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Observation Studies of Wells in Sorgun Geothermal Field (Yozgat-Turkey)

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ABSTRACT

A total 10 geothermal wells have been drilled ranging from 104 m to 444 m depth between the years 1988-2008 in Sorgun (Yozgat-Turkey). Geothermal area today, 1300 equivalent houses heating are performed with geothermal district heating system which founded in 2007. A part of this water which returning to use the heating center, are transmitted for thermal spas and greenhouses as an integrated using. The remain part of the water is injected to the underground by a reinjection well.

At the production wells in the field, physical and chemical measurements of thermal waters and water level observations have been made for the period of 5 years, covering 2007-2012. Waters of geothermal wells have been measured as between 75 °C and 81 °C temperature, between 2510-3000 µS/cm electrical conductivity and between 7.1-8.5 pH. Before production, static water level was determined as 63 m. After production, water level has been measured between 83 m and 110 m. According to preliminary data, when the relationship between flow rate and the dynamic level examined, it was observed that reinjection contribute to the system. The production and reinjection data have to be followed more sensitive and for development and sustainable using of the geothermal system.

1. INTRODUCTION

The Sorgun geothermal field is located 40 km East of the Yozgat province in the central Anatolia of Turkey (Figure 1). Thermal waters have been used for many years for spa in the field. Existence of young tectonics in the region shows that the thermal gradient of the field is higher than in other regions. Geothermal waters, rising up through the faults, are stored in the cracks and altered sections of granodiorites and Eocene basal conglomerates. The hot water requirement of Sorgun spa was supplied with a 5 shallow caisson well with a temperature range between 50 and 63ºC when thermal waters spreaded in the alluvium at the top. The first geothermal production wells (YS-1; 104.5 m, 69°C and Valilik-1; 105 m, 67 °C) was drilled in 1988 to contribute for the spa area by MTA (General Directorate of Mineral Research and Exploration) on behalf of the Yozgat Governorship (Keskin ve Ozeke, 1988). There are also lignite layers in the geothermal area. During search for the lignite, thermal waters flooded the gallery. Thereupon, wells (Madsan-1, YS-3, YS-4, and YS-5) were drilled for drainage of thermal water by Madsan Co. and MTA in 2004. To obtain hot water and determine the boundary of the field, an evaluation report was prepared by Hacettepe University and ORME Geothermal Inc. (HU-ORME, 2005).

After eveluation report, some research/production/ reinjection wells (SG-1, SG-2, SG-3, SG-4, and SGR-1) drilled for five years, from 2005 to 2008 by consulting of Hacettepe University.

Geothermal wells have been used for central heating, greenhouse heating, thermal tourism and balneology in Sorgun.



Figure 1: Location map of Sorgun (Yozgat) geothermal field and its vicinity.

A part of observation studies (between 2010 and 2012) is supported by TUBITAK Project, (The Scientific and Technological Research Council of Turkey). Water samples have been taken from

geothermal wells at different periods and some physical properties such as temperature, electrical conductivity, pH in situ and chemical properties has been analysed. Dynamic water level has been measured at observation well.

2. SORGUN GEOTHERMAL FIELD

Geothermal reservoir units are Paleocene granodiorites in the field. Fracture, fault and altered zones of granodiorites are permeable. While the top border of granodiorites is Eocene caprock, the bottom limit of the units is undefined. Normal and strike-slip faults are developed in the region depending on tentional tectonics in Neogene and Quaternary.

A total 10 geothermal wells examined for the study. Well depths ranged from 104 m to 444 m and temperatures have been measured between 67°C and 80°C in the field. (Table 1). Characteristics of these wells are given in Table 1 and their locations and lithologies are shown in Figure 2.

Table 1: Characteristics of the geothermal wells in Sorgun geothermal field (Simsek et al., 2010)

Well No	Date	Depth (m)	[1]Product (l/s)	[2]Temp. (°C)	Explanation
YS-1	1988	104.5	4	75	[(3)]Production
Valilik-1	2003	105	17	67	[(4)]Production
YS-3	2004	334	6-8	75	[(5)]Drainage
YS-4	2004	243	20	80	[(5)] Drainage
YS-5	2004	336	0.1	-	[(5)] Drainage
SG-1	2005	275	-	50	[(6)]Nonproduction
SG-2	2005	300	66	80	[(6)]Production
SG-3	2006	357	40-60	71	[(6)]Production
SGR–1	2006	444	70	75	[(6)]Reinjection
SG-4	2008	390	[(2)]35	79	[(6)]Production

1): First production flow rate at production test, (2): Wellhead production flow rate at compressor test, (3): not used, (4): production with the pump (5): Madsan wells, (6): Yozgat Province wells

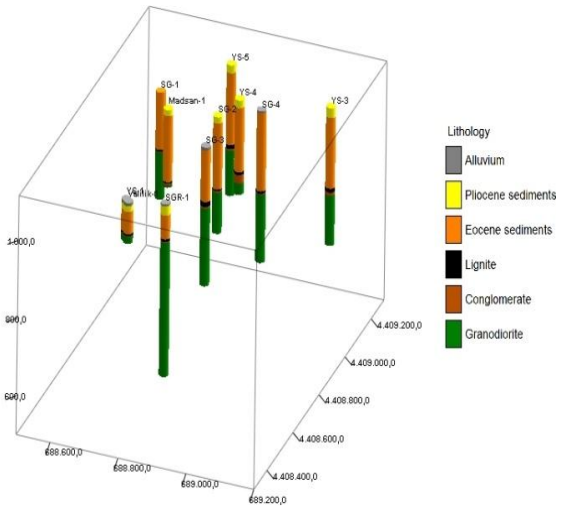


Figure 2: Locations and lithology of geothermal wells in Sorgun geothermal field.

The water levels range of the wells measured between 5 m and 70 m after production tests (Figure 3). Changes of water levels in SG-2, SG-3 and YS-3 were observed during simultaneous production tests of SG-2, SG-3 and YS-4 wells (118 l/s total production) with a pump. It showed that water levels decreased to around 63 m and becoming stable at this level (Iller Bankasi, 2005-2006).

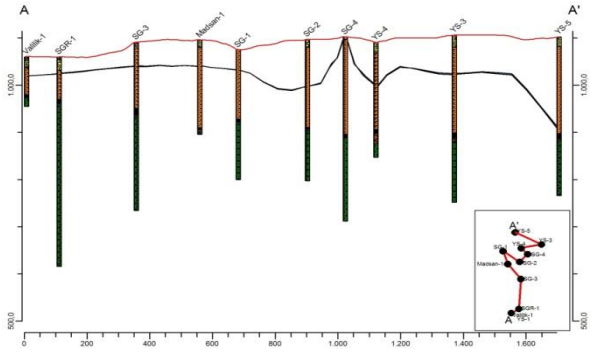


Figure 3: Static water levels of geothermal wells before production.

3. RESERVOIR RESPONSE TO PRODUCTION

District heating system became operational with SG-2 and SG-3 wells in November 2007 at the field. Heating period is six-months from November to May. The initial production rates of SG-2 and SG-3 wells were respectively 60 l/s and 55 l/s, temperatures were respectively 80 °C and 75 °C. After the first heating period, water level and flow rate didn't change at these wells but temperature of SG-3 decreased to 40 °C. SG-3 well has become unproductive for a result of reservoir connection with coal mining galleries. Hydraulic level was measured about 110 m with 115 l/s production in 2007-2008 heating period and it has been rising up to 96 m during summer period (Figure 4). Reinjection started in February of 2009 with 15 l/s (Figure 5). In March of 2009, due to the explosion that occurred in Coal Mine, dynamic water level of SG-2 declined to 130 meters (a total of 20m) in a day. It reached in a week its normal level at 110 meters (Figure 5). SG-4 well has been included to the system in 2010. Depth of the water level was observed about 104 m with 70 l/s production and 30 l/s reinjection rate during 2010-2011 heating period. It was measured about 96 m at the same production and injection rate in 2011-2012 heating period and it has been rising up to about 84 m during summer period (35 l/s production rate). Although production had the same flow rates, after the practice of injection, increasing of the hydraulic level is interpreted as begin injection to contribute to the geothermal system.

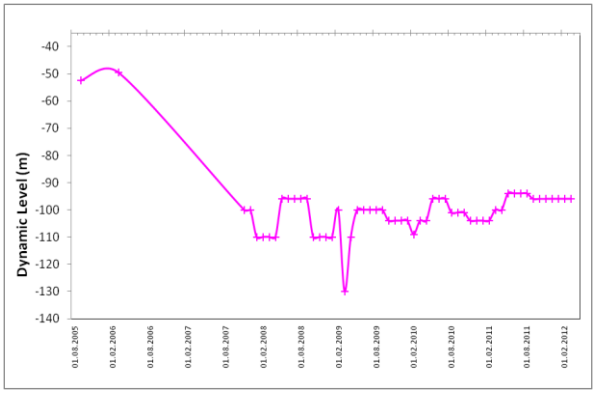


Figure 4: Water levels of YS-3 observation well after production

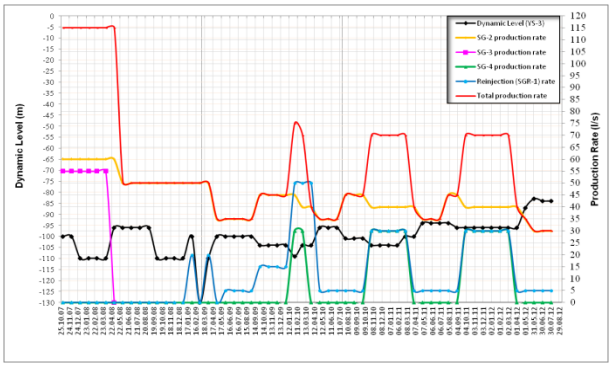


Figure 5: Dynamic water levels and production/injection rates of geothermal wells after production.

4. HYDROGEOCHEMISTRY

Waters of geothermal wells have been measured in situ as between 75 °C and 80°C temperature, between 2510-3000 µS/cm electrical conductivity and between 7.1-8.5 pH (Table 2). Water sampling has been taken periodically for chemical and isotopic analyses. According to chemical analyses, thermal waters are Na-Cl type and theirs compositions have relatively high Na-Ca and Cl-SO_4 concentrations. Periodically, slight changes in the chemical content of the waters are observed.

Table 2: Physical parameters of Sorgun geothermal well waters.

Well No	Date	T(°C)	pH	EC (µS/cm)
SG-2	2005 May	80	8,50	2770
SG-3	2006 Jan	80	8,45	2510
SGR-1	2006 June	75	8,13	2940
SG-4	2008 Dec.	80	8,07	3000
SG-2-A	2011 May	75,2	7,12	2580
SG-4-A	2011 May	79,5	7,02	2760
SGR-1-A	2011 May	78,3	7,23	2751
SG-2-B	2011 Sept	75,5	7,1	2568
SGR-1-B	2011 Sept	77,2	7,23	2551
SG-2-C	2012 March	80	7,14	2657
SG-4-C	2012 March	78	7,34	2785
SGR-1-C	2012 March	76	7,17	2703

5. CONCLUSIONS

Sorgun geothermal system is shallow and low temperature system. A total of 2 production (SG-2 and SG-4) wells and 1 injection (SGR-1) well have been used in service. During five year period from November 2007 to August 2012, thermal water of about 4923 m^3/day were produced and about 1076 m^3 /day were reinjected.

Depending on production, the pressure and/or temperature decline can be taken into account. Beginning of production, depth of water level is about 100 m but today this level is up to 96 m due to reinjection. After reinjection, there is no any negative effect as cooling in the wells and hydraulic level has been increased.

Evaluations of this study will provide a significant contribution to the creation of a dynamic hydrothermal conceptual model.

The production and reinjection data have to be followed long term and tracer tests should be performed for development and sustainable using of the geothermal system.

This study is one of the good sample for relations between university and industrial research and development (R&D) on geothermal energy.

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