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PRODUCTION HISTORY AND RESERVOIR MONITORING IN KIZILDERE FIELD, TURKEY

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ABSTRACT

Kızıldere, which is the only high temperature geothermal field utilized for electricity generation in Turkey, has six years of production history. High carbon dioxide content and relatively low pressure and temperature of the reservoir, calcite scaling became a major problem in wells, in surface facilities and in the reservoir.

During the period of October 1987-February 1989, an extensive testing and monitoring program was completed in the field according to a bilateral agreement between Turkish and Italian governments.

This paper will present an upto-date production data and reevaluation of reservoir behavior discussed before (Okandan 1988).

INTRODUCTION

Kızıldere field is located in the Büyük Menderes graben in Western Anatolia. The first deep well KD1 was completed in 1968 where reservoir temperature of 198°C was measured in Sazak formation. Deeper wells, completed after this date encountered higher temperatures at a deeper formation, Iğdecik which is composed of marble quartzite and schist which are interbedded. The geochemical survey conducted indicates maximum temperatures of 220-240°C can be expected. The lower temperatures encountered in southwest part of the field implies mixing with cooler meteoric waters which is also predicted from geochemical stuides (Final Report to TEK, 1989)

The geothermal fluid produced from deepwells is saturated with CO_2. Steam seperated at 5 bars contains 15% CO_2 by weight. The calculated saturation pressure of this fluid at 200°C is 62.4 bars.

During the exploration and development phase in Kızıldere 16 wells were drilled. Six of these were selected as suitable wells for power generation. KD6,7,13,14,15 and 16 were connected to the power plant which started its operation in February 1984. Power plant is a 20.6 MW_e, single flash unit.

Power plant performance during the six years of production history had shown decreasing output as scaling in wells and in the reservoir caused declining fluid production rates. Periodic cleaning of well bores in 3-6 month intervals had helped in increasing the power output, however decline in rates after a short period was always observed.

PRODUCTION WELLS

In 1986, three infill wells KD20,21 and 22 were drilled in order to supplement declining production rates. The average distance between wells is about 150 meters (Figure 1). The fluid feed for all wells is from a single source (Okandan 1988) and due to small spacing of wells the interference between them was inevitable. This was demonstrated during the recent testing period.

Feed zone depths of producing wells and well completion data indicated that slotted liner completions cause rapid reduction in flow rates due to clogging of slots caused by $CaCO_3$ deposition (Table 1). Temperature and pressure distribution in the field shows the cool water invasion from SW direction (Figure 2).

During the testing period, first all the wells were cleaned by reaming then acidizing was performed except in KD6 and KD7. The increase in productivity of wells (Allegrini et al, 1989) after the acid job indicated either the old fractures were cleaned and/or new fractures were created due to acid-fracturing.

At the end of 1989 it has been reported by Turkish Electricity Authority (TEK) that power output had declined to a very low level and cleaning in wells will start soon.

Pressure measurements are taken in wells at intervals to monitor the reservoir behavior. Initial pressure measurements after the acid job indicates 2-3 bars pressure drop in the field with respect to the initial reservoir conditions.

Table 1. Feed Zone Depths and Well Completion Data

	Feed depth, m from surface	Well Completion at feed depth	Measured Temp. °C	Godevil,cm,at feed depth (Aug.1989)
KD6	700	6 5/8" open hole	194	-
KD7	620	5 5/8" open hole	203	-
KD13	725	8 3/4" open hole	194	3.4
KD14	500	7" slotted liner	207	-
KD15	450	7" slotted liner	206	3.4
KD16	625	7" slotted liner	207	11.4
KD20	650	8 1/2" open hole	201	-
KD21	550	7" slotted liner	203	11.4
KD22	625	8 1/2" open hole	204	-

Table 2. Static Bottom Hole Pressures in Wells, bars
(Final Report to TEK, 1989)

Well	02-03/1988	May 1988	May 1989	Nov. 1989
KD6	-	66.34	-	-
KD7	-	55.85	-	-
KD13	65.73	65.46	64.67	-
KD14	47.85	47.51	45.02	44.56
KD15	41.47	41.10	39.60	39.14
KD16	57.81	56.23	54.98	54.14
KD20	56.30	-	53.49	53.28
KD21	51.00	49.75	48.43	56.84
KD22	58.73	56.96	-	-

All the wells except KD6 and KD13 have bottom hole pressure less than the flash point pressure of water containing 15% CO_2 by weight. It is obvious that scaling is occuring in the fractures around the well bores causing decrease in their productivities. 10-100 fold increase in the PI of wells after the acid job confirms this observation (Allegrini et al 1989).

OBSERVATION WELLS AND FIELD PERFORMANCE

Three non-producing wells; KD8 in the producing well field, KD2 in the west and KD9 in the south of the present field were selected as observation wells. Continuous water level measurements taken in KD8 are presented in Figure 3, as given in reference (Final Report to TEK, 1989) until April 1989 and additional data provided by TEK until December 1989.

The total field production rate (Figure 4) after a constant production period of about 70 days started to decline from its initial value of 1200 t/h. The well head pressures are kept at a level of 15 kg_f/cm^2.

The pressure decline rates are estimated from KD8 measurements, and as seen on Table 3 constant decline rates may imply pseudo-steady state flow. However it is predicted from hydrogeology that hot water recharge to the the producing field occurs through a permeable north bounding fault near KD15. (Şimşek 1985, Final Report to TEK, 1989). Therefore

Table 3. Pressure Decline Rates as Measured in KD8

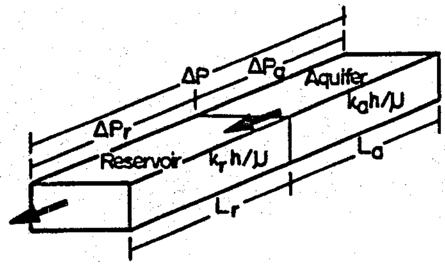
	Δt,days	q,t/h	q_{av},t/h	ΔP/Δt, Pa/h
Feb.27	0	200	1200	-
1988	70	1200-900	1050	7.8
	100	900-850	875	7.6
	100	850-800	825	7.8

reservoir cannot be treated as a closed system. However if recharge is less than fluid withdrawal and if reservoir conductivity $k_r h/\mu$ decreases with time due to scaling in fractures then observed behavior can be expected.

If we consider the producing field and aquifer as a linear horizontal system, flow rate equation using darcy relationship for two beds in series is

$$q = \frac{\Delta P A}{\frac{\mu L_r}{k_r} + \frac{\mu L_a}{k_a}}$$

where subscript "r" stands for reservoir "a" for aquifer.



It is obvious that decrease in q is the result of an increase in $L_r/k_r + L_a/k_a$. If aquifer properties are not changing then k_r must be decreasing which is possible if fractures are closing due to $CaCO_3$ scaling.

Decline in well and total field productivity indices (Table 4,5) also indicate that such a phenomenon is occuring in the reservoir.

Table 4. Example of Decline of Well PI's, t/h/bar

	Before Acid	After Acid	July'89
KD15	3.05	133	100
KD21	-	159	105

Table 5. Field Productivity Index, t/h/bar

q, t/h	P, bar	q/ΔP
1050	0.13	8077
875	0.13	6731
825	0.13	6346

A new reinjection program is proposed for pressure maintenance in the field. The performance of this operation will be also affected by the degree of scaling in the reservoir.

INHIBITOR INJECTION

In order to eliminate well reaming operations for cleaning the scales, in-well bore inhibitor injection was tested. KD6 was selected for injecting Dequest 2066 at 15 ppm concentration. CO_2 measurements are continuously taken at well heads in all wells and data for KD6, 13 and 14 are given on Figure 5.

If inhibitor injection operation is expanded to other wells also, only well bore scaling rate will be reduced however no effect on reservoir scaling can be expected.

CONCLUSION

The six year production history of Kızıldere field and recent extensive testing activity, show that scaling in the reservoir and proably unbalanced fluid withdrawal with respect to recharge will limit power production. Periodic acid jobs may increase well and field productivities however eventual decrease will be unavoidable. Proposed reinjection program probably will not change this picture drastically. If new exploration wells are planned towards north east, they will not be affected by the cool recharge from SW and will encounter hotter fluids at shallower depths as predictable from temperature and pressure profiles. In optimizing the field development this is proposed as the next step to be taken.

ACKNOWLEDGEMENT

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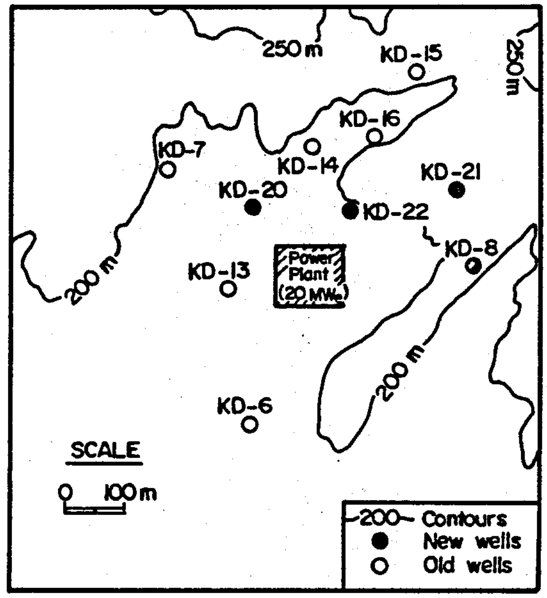

Figure 1. Producing Wells in Kızıldere Field

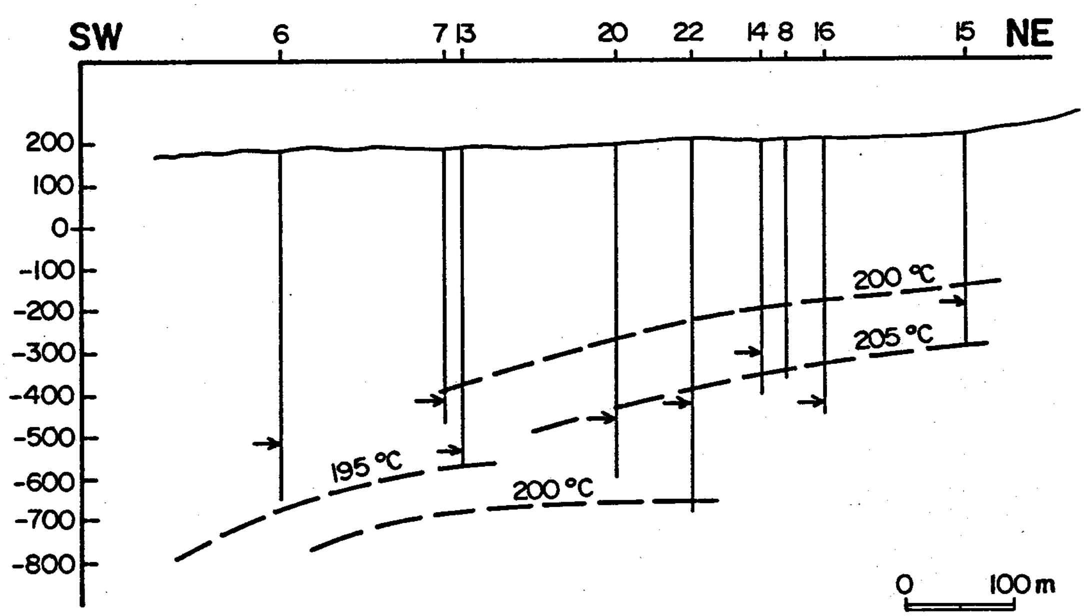

Figure 2. Feed Zone Depths and Temperatures Measured in Producing Wells

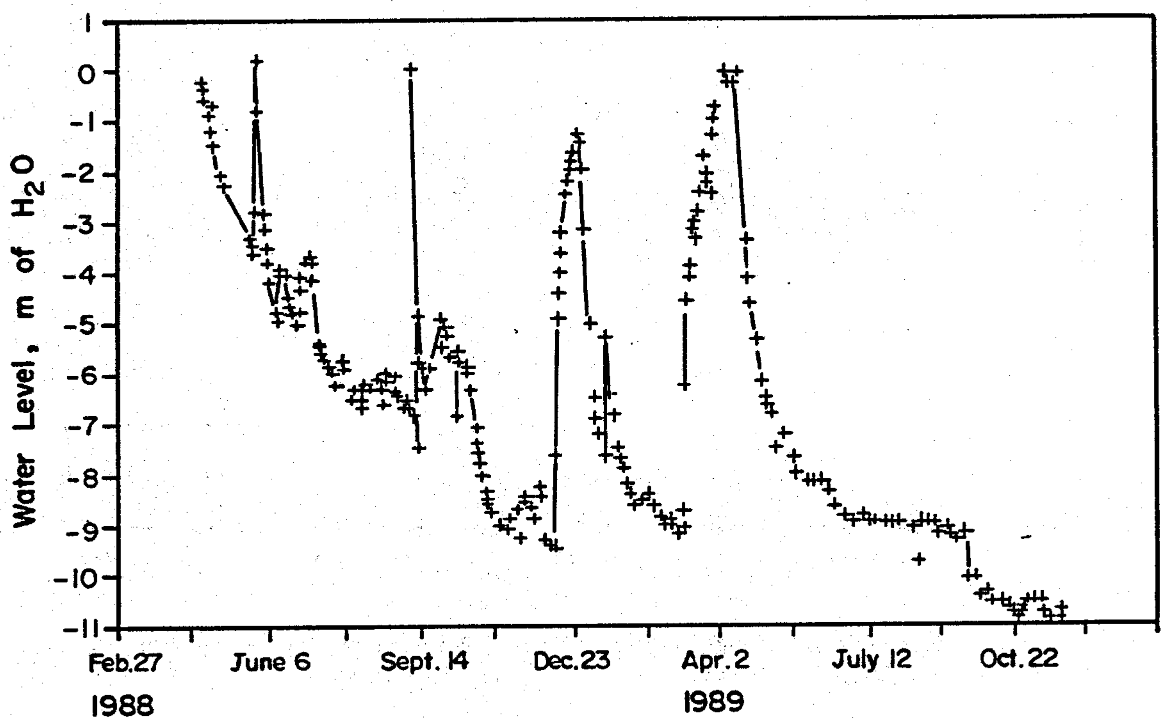

Figure 3. Water Level Measurements in Observation Well KD-8

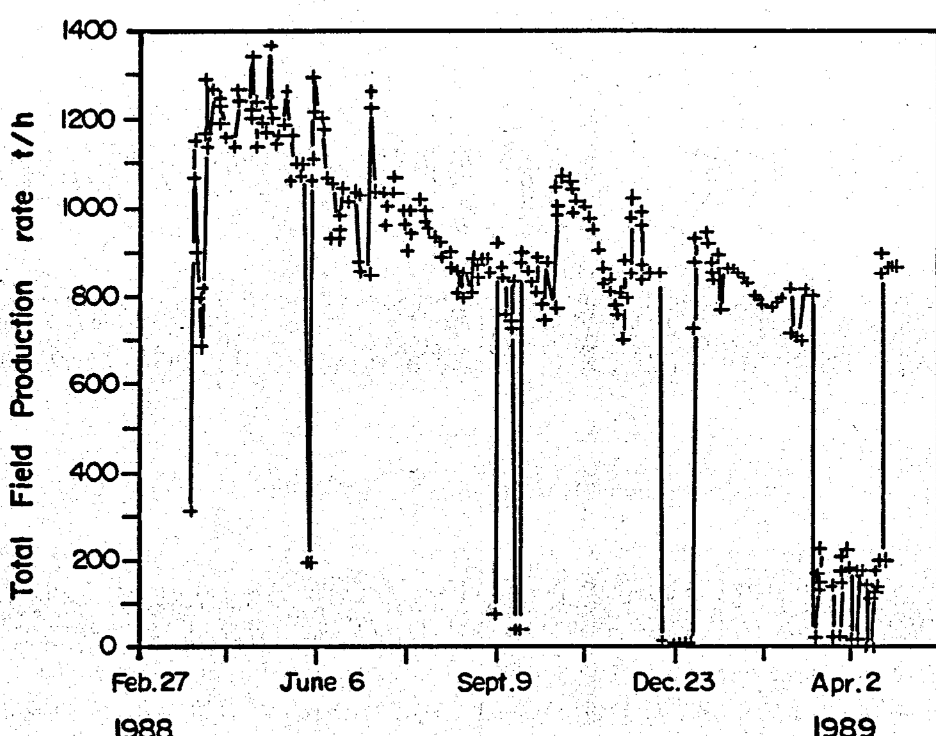

Figure 4. Total Field Production Rate

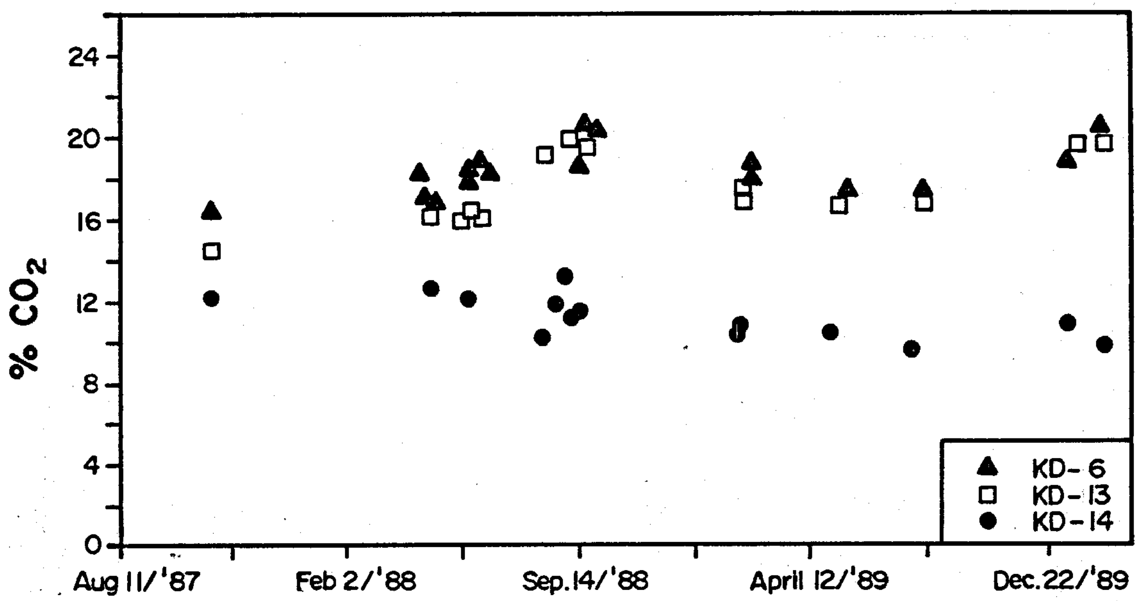

Figure 5. CO_2 Content of Produced Steam Separated at 5 bar Pressure, in wells KD6,13,14.