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Geochemical Appraisal of Hot Springs of North Eastern Region, India

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ABSTRACT

The Himalayan range is storehouse of signature of various geological activities manifested in form of structural features and hot springs. The geothermal activity is manifested in form of hot springs along the Himalayan ranges. The hot springs are reported at Garam pani (45°C), Assam; Jakrem (47°C) in Meghalaya; Chhetu (35°C to 65°C) in Arunachal Pradesh and Sechu (42°) in Sikkim. Reservoir temperature of 150°C is estimated for hot springs in Sechu area. Reservoir temperature around 100°C is estimated for the hot springs in Assam and Meghalaya. Most of these hot springs are located along the lineaments indicating deep circulation of water. Besides these, hot springs are also located at Dirang, Thimbu and Gange Khor.

The hot spring at Jakrem contains 80 ppm Cl, 13.5 ppm SO_4, 98 ppm HCO_3, 70 ppm Na, 8 ppm Ca, 1 ppm K, The Chetu hot spring contains 332 to 444 ppm HCO_3, 105 to 170 ppm Cl, 334 to 368 ppm SO_4, 135 PPM, Ca, 151 to 242 ppm sodium, 11 to 180 ppm potassium, and 24 to 85 ppm silica. Silica geothermometer indicates reservoir temperature of around 125°C at Chhetu. Hot spring at Sechu contains 220 ppm HCO_3, 87 ppm, 922 ppm SO_4, 192 ppm Ca,256 ppm Na, 35 ppm K and 129 ppm Si. The indicated reservoir temperature is 145°C. These hot springs indicate mostly immature water with mixing at shallow level.

Considering this, there is need to take up detailed study of hot springs in North Eastern Region of India. The geothermal resources in North Eastern Region, which are mostly low enthalpy resources, can be used for binary cycle power plant for electricity generation and direct heat uses like green house cultivation, refrigeration, cement curing, fish drying, processing of forest products and tourism, in Assam, Arunachal Pradesh and Meghalaya states to improve the economic activity of the region.

1. INTRODUCTION

The North Eastern Region of India comprising Assam, Meghalaya, Nagaland, Manipur, Mizoram, Arunachal Pradesh and Sikkim states, cover the eastern part of Himalayan Mountains. The terrain is mostly hilly and structurally disturbed, hosting a number of hot springs. The main hot springs are Garam pani (45°C-54°C) and Nambor (35°C) in Assam (Krishnaswamy & Ravishanker 1982, GSI 1991); Jakrem (47°C) near village Umjaram in Meghalaya; Chetu (35°C to38°C), Takshing (52°C) and Maja (38°C) in Arunachal Pradesh and Sechu (42°) in Sikkim (GSI 2002). Geochemical study is need of the hour for the hot springs from Assam, Meghalaya, Arunachal Pradesh and Sikkim.

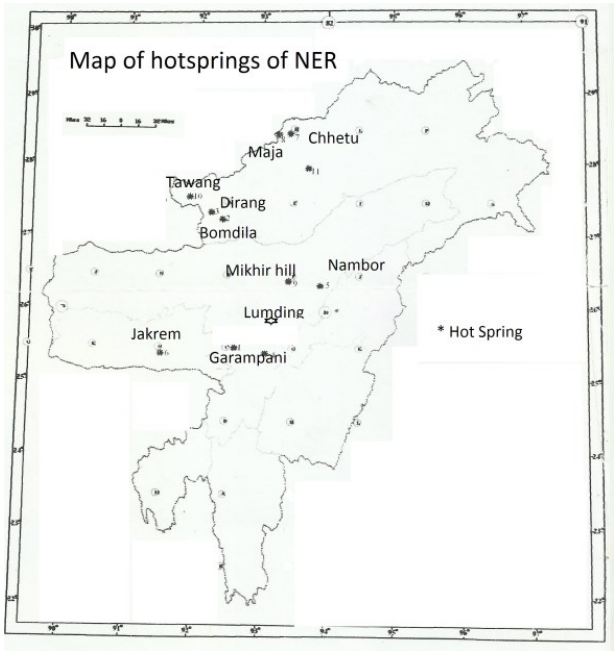

Fig 1: Location map of these hot springs of North Eastern Region

2. CHEMICAL COMPOSITION

Preliminary study of hot springs was done by Geological Survey of India (GSI 1991). The water analysis was carried out by A. Absar (2006). Verma (1984) also reported water analysis of the hot springs of Assam and Meghalaya. Geochemical appraisal of hot springs is attempted in this article. The chemical composition of thermal water is presented in table 1 below.

Table 1: Chemical composition of hot springs of North Eastern Region

Source	TDS	HCO_3	Cl	SO_4	F	Ca	Mg	Na	K	SiO_2
GSI 2002	Takshing+	435	18	28	0.4	37	11	133	10	80
	Jakrem2+	190		31.8	15	5	0	60	1	10
Absar	Takshing*	360	23	23	1	88	2	61	6	41
	Maja*	353	35	36	0.4	54	5	86	9	40
	Timbhu*	126	77	331	7	13	1	205	23	106
	Sechu*	220	87	922	1.5	192	35	256	35	129
	Dirang*	244	140	364	1.5	55	11	250	38	58
	Chhetu1*	444	170	368	2.6	135	8	242	180	85
	Chhetu2*	332	105	334	1.6	135	7	151	11	54
	Chetu*	269	119	370	0.4	127	11	150	17	60
Verma	Garampani@	300	15	109	0	7.9	0	75	3.9	20

Source-+ GSI 2002, * A. Absar (2006), @ R.N Verma (1984)

The hot spring at Jakrem in Meghalaya contains 80 ppm Cl, 13.5 to 31.8 ppm SO_4, 98 to 190 ppm HCO_3, 60 ppm Na, 5 to 8 ppm Ca, 1 ppm K and low silica. Besides, fluorine is reported to be very high in Jakrem hot springs (GSI 2002). The Garampani hot spring in Assam contains HCO_3 300ppm, Cl 15 ppm, SO_4 109 ppm, Na 75 ppm, Ca 7.9 ppm, K 3.9 ppm, low silica and fluorine content (Verma 1984). The Chetu hot spring contains 269 to 444 ppm HCO_3, 105 to 170 ppm Cl, 334 to 370 ppm SO_4, 127 to 135 ppm Ca, 151 to 242 ppm sodium, 11 to 17 pp m potassium, and 54 to 85 ppm silica. Fluorine content is reported upto 1.5 ppm. Hot spring at Sechu contains 220 ppm HCO_3, 87 ppm Cl, 922 ppm SO_4, 192 ppm Ca, 256 ppm Na, 35 ppm K and 129 ppm Si with low fluorine content. These hot springs indicate mostly immature water with mixing at shallow level.

The Takshing hot spring in Arunachal Pradesh contains upto 435 ppm HCO_3, low 18 to 23 ppm Cl, 23 to 28 ppm SO_4, 133 ppm Na, 10 ppm K, 37 ppm Ca and upto 11 ppm Mg. Silica is reported 41 to 80 ppm and low fluoride (Absar 2006). The Dirang hot spring contains 244 ppm HCO_3, 140 ppm Cl, 364 ppm SO_4, 230 ppm Na, 38 ppm K, 11 ppm Mg and 55 ppm Ca. Silica is 58 ppm and fluorine 1.5 ppm. Maja hot spring contains 353 ppm HCO_3, 38 ppm Cl, 36 ppm SO_4, Na 86 ppm, 9 ppm K, 5 ppm Mg and 54 ppm Ca. Silica is reported 40 ppm and low fluorine content is reported. Timbu hot spring contains 126 ppm HCO_3, 77 ppm Cl and 331 ppm SO_4, 205 ppm Na, 23 ppm K, low Mg and 13 ppm Ca. Silica is reported 106 ppm, and 7 ppm fluorine content is reported. Most of the hot springs show high HCO_3 and SO_4 content as compared to Cl suggesting marginal or steam heated water. Besides, the high Mg content in the hot spring water indicates mixing with shallow surface water. Sinha R.K. (1984) reported Na 150 to 250 ppm, K 9 to 45 ppm, Mg 5 to 12 ppm, HCO_3 77 to 316 ppm, Cl 20 to 123 ppm, in Dirang hot spring. These hot springs mostly show sodium – bicarbonate, sodium sulphate type water, suggesting that geothermal source is yet to be tapped.

The maximum steam loss silica geothermometer (Fournier, 1981) suggests indicated reservoir temperature of 95 to 122°C at Takshing, 145°C at Sechu, 105°C to 125°C at Chhutu, 108°C at Dirang, 95°C at Maja and 135°C at Timbu. The NA/K geothermometer gives very high results ranging from 121°C at Jakrem to 268°C at Dirang hot spring. Most of these are single sprout discharge hot springs, suggesting limited extend of the resource. The chemical data suggest that the water sampling may be repeated to get more representative results showing present day composition of the hot springs.

2.1 Triangular Diagrams

The Cl-HCO_3-SO_4 triangular diagram indicates that hot water from Jakrem, Garampani, Takshing and Maja is HCO_3 rich marginal water which may be termed as sodium bicarbonate water. The water from Timbu, Dirang, Chhetu and Sechu may be bicarbonate SO_4 rich steam heated water. The SO_4 content may be attributed to water rock interaction also. There is no water falling in chloride rich zone, suggesting that hot spring water does not represent the actual geothermal water, it is modified before discharge. This also suggests that to get true information about geothermal water quality, samples need to be collected by drilling shallow boreholes to get more representative water samples.

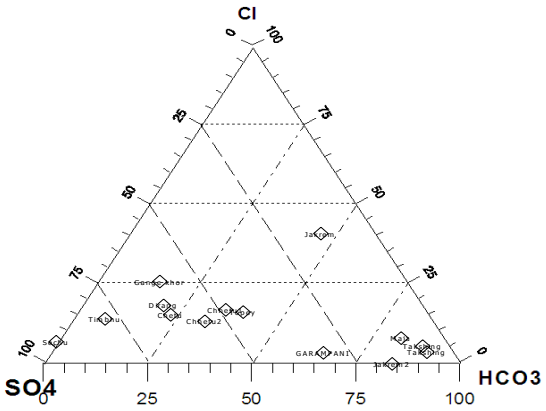

Figure 2: Cl-HCO3-SO4 diagram of hot springs of NER

The Na-K-Mg ternary diagram (Giggenbach 1997) of hot spring water composition also support the above observation, as almost all water samples fall in Mg rich domain, suggesting immature water, affected by shallow level mixing/ dilution. The water from Jakrem and Garampani hot springs fall in Na rich domain representing comparatively less mixing. Thus, both the ternary diagrams indicate that fresh sampling is required for knowing present day water composition to get better understanding of hot spring geochemistry.

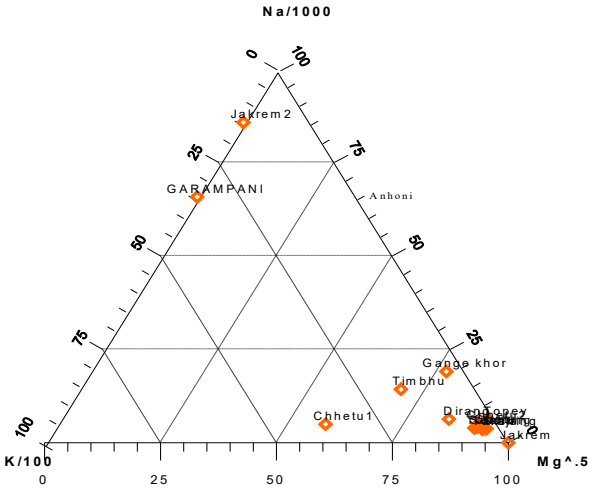

Figure 3: Na-K- Mg diagram of hot springs of NER

Considering the continuous discharge of these hot springs with low to medium temperature, these hot springs are very useful as tourist attraction places. Garamapani and Jakrem hot springs have developed the springs by constructing concrete tanks for channelizing the hot water discharge for use by tourists and as a measure for safety of visitors. At Jakrem, hot water bath facility is also developed. Similar facility can be developed at Chhetu, Dirang and Takshing for attracting tourists.

3. CONCLUSION

The water composition of hot spring water from North Eastern Region indicates that most of the water is sodium bicarbonate type, or sulphate rich marginal water. Hot spring water also indicates heavy mixing with shallow/ surface water. The indicated reservoir temperature varies from 95°C to 145°C, suggesting low temperature geothermal resources. It is suggested to drill shallow boreholes to get representative water samples of these geothermal resources which may help in proper assessment of resource potential. Bath centers and spa facility can be developed at these hot springs to attract tourists.

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