Understandings about Springs of Sikkim and a few words about roof-top rain water harvesting

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A **spring** is any natural occurrence where water flows on to the surface of the earth from below the surface, and is thus where the aquifer surface meets the ground surface.

In Sikkim, mountain springs, *i.e. dhara* in local parlance, have been traditionally playing a vital role in providing water security to nearly **80%** rural households.

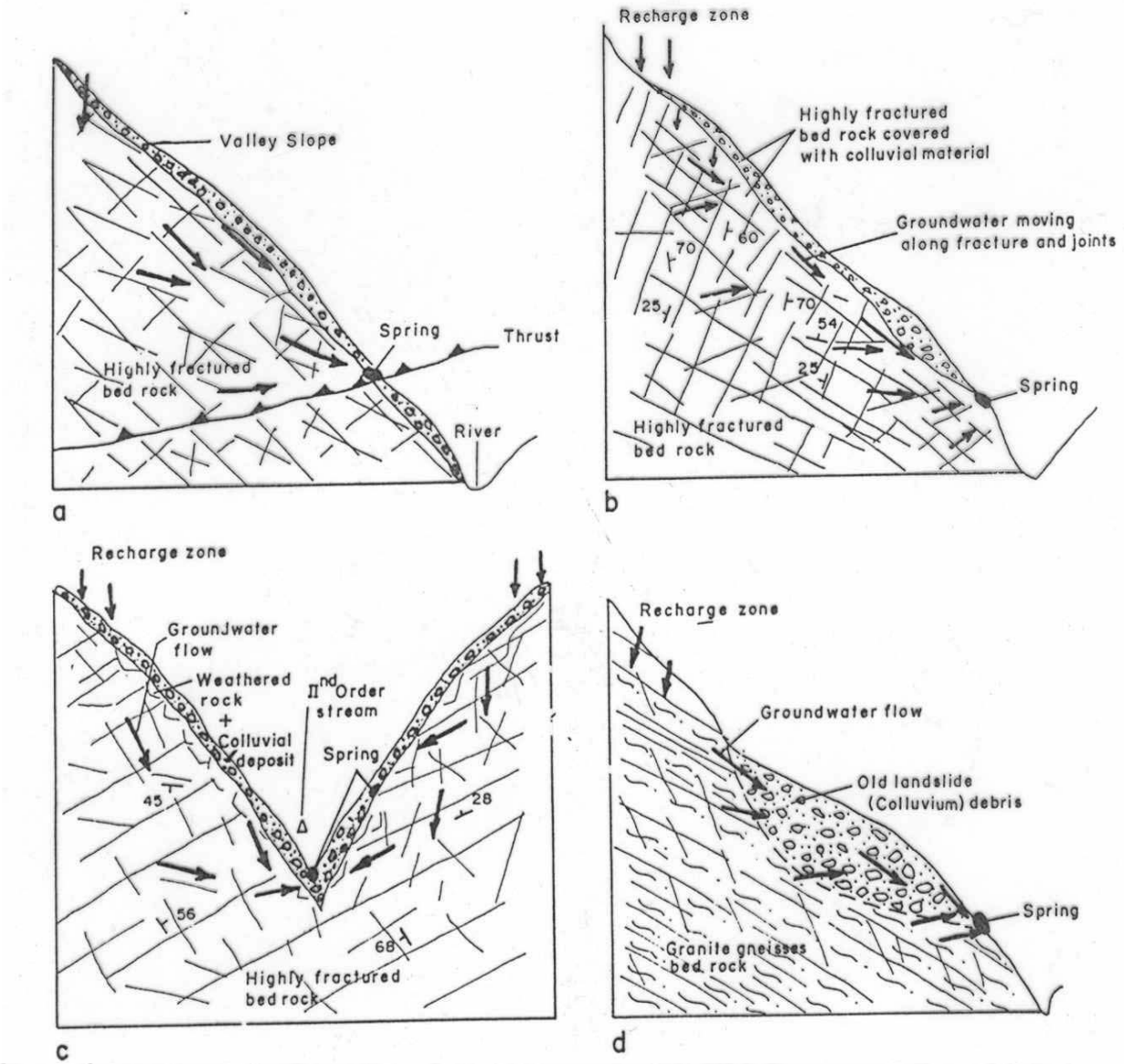
Characteristics of SPRINGS of Sikkim

- Mainly gravity springs are available;
- Springs result from water flowing under hydraulic pressure;
- Two types of gravity springs are available

    a) Depression Spring

    b) Fracture Spring
- Depression springs are formed where the land surface intersects the water level;
- Fracture springs are formed in impermeable fractured and jointed rock strata connecting with ground water supply;

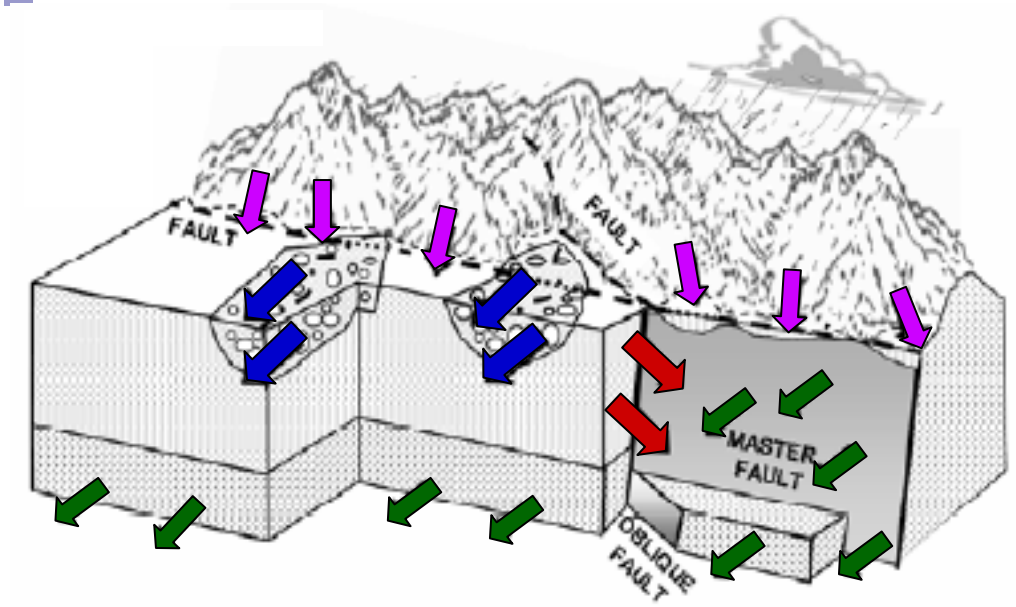
- Structurally weak plains, mainly joints, fractures and small scale faults are good avenues for movement of spring water;
- During monsoon season discharge of the spring increases by 2 to 6 times from that of pre-monsoon;
- Spring discharge decreases during Dec. to April and increases during May to Sept;
- Spring water temp. varies from 11^0c to 24^0c and it is higher in lower altitudes;
- Quality of Spring water is potable for drinking purposes.



. Schematic Section diagram of spring types. (a) Fault - Lineament related spring (b,c) Fracture - Joint related spring (d) Colluvial spring (e) Fluvial related spring (f) Karst spring.

Significance of Springs w.r.t Regional Groundwater Flow Conditions

- Due to high relief and steep gradient GW comes out as seepages and springs, whenever the surface intersects ground water table;
- Due to higher slope most of the precipitation flows off as surface runoff through streams, *kholas,* and intermittent springs;
- Direct infiltration of rainfall through joints, fractures, weathered zones of the rocks and through soil covers is principal mode of recharge of the springs;
- Relatively flat areas on tops of hills and ridges, saddle, spurs form the potential recharge areas;
- Steeper hill slopes dominantly form the areas of spring discharge;
- The movement of ground water in Sikkim is mainly controlled by the structural set up of the area and physiography;

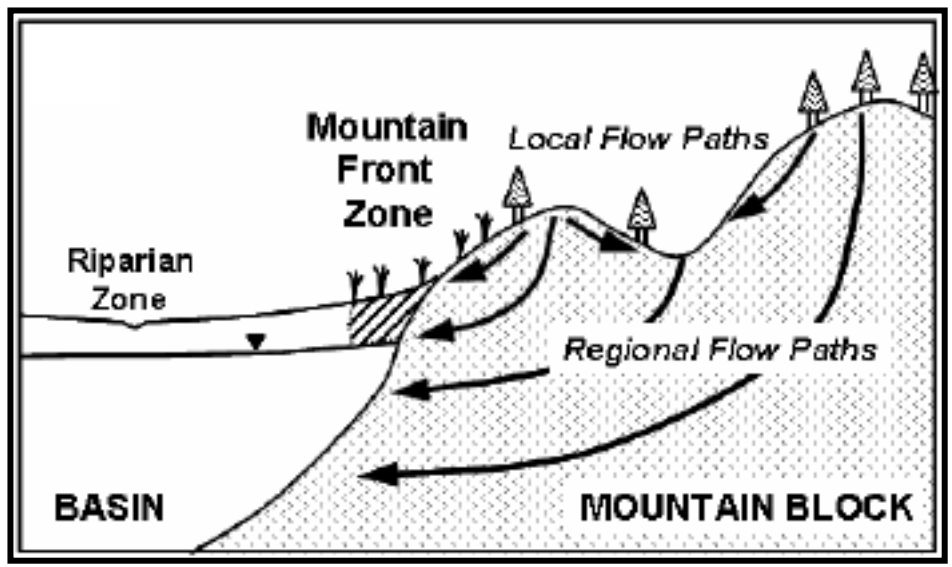


➡ ***FS*** **= focused near-surface recharge**

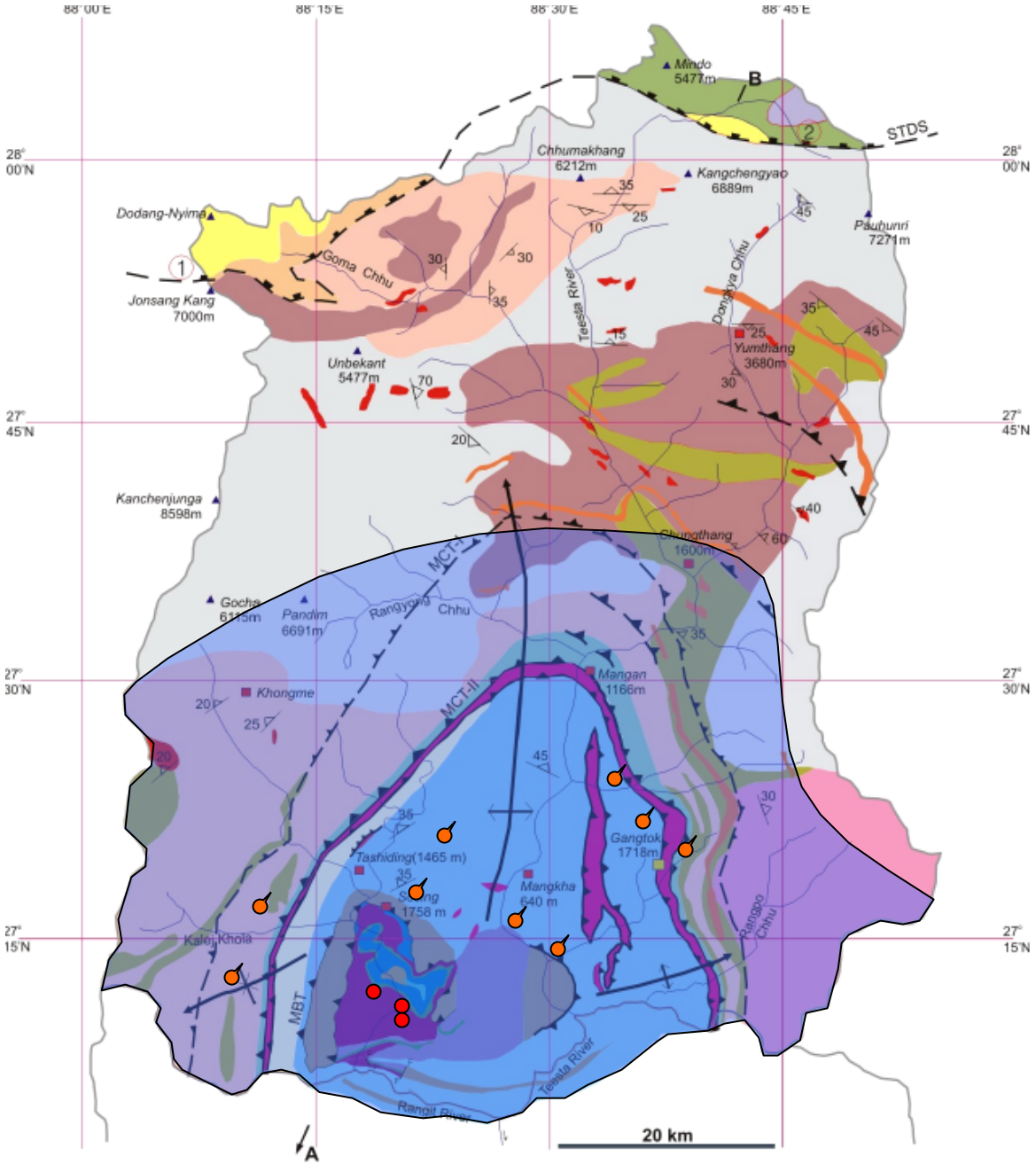
➡ ***DS*** **= diffuse near surface recharge**

➡ ***FR*** **= focused subsurface recharge**

➡ ***DR*** **= diffuse subsurface recharge**



Hydrogeological Map of Sikkim



- Springs
- Exploratory Wells
- Permafrost Area
- Non - Permafrost Area

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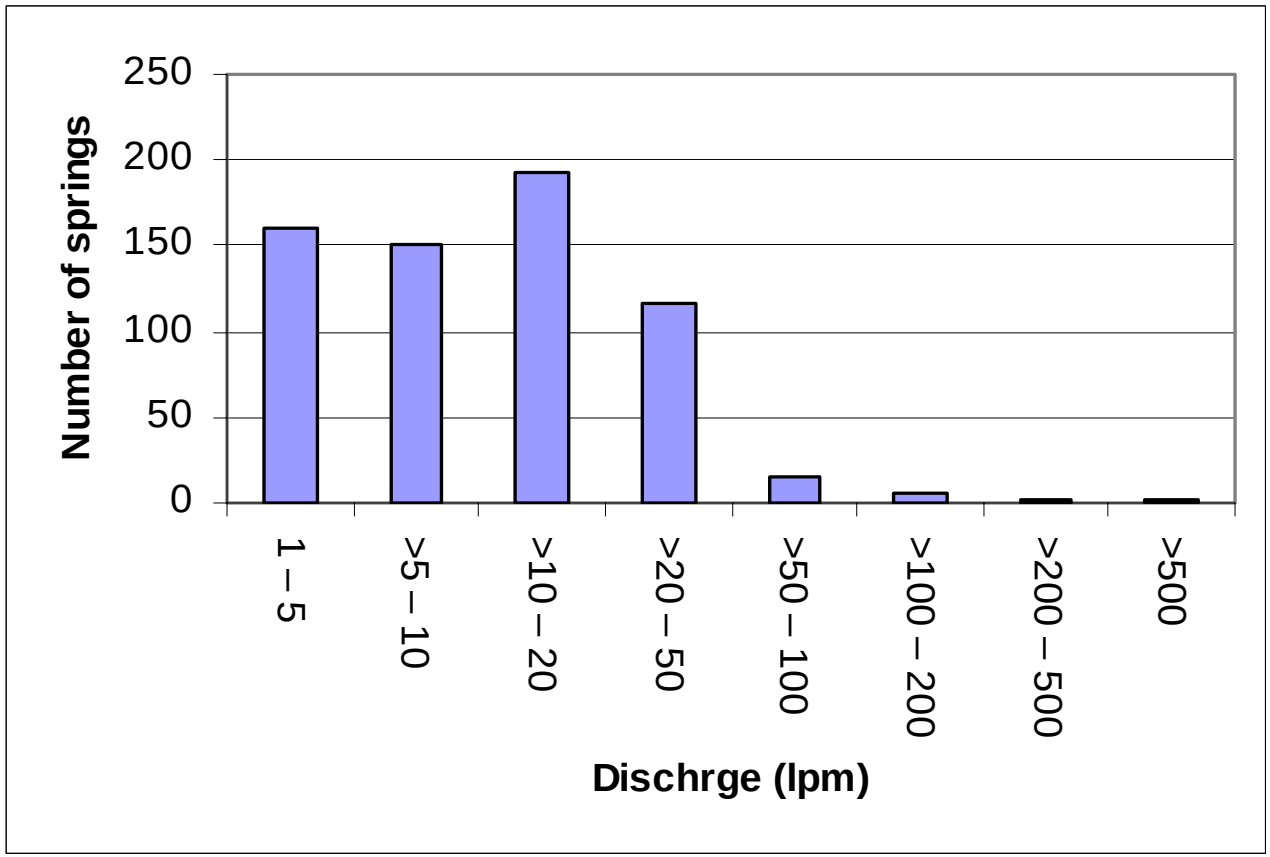
Formation-wise Spring Discharge

ROCK TYPE	ALTITUDE (in m above msl)	DISCHARGE (in lpm)
Lingtse, Chungthang, Darjeeling granite gneiss, biotite gneiss, quatrzite, impure marble, graphitic schist, migmatitic gneiss	**500 - 1000**	**3 – 120**
	1000 - 1500	**2 - 60**
	1500 - 2000	**1 - 60**
	2000 - 2500	**3 – 30**
Dalings Phyllite, quartzite	**300 - 500**	**4 – 24**
	500 - 1000	**1 – 180**
	1000 - 1500	**1 – 120**
	1500 - 2000	**1 – 2100**
	2000 - 2500	**15 – 1800**
Buxa Phyllite, dolomite, quartzite	**1000 - 1500**	**1 – 10**
	1500 - 2000	**1 – 6**
Gondwana Sandstone,slate, pebbly slate	**500 - 1000**	**1 – 120**
	1000 - 1500	**1 – 100**
	1500 - 2000	**1 - 8**

Discharge variation in Springs (West Sikkim)



Physical Properties of few spring water near Gangtok

Physical analysis of water quality of streams and jhoras									
Source Name	Source	Set.	Temp. Ai	Temp. wi	pH	Cond	Sal	Odr.	Cor.
Goshkhan ihora	Spring	12.10(pm)	13.5 °C	*1tC*	5.3	650	0.5 %	Toxic	Blackish
Hospital jhora	Spring	12.20(pm)	10.5 °C	10°C	5.S	300		Toxic	Muddy
Paljor Stadium ihora	Spring	12.10(pm)	17 °C	Wc	5.5	200		Toxic	Yellowish
Fisheries ihora.	Spring	1.00(pm)	15 °C	15°C	5.4	200		Toxic	Darkish
Rani Khola	Stream	1.35(pm)	19 °C	12.5°C	6.1	60	5.3	-	Clear
Adam Pool Khola	Stream	3.10(pm)	19 °C	17'C	6.3	100	5.3	Toxic	Muddy
Source: SPCB, Government of Sikkim									

Chemical Quality of few spring water near Gangtok

Chemical Analysis of Water Quality of Streams and *Jhoras*							
Source Name	**Source**	**D.O**	**D.$C0_2$**	**Cl.**	**Alk**	**Aci.**	**Hard.**
Goshkhan ihora	Spring	5.332	89.34	4.496	201.83	49.67	199.460
Hospital jhora	Spring	8,532	20.66	2.596	118.67	15.17	93.476
Paljor Stadium ihora	Spring	8.132	27.34	1.659	84.67	11.33	68.260
Fisheries ihora.	Spring	8.468	7.34	11.418	72.33	4.33	75.436
Diesel Power House jhora	Spring	7.868	11.34	18.907	58.67	6.83	63.844
Rani Khola	Stream	8.468	4.34	6.624	16.33	1.33	14.164
Adam Pool Khola	Stream	6.868	9.34	8.269	20.67	5.33	12.884
Source: SPCB, Government of Sikkim							

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METAL ANALYSIS

Source Name	Source	Ca	Mg	Fe	Na	K
GJ	Spring	38.613	ND	2.120	51.155	92.902
H.J	Spring	28.320	ND	0.008	35.478	57.322
P.S.J	Spring	22.709	ND	0.179	41. 749	33.603
F.J	Spring	27.118	ND	0.024	37.046	37.556
D.J	Spring	24.713	ND	0.204	28.977	37.556
R.KH.	Stream	4.545	ND	0.139	13.036	9.883
A.KH.	Stream	8.954	ND	10.351	29.868	17.790

Source: SPCB, Government of Sikkim

Compound Analysis

$P0_4$	$N0_3$	SiO_4	T.S	T.D.S	T.S.S
67.101	0.0002	25.252	428.0	332.600	95.400
4.111	0.0154	18.499	455.2	384.200	71. 000
7.921	0.013	11.601	240.2	202.000	38.200
6.542	0.009	10.997	104.7	83.700	20.660
4.195	0.010	12.952	23008.1	22629.500	378.600
0.248	0.001	13.720	563.0	455.600	107.400
2.431	0.003	131. 940	531.6	302.200	229.400

Source: SPCB, Government of Sikkim

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Hot Springs of Sikkim

Sikkim has several hot springs which are known for their medicinal and therapeutic value. The most important hot springs are located at Phurtshachhu (Reshi), Yumthang, Ralang and Momay Samdong. All these hotsprings have high sulphur content and are located near river banks. The average temperature of the water in these hot springs is 50°C.

Major hot Springs of Sikkim

i. Phur tshachhu at Khadosangphug, South/West Sikkim

ii. Ranglop tshachhu at Borong, South Sikkim

iii. Gangyab chhutshen, West Sikkim

iv. Takrum tshachhu, North Sikkim

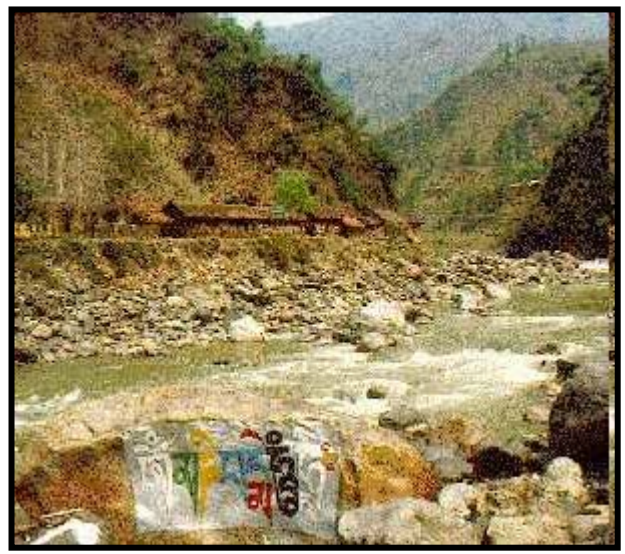
v. Yumasamdong tshachhu, North Sikkim

vi. Yumthang tshachhu, North Sikkim

vii. Zee tshachhu, North Sikkim

viii. Shagyong phedok tshachhu, North Sikkim

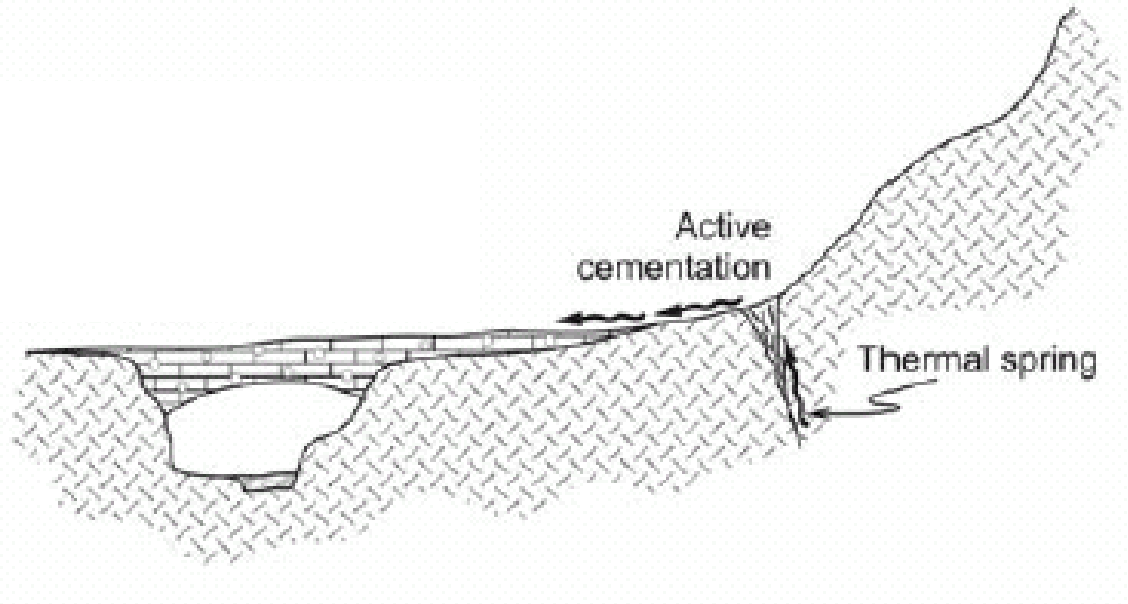
ix. Tholung kang tshachhu, North Sikkim



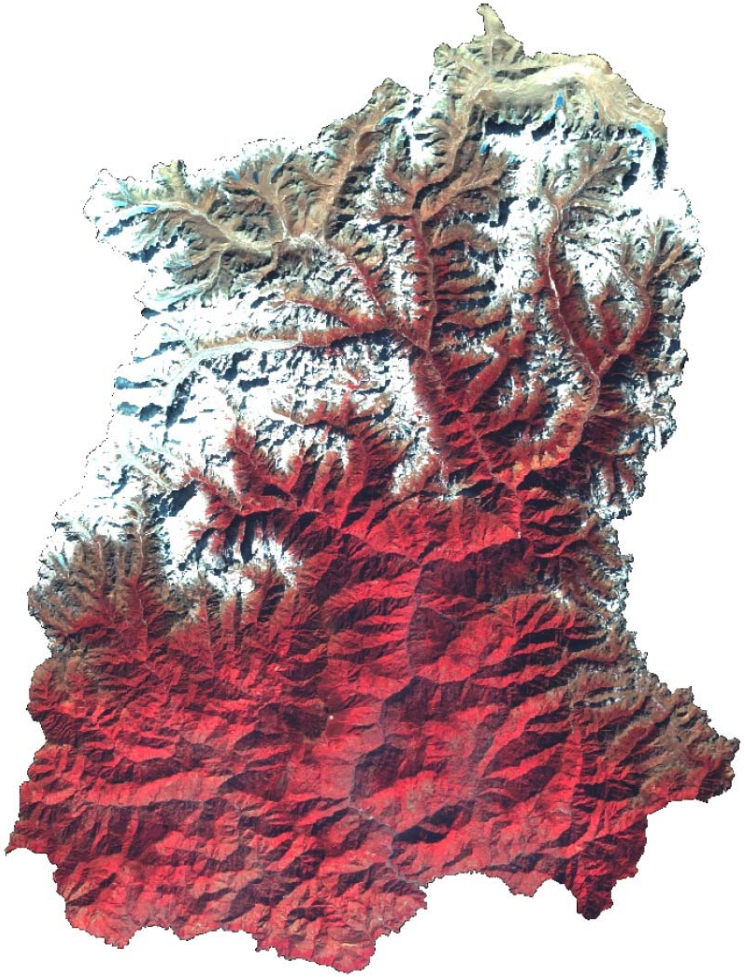
RESHI HOT SPRING

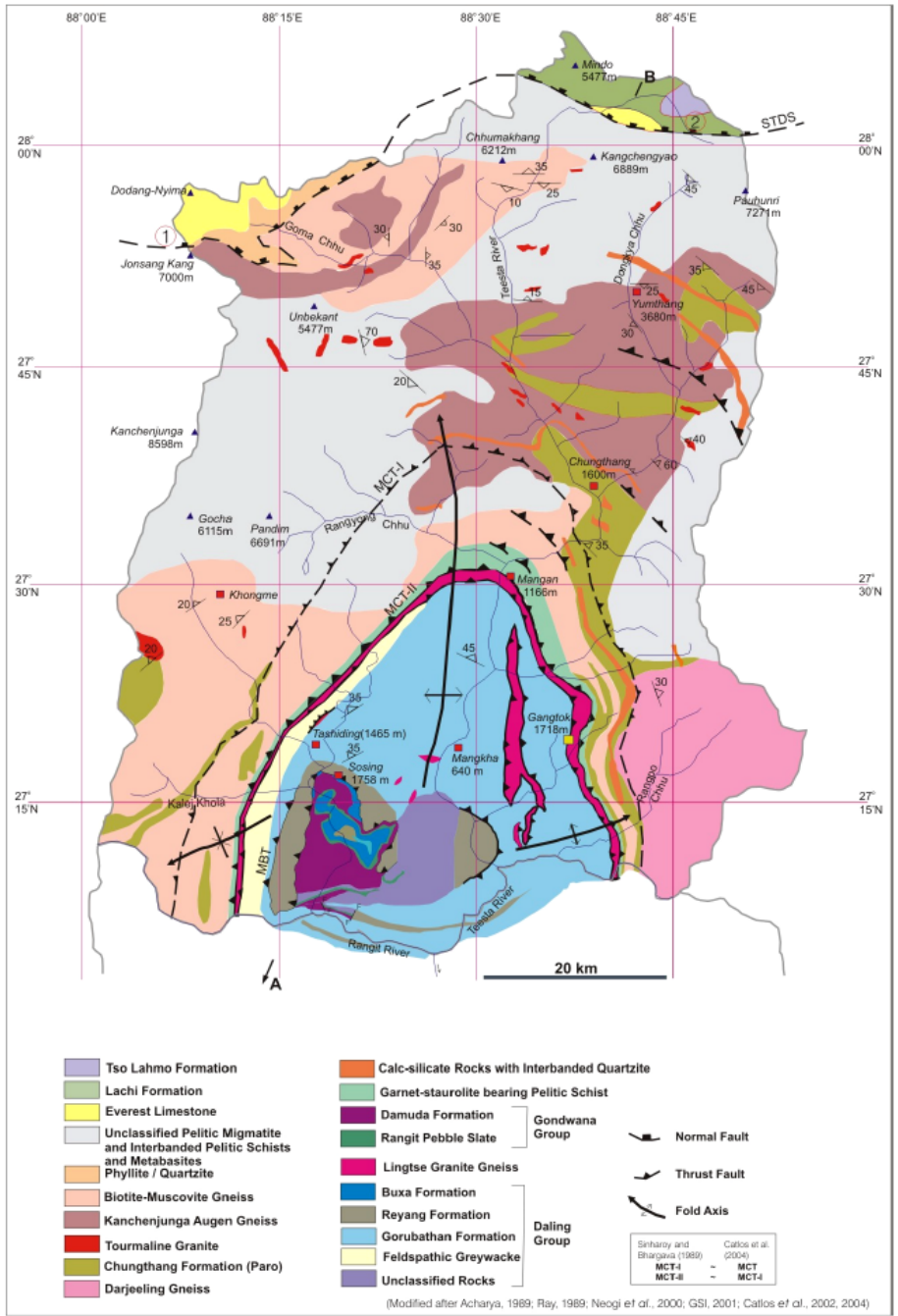
Hot Springs at Ralang region within Rangit Window

- **Hot springs in this region occurs along a NNE-SSW alignment, more or less paralleling the Rangit river course.**
- **Phyllite and quartzite rocks of the Gorubathan Formation belonging to the Daling Group are mainly exposed in the area.**
- **The strikes of the beds are sub-parallel to the river course. The NW-SE and NE-SW alignments of drainage in the region indicate that two distinct sets of shear plane occur in the region. The strike of foliation of the rocks are N40°E to S40°W with dips of 40° towards N60°W. The MBT surface is also folded.**
- **In the area upstream of confluence of Rangit river and Chil Khola, wide-open joints, shear zones and widespread fracturing are observed. These fracture planes reveal that the region was subjected to high tectonic stresses in the past and are indicative of the possible presence of weak zones in the basement rocks.**



Schematic diagram of hot springs





Geological Map of Sikkim

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MONITORING OF THE HOT SPRINGS OF SIKKIM HIMALAYAS

Sl. no	Parameters	Sampling Site				
		I	II	III	IV	V
1	Colour (HazenUnit)	Less than 5	Less than 5	Less than 5	Less than 5	Less than 5
2	Appearance	Clear	Clear	Clear	Clear	Clear
3	Turbidity (NTU)	22	20	15	20	16
4	Conductivity uMHOS/cm	950	980	1000	1000	1020
5	Total dissolved Solids (Dried at 105°C)	280	250	600	580	580
6	Ph	8	8.2	8.5	8	7.6
7	Temperature at source °C	50	40	34	40	35
8	Temperature at bathing pool °C	45	38	32	38	34
9	Dissolved Oxygen mg/I	1.5	4	NO	NO	NO
10	Carbonate hardness as $CaC0_3$mg/1	NO	NO	NO	NO	NO
11	Calcium Hardness as $CaC0_3$ mg/I	NO	NO	NO	NO	NO
12	Chlorides as CI mg/I	7.2	7.0	3.5	3	8.0
13	Silica as $SiS0_2$mg/1	22	26	24	22	14
14	Chromium as C mg/I	NO	NO	NO	NO	NO
15	Fluorides as F mg/I	NO	NO	NO	NO	NO
16	Sodium as Na mg/I	40	44	81.6	85	100
17	Potassium as K mg/I	4.2	4.0	1.5	1.8	1.8
18	Manganese as Mn mg/I	NO	NO	NO	NO	NO
19	Sodium chloride as NaCI mg/I	80	90	100	95	140
20	Nitrates as N mg/I	0.8	0.7	0.3	0.3	0.2
21	Phosphate as $P0_4$ mg/I	ND	NO	NO	NO	NO
22	Sulphates as $S0_4$mg/1	38	41	25	28	20

Source: State of Environment Pollution, Sikkim, 2004

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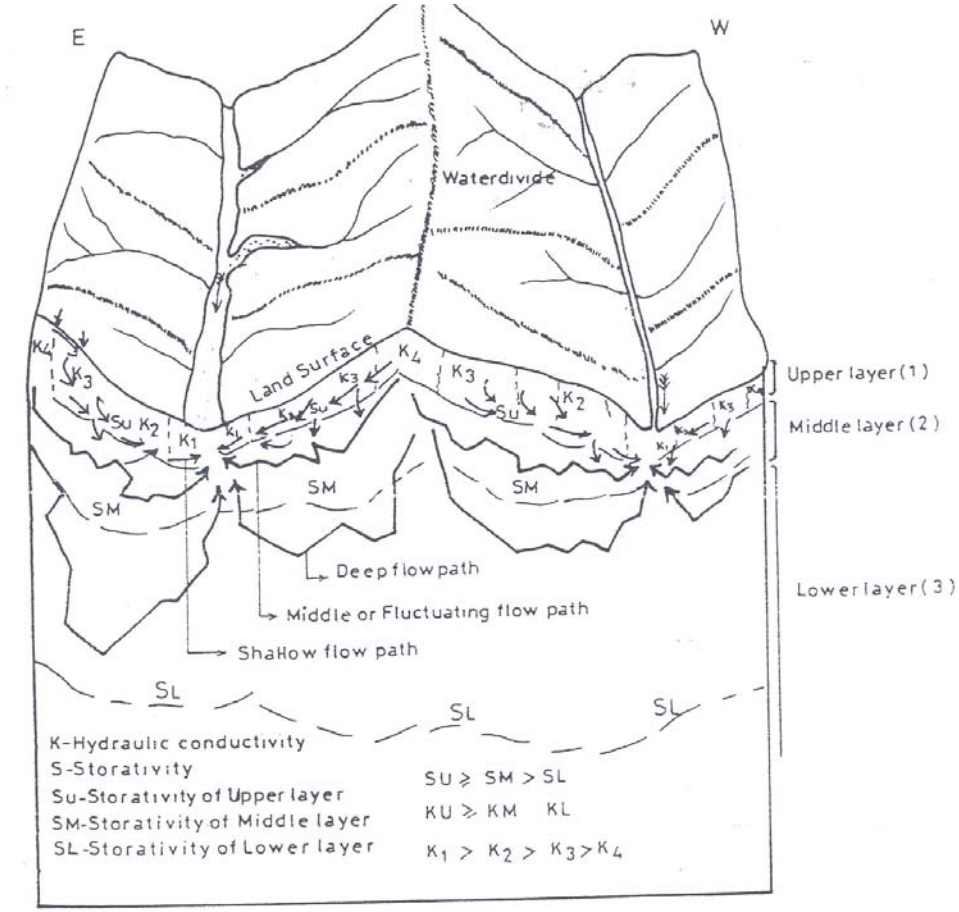
Findings from Groundwater Exploration

(South Sikkim)

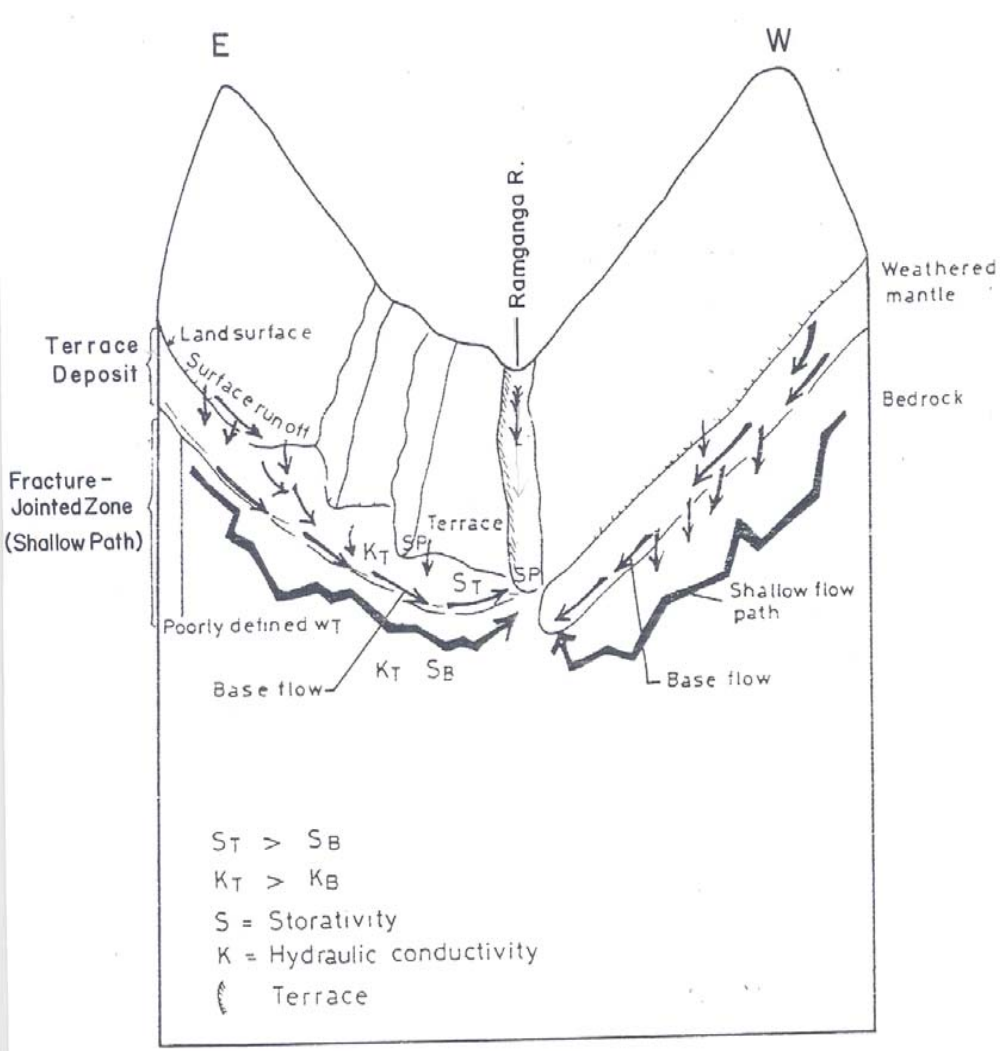
- 6 sets of fractures are encounter within depth range of 10 to 70 m bgl;
- Fractures below 45 m bgl are persistent and regional in nature;
- Many of these fractures are linked with Springs;
- Discharges in Borehole is partly related with Spring discharges;

Spring Flow Model

- Three pattern of ground water flow observed in the area
  - a) Shallow circulation
  - b) Moderate circulation
  - c) Relatively deep circulation.
- In the first pattern groundwater follows shallow to moderate flow paths and hydraulic conductivity is confined to the upper and middle layer eg. springs and seepages
- In the second pattern groundwater follows moderate to deep flow paths and hydraulic conductivity is confined to the middle and lower layer The hot water springs have deeper circulation



Spring Flow Model



- Combination of the flow patterns of the two systems exists in the lower reaches
- This flow pattern are also evident from the water chemistry data. The water from hand pumps / bore well shows relatively higher conductivity, TDS and major ions in comparison to springs present in the close vicinity which have shallow circulation.

Sum up about Springs of Sikkim

- In Sikkim, mountain springs, have been traditionally playing a vital role in providing water security to rural households, hence they have utmost significance in water resource management;
- Maintaining Quality and Quantity (Q & Q) of spring water is of prime imporance;
- Proper scientific study is needed to understand the underlying earth system processes and interactions between various components at wide range of nested temporal and spatial scales;
- Development with the aim of sustainability should be the aim;
- Peoples participation plays pivotal role.