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GEOCHEMICAL APPRAISAL OF BAKRESHWAR-TANTLOI HOT SPRINGS, WEST BENGAL AND JHARKHAND, INDIA

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ABSTRACT

Hot springs are reported in Eastern India at Bakreshwar, West Bengal and Tantloi, Jharkhand. These hot springs are located on the eastern continuation of Son-Narmada lineament zone. The hot springs at Bakreshwar show temperature of 35°C to 66.5°C on surface, while the hot springs at Tantloi record temperature of 30°C to 70°C at surface. The discharge of these hot springs varies from 90 lpm to 480 lpm.

The thermal water at Bakreshwar is alkaline with low to moderate sodium, HCO_3 and SO_4 as compared to chloride. Bakreshwar water shows profuse gaseous activity with 0.31 to 1.33% He. The hot springs at Tantloi are more alkaline with low silica, moderate HCO_3, and higher Mg content. Tantloi hot springs have 1.29 to 2.77% Helium content. The thermal water from these springs indicates immature nature. The indicated reservoir temperature at Bakreshwar varies from 110 to 124°C by $TSiO_2$, and 130 to 175°C by T Na/K method. Besides, it is observed that in both the hot springs areas show high fluoride content.

The Cl- HCO_3 – SO_4 ternary plot of thermal water from Bakreshwar falls in HCO_3 field indicating Na – bicarbonate type water. The Na-K-Mg ternary plot indicates that the thermal water mostly falls in Mg field, indicating immature water and mixing of thermal water and shallow ground water. The thermal water of Bakreshwar and Tantloi hot springs falls on meteoric line in the δD and δO^{18} plot suggesting deep circulation of meteoric water in the geothermal system. Bakreshwar thermal springs show high emission of helium gas. The present data also suggests that deeper level investigation is necessary to assess actual reservoir potential.

INTRODUCTION

The search for non-conventional energy resources in India lead to inventory of 340 hot springs in India. Puga valley, Jammu & Kashmir State and Tatapani, Chhattisgarh, are important geothermal prospects in India. Besides these, Bakreshwar in W. Bengal and Tantaloi hot springs in Bihar, now Jharkhand, are promising geothermal areas as these springs are located in the vicinity of urban agglomeration. This geothermal occurrence gains importance as a source of non-conventional energy for the utility of local population.

Bakreshwar (W. Bengal) and Tantaloi (Jharkhand) are main hot springs areas amongst the group of hot springs located on the eastern continuity of Son-Narmada lineament. Considering the increasing demand for energy in India and the need to reduce the consumption of fossil fuel, the use of geothermal energy as a supplementary source of energy assumes a greater importance. An attempt has been made in this article to analyse the available chemical data of these hot springs (Mukhopadhyay. 1996), for assessing characters of geothermal water.

Location

The Bakreshwar hot springs located in Birbhum district of W. Bengal are accessible by road via Panagarh on NH 2, through Illambazar, Dubrajpur and Suiri. These hot springs are located 210 km from Howrah by rail and 15 km west of Suiri (Fig.1).

Fig.1, Location of Bakreshwar hot springs

Tantaloi, Dalahi and Bara Palasi group of hot springs are located in Dumka district, Jharkhand. The Tantloi -Bara Palasi area is approachable by Howrah- Delhi railway, 60 km away from the Dumka town.

GEOLOGY

The Bakreshwar area-comprises Chhotanagpur gneiss, intrusive dolerite and amphibolite dykes. Lenticular outcrops of brecciated cherty quartzite discordant to granitic gneiss are observed around 1.5 km north of Bakreshwar (GSI 1991). A shear zone trending N-S marked by brecciated, silicified quartzite, is exposed from Gohaliara to Tantiapara. These rocks show NE-SW trend of foliation with dip of 20° to 40° towards NW. The hot springs in Bakreshwar are located along N-S trending regional fault. Metamorphic rocks at Bakreshwar show anticlinal fold along NE-SW axis. Dolerite dykes appear to have intruded along the axial plane of the fold. The thermal manifestations are in the form of hot sprouts on the abandoned course of Bakreshwar *nala,* which show profuse discharge of hot water with gas emission, discharging hot water of 35 to 66.5°C. There are 7 springs viz. 1) Agnikund- 65-66.5°C, (Mukhopadhayay 1996) 2) Soubhagya Kund- 45-47.5°C, 3) Suryakund - 55-57°C, 4) Brahmakund-43-45°C, 5) Swetganga - 35°C, 6) Kharkund-58-66°C, 7) Bhairab kund-55-59°C. The gases collected from Bakreshwar hot spring contains 0.31 to 1.33 % He. The details are given in Table 1.

Table 1-Dischrge of hot springs

Area	Surface Temperature°C	Discharge LPM
Bakreshwar Hot springs		
Agnikund	33 -66.5	780
Kharkund	66	--
Tantaloi- Bara palasi hot springs		
Bara Palasi	33-66. 5	480
Tantaloi	48-70	420
Dalahi	48	120
Philasahari	35	90

The Tantaloi- Bara Palasi group of hot springs are located in the Chhotanagpur Granitic Complex, comprising migmatite, which locally shows gradation to charnockite and porphyrytic granitic gneiss. Patches of Talchir shale, boulder bed and gritty, white, sandstone of Barakar formation, Lower Gondwana Group, are exposed near the Dalahi and Tantloi hot springs.

The Tantaloi hot springs are located at the northern margin of Gondwana sediments along a NE-SW to WNW-ESE trending fault. (Mukhopadhyay1989). A ferruginous, siliceous breccia trending E-W is present near Tantaloi hot springs. Sheared granite, with aplite and pegmatite is observed NE of Tantaloi. Two boreholes (<200m deep) have been drilled at Tantaloi to decipher the sub-surface geology. The boreholes yield continuous discharge of hot water of 65°C with profuse gaseous activity. The gas emission from hot springs at Tantaloi contains 1. 29 % to 2.77 % He, upto 4.23% (O_2 and Ar) with high N_2 content.

CHEMICAL COMPOSITION

Hot springs at Bakreshwar show pH of 9, chloride content in hot springs in Bakreshwar ranges from 30 ppm to 100 ppm, SO_4 content is low <10 ppm. Thermal water from Bakreshwar contains high Na ranging from 30-100 ppm, low K< 4.8 ppm and low Ca and Mg, moderate TDS and silica ranging from 60 to 82 ppm. Fluorine content is high 9 to 12 ppm and needs caution before supply for direct uses. Fluorine content of 0.7 to 1.5 ppm is acceptable for drinking water (Deshmukh et al 1996). Li content is rather high in Bakreshwar water. HCO_3 and SO_4 is less in Bakreshwar water as compared to Cl, suggesting less component of ground water mixing at Bakreshwar. Stable isotope enrichment in Bakreshwar water may be due to deep circulation of meteoric water and subsequent water rock interaction. The uniform boron content in these samples point out to common source of water (Wright 1991).

The thermal water from Tantaloi / Dhamni is mostly neutral to alkaline with pH ranging from 6.9 to 8.7. Low to moderate Na –K content and higher Mg content is observed in the thermal water at Tantaloi suggesting large scale contribution of shallow level ground water in Tantaloi area. Silica content is low at Tantaloi. HCO_3 is moderate in Tantaloi water ranging from 145 to 595 ppm, indicating that the water at Tantaloi is more of bicarbonate type. Uniform boron content in Tantaloi/ Dhamni area indicates common source of hot springs similar to Bakreshwar hot springs.

The indicated temperatures of Agnikund and Khar Kund hot springs of Bakreshwar by $TSiO_2$ ranges from 110 to 124°C, and TNa/K ranges from 130-175 °C. Thus, the thermal sprout may be around Agnikund/ Khar Kund. Aqueous geo thermometers give large variation in indicated

reservoir temperatures, probably due to variation in intermixing pattern of waters from different sources. Indicated temperatures of Bara Palasi-Dalahi group of hot springs are not in conformity with surface observations.

The Chloride enthalpy plot of hot spring water is shown in Fig. 2. The Chloride enthalpy diagram points that the thermal water from Agnikund Kharkund hot springs is of geothermal characteristics having less mixing and may have deeper source. The water from the other springs might be mixed with shallow ground water. Hence, the water samples from Agnikund and Kharkund hot springs may represent hot water with lesser dilution as compared to the other samples. The above inference is supported by Cl-SO_4-HCO_3 ternary diagram (Fig. 3). The Cl-SO_4-HCO_3 ternary diagram depicts that the thermal water from Tantaloi clusters around HCO_3 end while the thermal water from Agnikund, Kharkund- Bakreshwar falls on the HCO_3 –Cl mixing line.

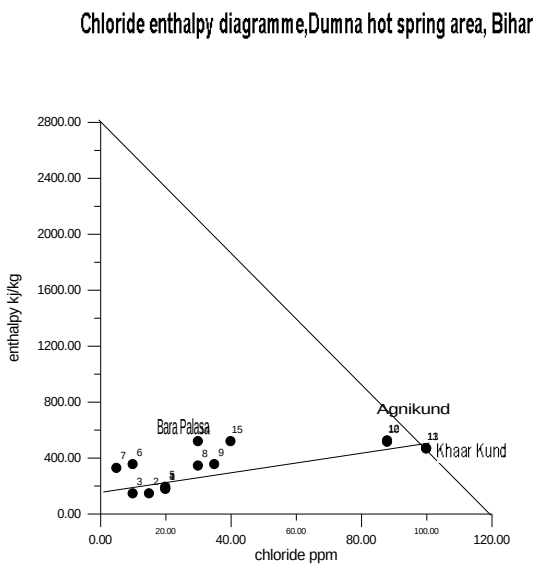

Fig.2, Chloride enthalpy diagram

The content of SO_4 in hot water is negligible showing more affinity towards bicarbonate type. Therefore, it may be inferred that the clustering of data points in this plot that the clustering represents a similar source. The thermal water from Agnikund is chloride rich suggesting less of mixing and nearness to source.

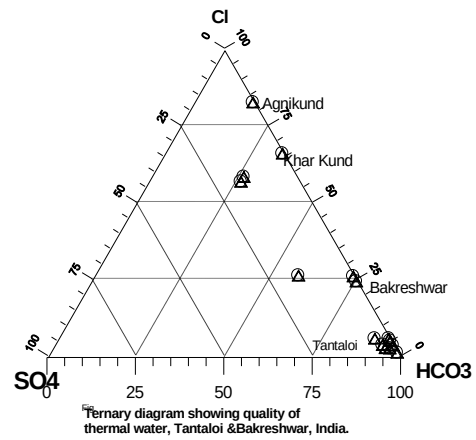

Fig. 3, Ternary Chloride-bicarbonate- sulphate diagram.

The Na-K-Mg ternary diagram (Giggenbach 1980) shows clustering of most of the water samples from Tantaloi in Mg zone. The water samples from Bakreshwar area also fall in Mg domain suggesting that the mature geothermal waters are yet to be encountered in these areas (Fig. 4). This also suggests that the thermal waters from these hot springs have variable proportion of mixing with ground water. The original source of the geothermal water is yet to be established.

The assessment of reservoir temperature based on this diagram is not possible. The enrichment of Mg may be attributed to influx of cold ground water into the ascending thermal water. Similar mixing is observed in Waimangu valley of New Zealand also. The water from the upper Waimangu valley plot along a linear trend, towards the Mg apex, which indicates their compositions are affected by admixture of varying amount of secondary water, relatively rich in Mg and of likely shallow origin (Simmons *et al*, 1995).

Stable isotope composition of thermal water from Bakreshwar and Tantaloi area (Bandopadhyay 1991) has been used for analysing the proximity of geothermal reservoir and mixing trends. The isotope content of Dalahi hot springs show a positive shift from meteoric line indicating possibility of water rock interaction in rock dominated environment (Fig 5, Bandopadyaya 1991).

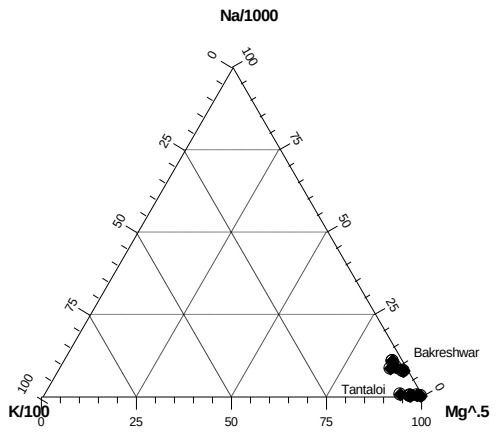

Fig.3,Na-K-Mg diagram showing thermal water quality, Bakreshwar and tantaloi, India.

The thermal water that falls very close to the meteoric water line, which indicates a meteoric origin (Pang and Wang 1995).

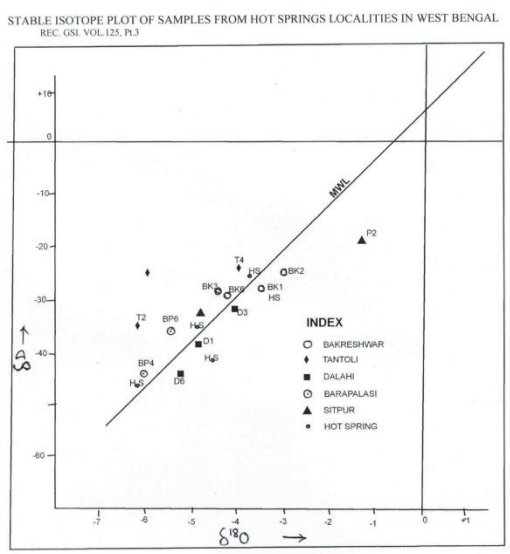

Fig5, Isotope analysis of thermal water,(after Bandopadyaya 1991)

The isotope study of water samples from Bakreshwar - Tantaloi by Bandopadhyay (1991) suggest that –

1. Bakreshwar water falls on meteoric water line, with slight enrichment in oxygen isotopes. The positive shift of oxygen isotope in these samples may be attributed to water rock interaction. The thermal water is of meteoric origin and gets heated during deeper circulation in the reservoir. The hot water samples from Bakreshwar area show similar ∂D and $\partial^{18}O$ composition suggesting common origin.

2. The isotope composition of thermal water from Bara Palasi and Tantloi show negative shift depletion from meteoric water line, which may be due to evaporation effect or due to mixing with steam-heated water. (Bandopadhyay A.K. 1991).

CONCLUSION

The chemical composition of hot springs at Bakreshwar and Dhamni indicate that the thermal water is of meteoric origin. Thermal water at Agnikund shows more geothermal component and less mixing with ground water as compared to the other hot springs areas. The thermal waters from Tantaloi, Bakreshwar and Dalahi springs are bicarbonate sodium type and immature in nature. The Agnikund hot spring shows nearness to source and may suggest mixing trend from Agnikund to Bakreshwar. The enrichment in isotope content of Bakreshwar hot springs may be attributed to water rock interaction or evaporation. The indicated reservoir temperatures of Bakreshwar hot springs ($TSiO_2$) vary from 110°C to 124 °C and 130 °C to 175 °C by Na /K ratio. The data suggest that higher temperatures may be available in deep reservoir. Exploration by drilling is necessary at Bakreshwar hot springs to assess the full potential of geothermal resource.

Thermal water at Bakreshwar has fluorine content more than the permissible limits for human consumption. Removal of fluorine is essential for using the thermal water for direct heat purposes. Systematic thermal water sampling and isotope analysis may be taken up to identify the zones of thermal anomaly and extent of geothermal source. The thermal water is useful for direct heating in refrigeration, green -housing, spa, therapeutic uses, aquaculture, sericulture, concrete curing and coal washing.

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TABLE2: CHEMICAL ANALYSIS OF THERMAL WATER FROM BAKRESHWAR GEOTHERMAL FIELD, W. BENGAL.

Sr no.	Place	pH	HCO3	CO3	Total hard	Cl	NO3	SO4	B	Na	K	Ca	Mg	TDS	SiO2	F	Total Fe	Li
1	Agnikund	9.3	39	44	4	88	0.22	28		125	2.5	1	1	400	78	10	0.04	
2	Khar kund	9.2	40	44	4	88	0.22	25		125	2.5	1	1	410	82	9	0.04	
3	Bara palasi	9.06	90	50		30		0.01						310	80			
4	Bara palasi (A)	8.7	420	75	9	30	0.22	19	0.5	86	0.81	2	1	260	28	15	0.04	26
5	BaraPalasi (C1)	8.6	75	26	9	35	0	20	0.5	87	1.1	2	1	268	30	16	0.51	28
6	Tantloi	9.4	24	34	4	53	0.25	39	-	10	2	1	traces	375	275	11	0.07	-
7	Dalahi	9.00	80	40	trace	60	0.1	.0.03	-	125	2	trace	trace	370	80			