

Geothermal areas	Flow rate Q l/s	Theor. heat discharge MWth
West	800	60
East	700	79
South	4 000	503
	Total:	642

The mean annual outdoor temperatures used for the calculations are 18°C for the northern areas and 30°C for the Sahara.
The flow rates are taken from Blavoux and Collignon, (1986) for the western area; from Dib (1990) and SONELGAZ (1982) for the eastern area and from Conrad (1983) for the South.

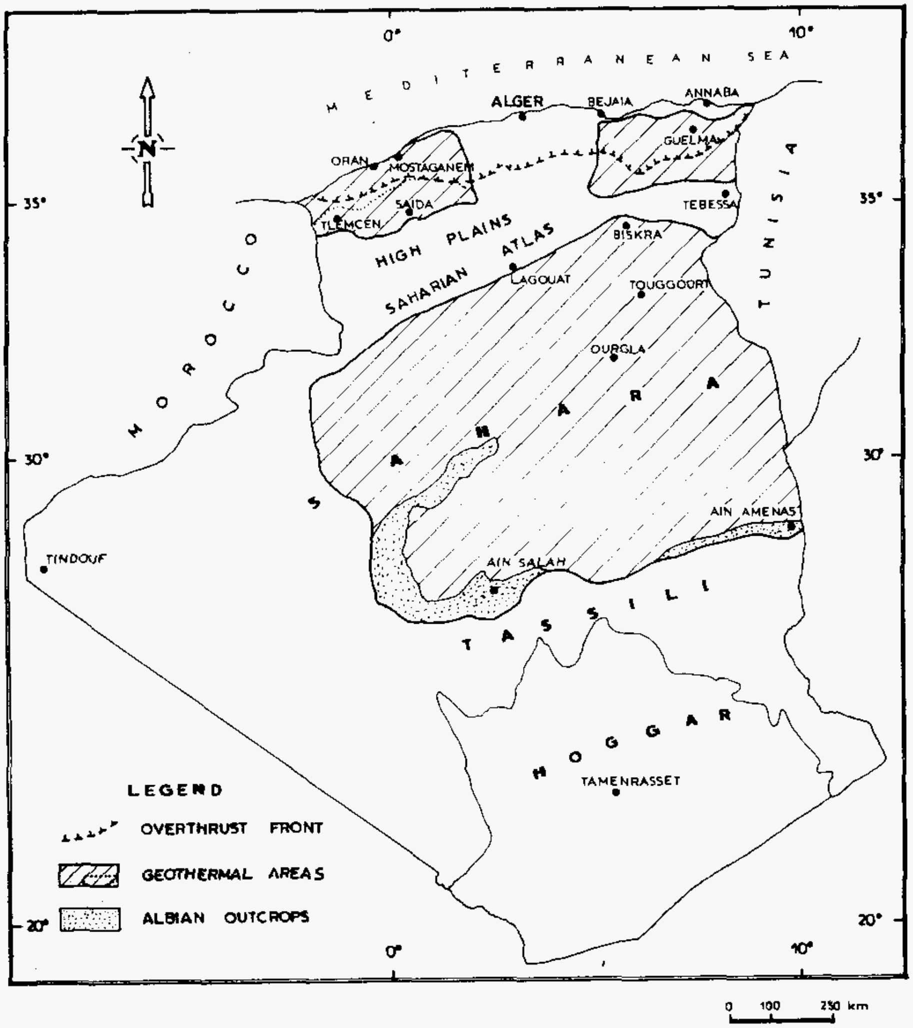

Fig:. 2 MAIN GEOTHERMAL AREAS

5. DIRECT USES

For practical reasons, Ouargla and Touggourt sites (Fig.2) have been chosen for the expetimentatim of greenhouses geothermal heating system (Bellache *et al.*, 1994). Melon and tomato plantation are used m these greenhouses.

Even though the Sahara is characterised by the hot weather, important temperature variations M recorded during the winter and the summer seasons where the night temperatures could reach a value below 0°C.

Eighteen greenhouses covering a total surface of 7200 m² are heated by the 57°C Albian geothermal water. The source temperature combined to a flow rate of 1 l/s is used to assure a minimum temperature of 12°C inside every greenhouse. The heating system, which is a reverse flow type, has been operating since 1992. The polypropylene tubes are put directly on the ground close to the plants.

The main results are a precocity of 20 days and an increase of 50% m production, compared to that of the unheated greenhouses.

6. CONCLUSION

Despite the determination of the three main geothermal areas, more detailed studies are needed to delineate the reservoirs and to evaluate their potential. Furthermore the High plains, according to their geological structures of sedimentary basins and some thermal springs of a high flow rate, could constitute promising geothermal reservoirs.

The evaluation of the heat discharge (642 MWth) concerns actually a part of the real flow rate. Because the data are incomplete, *only* 30% of the thermal springs have been considered. Concerning the *Albian* nappe, the total flow rate is abut 10 m³/s if traditional exploiting methods (foggaras) and shallow wells are included (Conrad, 1983).

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Total	
	Capacity MW$_e$	Gross Prod. GWh/yr	Capacity MW$_e$	Gross Prod. GWh/yr	Capacity MW$_e$	Gross Prod. GWh/yr	Capacity MW$_e$	Gross Prod. GWh/yr	Capacity MW$_e$	Gross Prod. GWh/y
In operation in January 1995				2000		350				2035
Under construction in January 1995				/		/				/
Funds committed, but not yet under construction in January 1995				/						/
Total projected use by 2000				/		/				/

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT IN DECEMBER 1994

1) I = Industrial process heat; C = Air conditioning; A = Agricultural drying; F = Fish and other animal farming; S = Snow melting; D = Space heating; B = Bathing and swimming; G = Greenhouses; O = Other (please specify by footnote)

2) Enthalpy information is given only if there is steam or two-phase flow

3) Energy use (TJ/yr) = Annual average water flow rate (kg/s) x [Inlet temp.(°C) - Outlet temp.(°C)] x 0.1319

Locality	Type[1]	Maximum Utilization: Flow Rate kg/s	Temperature (°C) Inlet	Temperature (°C) Outlet	Enthalpy[2] (kJ/kg) Inlet	Enthalpy[2] (kJ/kg) Outlet	Annual Utilization: Average Flow Rate kg/s	Energy Use[3] TJ/yr	Load Factor
H.Meskhoutine	B,O						50	330	
H.El Biban	B						10	72.6	
Ain Skhouna	B,O						80	316.8	
Ain Berda	B,O						100	26.4	
H. NBail	B						8	14.8	
H.Bouhadjar	B						10	33	
H.Boughrara	B								
H.S.Abdelli	B								
H.S.B.Abdella	B								
H.Bouhnifia									
H. Rabi	B								
H. Righa									
H. Melouane	B								
Touggourt	G,O	6	57	27					
Ouargla	G,O	12	57	27					
Total									

O: Drinking and irrigation.

TABLE 4. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES

1) Inst. thermal power (MW$_t$) = Max. water flow rate (kg/s) x [Inlet temp.(°C) - Outlet temp.(°C)] x 0.004184

2) Energy use (TJ/yr) = Annual average water flow rate (kg/s) x [Inlet temp.(°C) - Outlet temp.(°C)] x 0.1319

	Installed Thermal Power[1] MW$_t$	Energy Use[2] TJ/yr
Space heating		
Bathing and swimming	1344*	4224*
Agricultural drying		
Greenhouses	2.3	71.3
Fish and other animal farming		
Industrial process heat		
Snow melting		
Air conditioning		
Other uses (specify)		
Subtotal	1346.3	4295.3
Heat Pumps		
Total	1346.3	4295.3

* Approximative values

TABLE 6. INFORMATION ABOUT GEOTHERMAL LOCALITIES

1) Main type of reservoir rock

2) Total dissolved solids (TDS) in water before flashing. Put v for vapor dominated

3) N = Identified geothermal locality, but no assessment information available
R = Regional assessment
P = Pre-feasability studies
F = Feasability studies (Reservoir evaluation and Engineering studies)
U = Commercial utilization

Locality	Location To Nearest 0.5 Degree: Latitude	Longitude	Reservoir: Rock[1]	Dissolved Solids[2] mg/kg	Status[3] in January 1995	Reservoir Temp. (°C): Estimated	Measured
H.Meskhoutine (Guelma)	36°26'	8°35'	Carbonate	1600	R	120	
Bouhadjar area	36°27'	7°16'	Carbonate		R	120	
Tlemcen area	35°20'	1°25'	Carbonate		R	–	–
N E.Sahara			Sandstone Limestone	2000	R		56–60
Total							

TABLE 9. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with a University degree)

(1) Government (2) Public Utilities (3) Universities (4) Paid Foreign Consultants (5) Contributed Through Foreign Aid Programs (6) Private Industriy

Year	Professional Man Years of Effort (1)	(2)	(3)	(4)	(5)	(6)
1990	8		4			
1991	8		4			
1992	8		3			
1993	8		6			
1994	8	10	8			