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THE COZÍA-CĂCÍULATA GEOTHERMAL FIELD, ROMÂNÍA

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ABSTRACT

This paper provides information on a recent geothermal area discovered in Romania. Details of the geology and results from the drilling of two medium–depth wells are discussed. The actual and a possible future use of geothermal water in the Cozia–Caciulata zone are described.

1. INTRODUCTION

During the last 10 to 15 years Romania has carried out detailed geological research on the geothermal potential of the country. Structures already discovered, with water reserves and their calculated heat contents, have, for 1984, a utilisation value of about 100,000 tons equivalent oil (1 t.e.o. = 7 Gcal = 8,13 Mwh = 2.775.107 BTU).

Geothermal energy is used mainly for heating houses, greenhouses and for drying cereals. In 1984 it is expected that the first pilot experiment will produce electricfty (using a binary system power plant).

Practical problems for Romanian specialists are: deposition in pipes, utilisation of durable downhole pumps for geothermally depleted structures, and reinjection of waste water to maintain the reservoir energy. The French system using a "geothermal loop" is proposed, i.e. two drilled holes, one for production and one for reinjection for direct utilisation, and a downhole pump and reinjection scheme will be necessary. Obviously of great importance will be the utilisation of geothermal fluid (water) in a closed system, using a pressure under the saturation value to preserve dissolved gases, minimise salt deposition and corrosion. Fig. 1 presents the main geothermal fields which are being exploited in Romania,

2. COZIA-CACIULATA GEOTHERMAL FIELD

2.1 Location

Cozia–Caciulata field is located on the orogenic flank of the Getic Depression, between the Moesian Platform and the South Carpathian mountains.

2.2 History of thermal Fnvestieation

Shallow wells uere drilled here during the 1960's and early 1970's. These encountered, at 200 to 1200m, artesian aquifers with water temperatures up to 54°C. At the beginning of the 1980's (1981-1983) two medium deep holes were drilled to investigate the deeper Cretaceous formations (Senonian).

2.3 Geology

Cristalline rocks form the basement of this region, and over it is a layer of sedimentary rocks which belong to formations of the Cetic Depression; there are two sedimentary cycles:

- superior Cretaceous cycle (Senonioa)
- Palleogen cycle.

2.4 Hydrogeothermal considerations

Because it is situated at the contact of two geological units, the Getic Depression and Carpathian Mountains, Cozia–Caciulata area looks like a normal geothermal area with a thermal capacity which Includes hydrostructures with thermomineral water.

Senonian sedimentary deposits which overlap the basement are generally detrital rocks and in the contact zone have a secondary porosity accentuated by the presence of an intensive fissure system. As a result, sediments in the area constitute a fractured aquifer.

Feeding of the aquifer is from two directions:

(a) North to South: meteoric water, water from Olt River and its tributaries. Infiltration takes place along bedding planes, and fissures (joints), all allowing the water to descend.

(b) From depth to the surface, vith gases (mainly methane) being the main dynamic force.

The objectives of the two wells drilled here, 1,006 Caciulata (reference drillhole, 3,200m) and 1,008 Cozia (research drillhole, 3,100m) were to investigate the hydrochemical, hydrodynamic and thermal characteristics of deep aquifer horizons, at the base of Senonian and upper parts of altered cristalline basement.

3. GEOTHERMAL REFERENCE WELL 1,006 CACIULATA

3.1 Geology

The final depth was 3,250m. After interpretation of all data obtained during drilling and qualitative-quantitative interpretation of geophysical data it was concuded that the Senonian basement level is an important fissural-type aquifer. Some interpretations give good information of the existence, below 2,643m, of several intervals with rocks of high permeability and porosity; this is due to the existence of a horizontal system of fissures. Rocks drilled from 2,643m to the final depth (3,250m) comprise complex fissured gritstone which probably extends below the well.

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3.2 Drilling Report

Difficulties encountered during drilling were that at 278.50m and 362.50m, using 1.290 kgf/dm^3 mud density, 0.05 to 0.10 l/s Inflow from the formation occurred. It was necessary to increase mud density up to 1.500 kgf/dm^3, and at 278.50m a cement plug vas set.

Below 2,645m, using 1.180 kgf/dm^3 mud density, partial loss of circulation occurred: 2,645m to 2,712m ($40m^3$); 2,772m to 2,827m ($52m^3$); 2,909m to 2,997m ($46m^3$) and 3,075m to 3,100m($51m^3$).

At three depths the circulation loss vas total. For 1,198m mud density was 1.350m kgf/dm^3 and the level of mud in the well vas found at 91m; for 1,331m, mud density vas 1.250 kgf/dm^3 and the level of mud was found at 36m. Solutions adopted for both these depths vere to plug with mica, cellophane, gel-Diesel oil, cement.

The third total loss of circulation occurred at 2,645m when mud density vas 1.290 kgf/dm^3 and the level of mud in the well vas found at 520m. The solution for this case was to decrease the mud density until it reached 1.180 kgf/dm^3.

Cases monitored in mud during drilling, e.g. at 2,645m, were: C_1 = 2X; C_2 = 1.46%.

The casing programs for both wells are shown In Table 1.

TABLE 1: CASING PROGRAM

1,006 CACIULATA

O.D. (m)	DEPTH (m)	CEMENT LEVEL (m)	REM.
20	250.50	0	Surface
13 3/8	998	125	
9 5/8	1,999	1,500	
7	2.399	0	Surface

N.B: Interval 2,399m to 3,250m not cased.

1,008 COZIA

O.D. (m)	DEPTH (m)	CEMENT LEVEL (m)	REM.
20	264	0	Surface
9 5/8	1,738	0	Surface
Liner 7	1,646-2.637	-	258m: Slotted

3.3 Production tests

(a) After total loss of circulation at 2,645m and decreases of mud density, a 1m core vas taken and then a "Posi-test" packer probe installed (open interval: 1,999m to 2,646m). After 20 hours, on 9mm throttle, the flow of water "not yet clean" vas 3.7 l/s, 1.010 kgf/dm^3 and of 63°C temperature. On closing the drill pipes the pressure vas 40 at.

(b) After completion, vith $2^7/8$" tubing at 2,388m (Table 2). After the above test the $2^7/8$" tubing was replaced by 3½" tubing and the well dfscharged intermittently with an average flow of 7 l/s, 87°C, 13 gm/l salinity. During this experimental production period a receptivity test vas carried out and other measurements were taken (see Table 3).

3.4 Final Results

After examination of reservoir conditions vith vater feed from 2,399m-3,250m interval:

- P_{DYN} at depth of collection: 30.16 MPa (301.6 at)
- Bottom temperature: 102°C
- Final density of water at 20°C and 98066.5 Pa: 1.009 t/m^3
- Pressure for free gases from solution: 1 MPa (10.2 at)
- Solution ratio (for 1 MPa): 0.503 Nm^3/m^3
- Water volume factor (for 1 MPa): 1.03755 (estimated function of pressure and temperature - Dodson and Standing diagram)
- Gases volume factor (for 1 MPa): 0.112
- Water viscosity for 20°C and 980.66.5 Pa (visc. Hoppler): 1.19 cP.

4. GEOTHERMAL RESEARCH WELL 1,008 COZIA

4.1 Location - Geology

The well is situated 850m North from well 1,006 Caciulata. Final depth was 2,641m. By correlation using geophysics (electrical) with well 1,006, where the fissured layer vas intercepted at 2,640m, 1,008 Cozia was intercepted between 2,080m-2,641m.

4.2 Drilling Report

Difficulties encountered during drilling were: 0.3 l/s inflov at 264m and 0.15 to 1.5 l/s inflow through the Multiple Stage Cementer, after cementing the $9^5/8$" casing. Under 2,000m using 1.190 kgf/dm^3 mud density inflow, partial loss of circulation was encountered alternately (e.g. 2,312m; 2,484m, 2,590m: inflow; 2,115m-2,149; 2,300m-2,321m: partial loss of circulation). Only one total loss of circulation occurred at 2,312m.

Casing program: see Table 1.

4.3 Production test

With $2^7/8$" tubing fixed at 1,643m:

- Throttle 16mm: 7.5 l/s water, 77C, P_{tbg}/P_{cas} = 14/30 at.
- Without throttle: 11.2 l/s, 85°C, P_{tbg}/P_{cas} = 2/24 at.

Flow both tbg. $2^7/8$" and $9^5/8$" casing: 20/5 l/s, 89°C, P_{tbg}/P_{cas} = 6/8 at-
Well closed: P_{tbg}/P_{cas} 40.5/38 at.

Bottom hole measurements: see Table 4.

5. ACTUAL AND POSSIBLE USE OF GEOTHERMAL WATER IN THE COZIA-CACIULATA ZONE

The two wells are situated within the boundary of a small city (Caciulata, about 15,000 inhabitants) which is one of the largest health resorts in Romania.

Beginning in November 1983, geothermal water from vell 1,006 vas passed through a heat exchanger to heat a hotel (250 beds on 5 floors) and its treatment base. After passing the first heat exchanger the geothermal water passes into a second one to produce warm water for the same hotel. After this the vater is at about 48°C, and because of its health properties the third stage use is direct for bathing, in the treatment section.

Absolutely no corrosion or deposition problems occurred during the 90 days testing period. Both heat exchangers are counterflov shell and tube type.

Because of the fact that only half of the total possible flow of well 1,006 is used (about 3.5 l/s), a second hotel (larger than the first) will be connected during 1984/85 for heating by geothermal water. Both hotels are situated 150m - 250m from the well.

Well 1,008 Cozia, completed in December 1983, will also be used, as from the 1984/85 vinter, for heating and producing warm vater for a complex of three hotels (about 1200 beds). The hotels are 150m - 200m from the vell.

Because until now pressures have not fallen in the two wells, in both arrangements the waste water is discharged into the city sewerage.

It is obvious that the final arrangement will use, perhaps after 1 or 2 years of experimental production and utilisation, a "geothermal loop" closed system, with a downhole pump in vell 1,008 (to obtain, say, 50 l/s) and injection in well 1,006. With a temperature utilization between 89°C and 20°C and using heat pumps, this will provide much more heat for the city than its actual capacity.

To determine the life and depletion of the reservoir, using actual data, a computer model program will be prepared at the Geothermal Institute, University of Auckland, during August-October 1984.

REFERENCES

BUTAC, A., OPRAN, C: Considerations sur la presence des resources geotermiques en Roumanie. Internal paper, Ministry of Geology, Buc., 1983.

BOROSI, G., VULPE, F: Geological reference material - Cozia, Caciulata. Internal Paper, I.F.L.G.S., Ministry of Geology, Buc., 1983.

ÍSPAS, C., Measures to promote Geothermal Energy. Internal paper, Ministry of Geology, Buc, 1983.

TABLE 2: WELL 1,006 - PRODUCTION TESTS (3,250 - 2,399m)

DATE	THROTTLE WITHOUT	THROTTLE WITH	LENGTH	FLOW	WELLHEAD PRESSURE TUBING	WELLHEAD PRESSURE CASING	TOTAL VOLUME	SURFACE TEMP.	BOTTOM DYN.PRESS.	OBSERV. PAUSE	TUBING/ CASING PRESSURE	BOTTOM STATIC PRESSURE	BOTTOM TEMP.	SALINIT
-	-	mm	hours	l/s	at	at	m^3	°C	at	hours	at/at	at	°C	g/l
18.07	Tubing	-	20	5.2	0	8	374	80	322.25 at 3,200m	-	-	-	102	12.5
1982	-	10	2	4	10	25	28.8	72	-	-	-	-	102	12.5
19.07	-	10	12	4	10	25	172.8	72	335.47 at 3,200m	-	-	-	102	12.5
1982	-	-	-	-	-	-	-	-	-	12	30/40	341 at 3,200m	102	-
20.07	-	10	10	4	10	25	144	72	-	-	-		102	12.5
1982	-	-	-	-	-	-	-	-	-	14	30/40	353.37 at 3,200m	102	
21.07	-	-	-	-	-	-	-	-	-	14	30/40	353.37 at 3,200m	102	
1982	-	6	10	2	22	35	72	58	-	-	-	-	102	12.5
22.07	-	6	18	2	22	35	129.6	60	347.70	-	-	-	102	12.5
1982	Casing & Tubing	-	6	6.6	0	0	142.6	72	-	-	-	-	102	12.5
23.07 1982	Casing & Tubing	-	24	7.2	0	0	622	80	311.45	-	-	-	102	12.5
24.07	Casing & Tubing	-	15	72	0	0	388.8	80	311.45	-	-	-	102	12.5
1982	-	-	-	-	-	-	-	-	-	9	30/40	353.37 at 3,200m	102	-
25.07 1982	-	-	-	-	-	-	-	-	-	24	30/40	353.76 at 3,200m	102	-

TABLE 3: (A) INJECTION TEST (1,006 CACIULATA)

LENGTH	QUANT. OF INJECT WATER	FLOW	INJ. PRESS.
hours	m3	l/s	at
2½	90	10	65–70

TABLE 3 (B) MEASUREMENTS DURING EXPERIMENTAL PRODUCTION PERIOD (1,006 CACIULATA)

DATE	DEPTH OF MEASUREMENT	PRESSURE DYNAMIC	PRESSURE STATIC	FLOW	BOTTOM TEMPERATURE	SHUT-DOWN
-	m	at	at	m^3/day	°C	hours
12.09 1982	2,300	228.90	-	216.0	104	-
25.11 1983	2,900	297.50	328-65	605.0	103	2
20.01 1984	2,900	291.97		570.0	103	
27.01 1984	2,900	295.66	329.11	631.00	103	6

DATE -	MAX. DEPTH m	PRESSURE DYNAMIC at	STATIC at	FLOW m^3/day	BOTTOM TEMPERATURE °C	SHUT-DOWN hours	REMARKS -
18-01 1984	2,580	281.32	-	1,071	97	-	Flov only tubing 2-7/8 in.
19.01 1984	2,580	-	293.38	-	96	13	-
20.01 1984	2,580	258.77	-	1,754	98	-	Flow both tubing and casing
28.01 1984	2,580	260.73	295.84	1,754	97	2	Plow both tubing and casing
28-01 1984	2,580	286.36	293.98	1,080	97	6	Plow only tubing 2-7/8 in.