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GEOTHERMAL WELL TESTING AT TATAPANI GEOTHERMAL FIELD, DISTRICT SURGUJA, INDIA.

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ABSTRACT

Tatapani Geothermal Field, is located on the Son Narmada lineament, 100 km NE of Ambikapur, district Surguja. Downhole well testing of the borewells at TGF was ompleted by Geological Survey of India and Oil and Natural Gas Corporation, in 1995 to decipher the sub surface characters of shallow reservoir. The well testing data was published in 1999. Based on the investigations done by GSI during the last two decades, a 300 kWe pilot geothermal power plant is proposed at Tatapani. The borewells were not in use since 1995 hence the testing of these wells was repeated in 1999 to verify the temperature and pressure parameters.

The second phase of well testing data indicated that the temperatures are consistent while the discharge is reduced which may be attributed to caving in the boreholes. Maximum temperature of 112°C is recorded in the borewell. Inversion of temperature from 112 to 109°C is observed below the depth of 200m, indicating incursion of cold water in the borewell. The borewells need cleaning and proper casing programme before commencing the production.

The flowing pressure observed in the wells is 32.6 bars at the depth of 340m. The pressure gradient varies from 0.093 to 0.0958 bars / m which is near hydrostatic. The pressure parameters are found to be in conformity with the results of previous well testing data. A continuous discharge of bore wells over 7 days showed pressure drop of 0.22 bars at the bottom hole, indicating moderate productivity. The well testing has confirmed that the borewells are free flowing and interconnected.

The results of two well testing show consistent temperature and pressure parameters over a period of 4 years. Thus, it may be surmised that the wells may sustain regular production.

1. INTRODUCTION

Tatapani Geothermal Field (TGF) is located 100 km northeast of Ambikapur, head quarter of Surguja district. Exploration of shallow aquifers to the maximum depth of 350m was initiated under a GSI –ONGC joint programme. Four production wells, GW/Tat/23 to 26, were completed up to the depth of 350m. The production wells, GW/Tat/ 23 to 26 and the earlier drilled well,GW/Tat/6, produced thermal water of 100°C on surface @1800lpm. Based on the investigations by GSI over the last two decades, installation of binary-cycle pilot power plant has been initiated at TGF. GSI- ONGC in 1995 carried out well testing at TGF to ensure temperature and pressure parameters in the shallow reservoir (Sarolkar et al 1999). The wells were meanwhile not operational hence second well testing was carried out to verify the physical condition of bore wells and reservoir parameters. The data of well testing completed in 1999 are presented in this article.

1.a. Background information

Geothermal studies of hot spring area were initiated in Central and Northern India, by GSI, as a part of National Non-Conventional Energy Program. Five production wells GW/Tat/6, and 23 to 26 were drilled at Tatapani field (fig. 1).

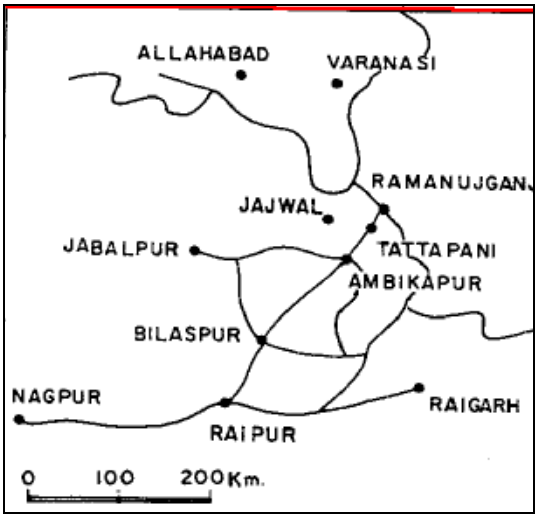

Fig.1, Location Map.

Reservoir temperature of 160°C and 180-190 C is indicated by Quartz and Na/K geothermometers,

respectively. The inferences of well testing in 1995 are summarized below.

The well testing indicated maximum temperature of 112.5 °C in the borewell. The temperature profile shows gradual increase in temperature with depth but slight inversion in temperature is reported below 300m depth indicating cold water incursion. Static pressure in the bore well ranges from 4-5 kg/cm^2 at well head to 34 kg / cm^2 at the depth of 350m. The pressure gradient is uniform and slightly more than the hydro static pressure. Permeable zones are interpreted around the depth of 110-150m, 175 to 275m and > 300m. Major thermal water feed zone is at 200m while the cold water incursion occurs at >300m and at shallow level. The interference tests show interconnection of bore well Tat/23 with Tat/6 and 24. The thermal profile indicates convective flow at the depth of 175m and below. The P and T data indicate single phase liquid dominated reservoir.

The RT-8 and RPG IV downhole testing units were used to carry out the well testing. Static temperature and pressure and flowing well T and P profile was measured. Interference test with other boreholes in flowing condition was conducted in the borewell Tat/23.

Table 1; Discharge parameters of the borewells at Tatapaani.

Borewell	Discharge lpm (1999)	Surface Temp C	Discharge (Pitale et 1996)
Tat/6	255	100	289
Tat/23	270	100	269
Tat/24	*	100	431
Tat/25	290	100	255
Tat/26	330	100	498

(*The bore well Tat/24 could not be tested as the gate valve was jammed).

The discharge parameters as recorded during the observation period are detailed in Table 1. The well discharge was measured intermittently over the period from 1995 to 1999. The data indicate that the discharge of the bore wells tat/6 and Tat/13 is rather consistent. The discharge of Tat/26 declines over a period after continuous discharge of all the other bore wells, suggesting interconnection of bore wells.

The temperature at surface is measured as 100^{o}C. Assuming that the saturation conditions exist in the bore well at 112.5^{o}C, steam fraction of 2.3% may be expected on flashing at the surface.

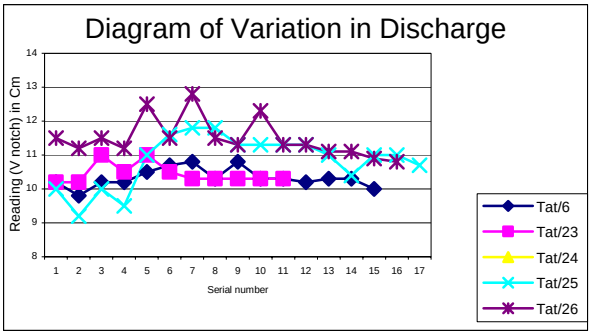

Fig.2, Variation in discharge of bore wells

2. BORE WELL CONDITION

The bore well Tat/24 could not be operated as the gate valve is jammed. The borewells Tat/23 and 6 are clear upto the bottom. During a dummy run, The bore well Tat/25 and Tat/26, have encountered a fracture cum caving zone at the depth of 234m and 219 m, respectively, hence , the testing was restricted to 215m and 190 m, only.

3. WELL TESTING DATA

3.a. Borewell Tat/6

The bore well Tat/6 is clear upto the bottom i.e.320m. The temperature and pressure profile of this bore well are shown in Fig.3. Static bore well temperature profile measures 85^o C at surface to 112.2 ^{o} C at the depth of 220m depth.

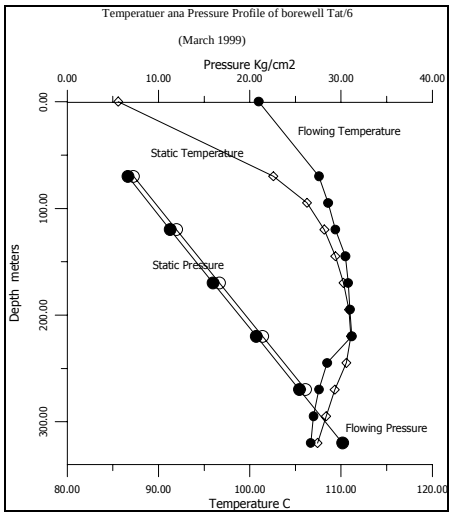

Fig.3, Temperature and pressure profile of borewell GW/Tat/6.

Temperature reversal is observed at the depth of 245m and below with temperature of 107.9 ^{o} C at bottom hole. The flowing well temperature profile indicates temperature of 101 C at the surface to maximum 111.2 ^{o} C in the borehole.

Reversal in temperature is prominent below the depth of 245 m, cooling down to 106.7 C at the bottom. Blow out zone is around 120m. below which zone of conduction is observed upto 170 m depth. Zone of convection is noticed around 240m depth and below suggesting fracture zone with good permeability. Cold water incursion in the borewell is inferred at the depth of 260 to 300 m. Thermal water feeder zones may be inferred at 110-120m, 150m, 180-220m depth. Thermal gradient in the bore well ranges from 0.01 C to 0.094 C per meter. At flowing condition, the temperature at bottom hole, is less than that in the static well condition, suggesting more mixing of cold water in the flowing condition.

3.b. Borewell Tat/23-

The borewell is clear upto the bottom and shows very consistent discharge parameters.

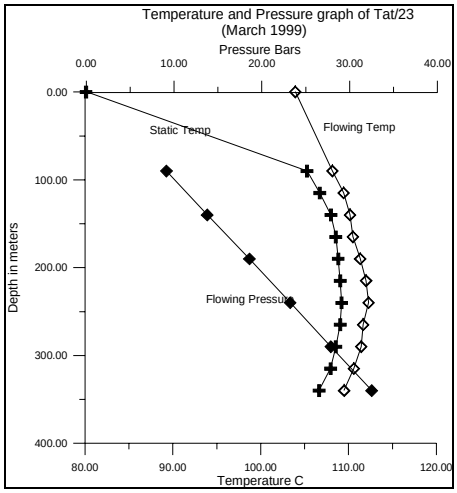

Fig.4, Temperature and pressure profile of bore well GW/tat/23.

The temperature and pressure profile is depicted in Fig.4. The temperature of 105 ^{o} C is measured at 90m depth, 109 ^{o} C at 190m depth and maximum of 109.2 ^{o} C at 240m depth. Reversal temperature is observed below 265m depth, measuring 106^{o}C at the bottom. The flowing well measures temperature of 104^{o} C at the surface, to 112.3^{o}C at 240 m. depth. The temperature at bottom is reported to be 109.5 ^{o} C.

The flowing well temperature profile is in conformity with the earlier reported data. Temperature gradient of 0.0112 to 0.0508 ^{o} C / m has been observed. The static well pressure profile and flowing well pressure profile are almost similar. The flowing well pressure is measured as 23.2bars at 240m depth and 32.5 bars at bottom hole. Δ P of 0.15 bar is reported at the bottom. Blow out zone is observed around 110m depth. Conduction zone is observed upto 180m depth. Zone of convection is noticed below 240 m depth. The main fracture zones are inferred at 110-120m, 180-220m, and below 300m depth. The borehwell shows good productivity with P I of 20 kg/bar-s. Good permeability is suggested below the depth of 300m.

3.c. Borewell Tat/25

Well testing of Ta/25 could be completed upto the depth of 215 m (Fig.5). Static temperature of 94.6 ^{o} C is recorded at the surface while maximum temperature of 109.4^{o} C is recorded in the bore well. The flowing well temperature ranges from 104 ^{o} C at surface to 112.1 ^{o}. C at the depth of 215m.

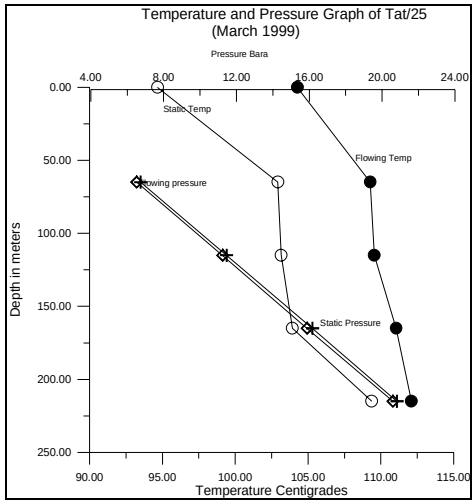

Fig. 5, Temperature and pressure profile of bore well GW/Tat/25.

The temperature profile indicates zone of conduction upto 70 m depth, below which zone of convection is noticed. Fracture zone with good permeability is reported at 175m – 220m as indicated by sharp spurt in the temperature at this depth. The temperature reversal could not be verified in this borewell as the probe could not reach the desired depth.

The pressure gradient shows steady increase in the static pressure from 6.7 bars at 65 m depth to 20.8 bars , at the depth of 215m. The static and flowing pressure profiles are similar in character. The static and flowing well pressure profile shows uniform gradient, which is near hydrostatic.

4. DISCUSSION

The well testing data indicates that the temperature and pressure profile measured in March 1999 is similar to the data of !995, suggesting that the downhole conditions are stable over he period of observation. The exact variation in the profile, if any, could not be verified, as the depths of observation in both the profiles are not same. The data more precisely points out the fracture zones locations. The temperature inversion recoded in 1995, below the depth of 250m is corroborated in the present testing.

Thus, the zone of good permeability and cold water mixing is delineated. The existence of feed zones is suggested at 110-120m, 150m, and 180-220m. The observation is supported by the data of injection testing of the borewell Tat/23and 25 in 1995 (Sarolkar et al 1999). The character of the P and T profile in Tat/23 is exactly similar to that reported from borewell TH#1 of Steam boat Geothermal filed, USA, which indicates single phase hot water reservoir (Combs and Goranson 1995).

The bottom hole pressure is nearly hydrostatic. The wells are free flowing which may be attributed to the high temperature of water and resultant buoyancy. The static pressure at well head was suggested to be 0.5 bar which needs verification. The flowing pressure will be subsequently still low. The flowing well bottom hole temperature in Tat/23, is more than that observed in static condition, but actually decreases in Tat/6, suggesting large scale mixing of the cold water.

The interference test of Tat/23 with Tat/25 and the other borewells shows slight pressure drop confirming the interconnection of all the borewells. Pressure drop of 0.22 bar was noticed at bottom hole when all the bore wells were allowed to flow for 9 days. The stabilized discharge after a continuous flow for 3 days is reported in table 1.

5. CONCLUSION

The observations during well testing in March 1999 corroborate the results of well testing in 1995. The temperature, pressure parameters are almost constant over the period of observation suggesting stable reservoir conditions at shallow level.

Maximum temperature of 112.3^{o}C is recorded in the bore wells. The discharge from the bore wells Tat/23 and 6 is stable while the discharge from the other bore wells is reduced which may be attributed to caving in the borewells. The borewells Tat/24, 25 and 26 are blocked due to caving at various depths and need cleaning. Maximum temperature is reported at the depth of 220-240 m below which temperature reversal is noticed. This is certainly a refinement over the earlier data which showed a feed zone upto the depth of 175m. The zone of mixing is confined below 250m depth. Very low P is recorded in the bottom hole after continuous flow of the wells suggesting good productivity.

The well testing of shallow bore wells is useful for deciphering the reservoir conditions and the results are encouraging for production at the present rate.

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