Thursday, 22 March 2018

FINAL EXPEDITION REPORT
Glacier melt and the Ganges River
MEF reference: 17-06

Expedition Leader/Organiser: Alexandra Winter-Billington
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Country/Region: India, Uttarakhand

Names of all expedition members, indicating leader, climbing members, and support:
Leader: Alexandra Winter-Billington
Team members: Michele Koppes, Surendra Badwal, Gajendra Badwal, Ramanchandra Shankar and Argha Banerjee
Support provided by team of 18 local professional porters-cum-cooks-cum-research assistants.

Original objective(s) of expedition –scientific:
Our objective was scientific research of Satopanth bamak (glacier). In particular, we aimed to 1. Carry out ground penetrating radar survey (GPR) of the rock debris that blankets the glacier, 2. Measure the change in glacier surface elevation since our last visit (to determine melt rate), 3. Collect data from instruments that were installed on the glacier in a previous expedition, 4. Move temperature sensors from one location on the glacier to another, to increase the spatial resolution of the dataset and 5. Move four of our 12 rain gauges from the Himalayan foothills onto the glacier to measure the on-glacier precipitation gradient precisely.

Overall dates of expedition (e.g. 'March-June 2015'), showing time spent on approach, climbing, and return:
14 May -15 May: Alexandra and Michele travel from Vancouver to Dehradun.
15 May – 23 May: Apply and wait for Research Permit from Wildlife Warden of Uttarakhand.
23 May -- 25 May: Travel to Badrinath Village; collect camping permits and rain gauges along the way.
26 May: Acclimatise in Badrinath.
27 May: Walk to Kunalin base camp.
28 May – 1 June: Work around Kunalin.

2 June: Walk to Chakra Tith camp.
3 June – 5 June: Work around Chakra Tith area.
6 June: Walk to Satopanth Tal camp.
7 June – 11 June: Work around Satopanth Tal area.
12 June: Walk to Chandra Kund camp.
13 June – 17 June: Work around Chandra Kund area.
18 June: Return to Satopanth Tal.
19: June: Work near Satopanth Tal.
20 June: Return to Chakra Tith.
21 June – 22 June: Work near Chakra Tith.
23 June: Return to Kunalin.
24 June – 25 June: Work near Kunalin.
26 June: Return to Badrinath Village.
27 June – 30 June: Travel back to Vancouver.

Details for each route climbed or attempted:

Walk to Kunalin base camp; 3176 – 3997m; 8.79km; 27 May; Grade: F; hiking; not first ascent; successful; high point reached: 3997m; weather: fine; Michele Koppes, Surendra Badwal, Gajendra Badwal, Ramanchandra Shankar, Argha Banerjee and Sourav Laha

Walk to Chakra Tith camp; 4152m; 5.36km; 2 June; Grade: F; hiking; not first ascent; successful; high point reached: 4152m; weather: light rain; Michele Koppes, Surendra Badwal, Gajendra Badwal, Ramanchandra Shankar, Argha Banerjee and Sourav Laha

Walk to Satopanth Tal camp; 4360m; 2.47km; 6 June; Grade: F; hiking; not first ascent; successful; high point reached: 4360m; weather: fine; Michele Koppes, Surendra Badwal, Gajendra Badwal, Ramanchandra Shankar, Argha Banerjee and Sourav Laha

Walk to Chandra Kund camp; 4574m; 2.93km; 12 June; Grade: F; hiking; not first ascent; successful; high point reached: 4574m; weather: fine; Michele Koppes, Surendra Badwal, Gajendra Badwal, Argha Banerjee and Sourav Laha

Swagarohine (bottom of neve); 4797m; 1.98km; 16 June; Grade: F; hiking; not first ascent; successful; high point reached: 4797m; weather: fine; Michele Koppes, Surendra Badwal, Gajendra Badwal and Argha Banerjee and Sourav Laha

Final Report:

The purpose of this expedition to Satopanth bamak in the Garwhal Himalaya was to collect data for research into the melt rate and meltwater discharge from debris-covered glaciers to the Ganges River. My academic Supervisor, Professor Michele Koppes, and I are working in collaboration with Professors Banerjee, Shankar and Nainwal from research institutes in India who have an established research station at Satopanth.

Rock debris accumulates on the surface of many Himalayan glaciers from failure of the surrounding steep mountain peaks and valley walls. The rate of tectonic uplift is very high and therefore the erosion rate is high. It is also likely the rate of supra-glacial debris accumulation is increasing with climate change because the retreat of glaciers is exposing valley walls that were previously buttressed by the ice, as well as moraines from past ice ages, so the source area for loose debris has increased.

The rock debris on glaciers can be as fine as a few millimetres or as thick as a few meters, and that makes an enormous difference to the total amount of energy that gets to the ice and melt it. To estimate the meltwater contribution to the Ganges, scientists need to know how thick the supraglacial debris is, but it is extremely difficult to estimate the debris thickness because it changes over very small spatial scales and its thickness is not expressed in any way on the surface. Our work is focussed on characterising the thickness distribution of debris on Satopanth bamak and related to measured rates of energy delivery to the ice, melt rates and meltwater discharge.

Our expedition to Satopanth bamak to collect research data was a complete success. We carried extensive scientific equipment including a Ground Penetrating Radar (GPR) as excess baggage and it was no great surprise that its delivery from the airline was delayed in transit through Germany and Indian Customs and Security. It was released to us only one day after our arrival, though, in perfect condition. Carrying the equipment as excess baggage was inexpensive by comparison with the quoted cost of freight in both dollars and time and our experience confirms that it is an efficient way of transporting scientific equipment internationally and to India specifically.

From Delhi we travelled by air to Dehradun in the Himalayan foothills, which is a lovely city and the location of the Chief Wildlife Warden (CWW) of Uttarakhand, whose permission we required for carrying out research on the glacier. This required a translator – although very many people in India speak English, the staff at the Wildlife Office spoke Hindi and we were not able to communicate with them directly. We met first with the CWW and were given forms to complete and submit in application for a permit. The CWW (Mr Negi) was highly amenable and efficient and we received the permit within seven days of submitting the application to his office.

In Dehradun, we were able to purchase most of the supplies we needed – such as copper wire for lightning rods, batteries, a spare ice axe (surprisingly, given it is a gateway to the Himalaya, we found only one outdoor shop catering to climbers in Derhadun, but they were well fitted out), tools and more. The only items we fund completely unavailable were pitons, guywires and the tripod needed for an auxiliary weather station; the rechargeable 12V batteries we were able to obtain were old and we would have been better buying them in Delhi in retrospect. We ordered the tripod online from The Virtual Electronics Company in Haridwar and it was delivered to the taxi company we were using by recommendation from our collaborators, Combined Tours and Travels, in Derhadun. To tie the tripod down, we had to improvise a bolt system that would stand in place of guywires, and make do with the few pitons we had brought from Canada.

While in Dehradun, we emailed ahead to our tour operator in Joshimath who applied for and obtained our camping permits in advance. Camping permits are required from the local Wildlife Warden, who is based in Joshimath. We hired the local tour operator Eskimo Travels to obtain permits on our behalf which was very efficient; sadly, the owner of Eskimo Travels has since passed away.

Travelling by taxi from Dehradun to Srinagar and Srinagar to Badrinath ensured our safety as well as efficient transport of the equipment. We were told the roads in Uttarakhand are the most dangerous in India, in terms of bandits. We spent one day acclimatising in Badrinath. I ate a banana on the trip from Srinagar, thinking only the outside of uncooked food would carry unfamiliar bacteria. I was wrong, so unfortunately, along with final preparations and packing, much of my day in Badrinath was spent in bed with a stomach bug.

Our collaborators have a long-term scientific research station at Satopanth bamak and they have two full-time logistics support people, Surindra and Gudju, who arranged a team of porters, cooks and assistants on our behalf. In total, we hired ten porters and two porters-cum-cooks, as well as six porters-cum-assistants to help with data collection. Due to the traffic of tourists, porters and porters-cum-cooks are readily available for employment from Mana and Badrinath Villages. Mana and Badrinath are seasonal villages catering to the traffic of tourists and there is plenty of accommodation in Badrinath for visitors. Many of our porters were Nepali and did not speak English, but they were highly experienced and communicating with them was not difficult. They were very strong, hard-working men and were a pleasure to travel with. Their labour is extraordinarily cheap for the work (around CA$10/day/porter); we also paid them tips because they worked extremely hard.

Badrinath and Mana were cool, and quite chilly overnight, but a comfortable temperature for hiking up the valley to Satopanth bamak. There was some light rain on the walk in, and light snow early in the trip, but typically the mornings were clear and a light rain would set in around 1-2pm.

Satopanth bamak is regularly accessed by religious pilgrims and tourists because it is a sacred site in the Hindu faith (Swagarohine literally means “Stairway to heaven” in Hindi, and is the route Krishna took to ascend to heaven), and as part of the ongoing scientific research program. There are two main routes from Mana Village to the toe of Satopanth bamak that are foot-worn by the traffic of tourists, which is intensive all summer, as well as local, traditional agriculturalists. There is also a military base in Mana and military exercises are sometimes carried out in the Alaknanda nadhi (river) valley (we passed by a military cricket tournament on our ascent).

The two routes to the toe of Satopanth bamak follow the true left and true right of the Alaknanda nadhi. Neither route is challenging; they follow gentle slopes and the valley is well sheltered.

However, there are rock fall, flood and landslide hazards along both routes that are most severe during the monsoon and spring snow melt seasons but exist year-round. During monsoon 2017, subsequent to our expedition, the bridge crossing the proglacial stream from Bangnyu Bamak was washed out during a flash flood (and has now been replaced). Local guides know the area and its hazards very well, we were very well advised by them with respect to the safety.

The route following the true right (south bank) of the Alaknanda is more hazardous than the other because the path cuts into a steep valley wall that is undercut by the river in some places whereas the route on the true left follows a gentle river terrace. But, the route via the true right is better for accessing the three primary tourist campsites that lead to Swagarohine (Chakra Tith, Satopanth Tal and Chandra Kund).

Campsites at Chakra Tith, Satopanth Tal and Chandra Kund are frequented by pilgrims and tour groups, and are spaced at perfect elevations for acclimatisation. There are roofless shelters at Chandra Kund and Chakra Tith, one additional closed shelter at Chandra Kund, and a number of closed shelters at Satopanth Tal. There is another campsite at Kunalin, at the confluence of Satopanth and Bhagirath Kharak, that was established as part of the scientific project headed by Professors R. Shankar and H.C.Nainwal. It is not used by pilgrims or tourists as I understand it and access to it would best be arranged through Prof's Shankar or Nainwal.

The route via the true left of the Alaknanda is better for access to Kunalin (we ascended via this route and descended by the other), but, to then gain access to Chakra Tith requires crossing Satopanth proglacial stream (which is doable but not straightforward) or the glacier above the proglacial outlet.

Streams supply fresh water to the camps at Chakra Tith, Satopanth Tal and Chandra Kund, although they are seasonal. The small stream at Chakra Tith was nearly dry during our trip since the previous winter's snow had all melted. At Satopanth Tal campsite, water is generally collected from the tal (lake) that is around 20m directly below the campsite. We drank water untreated from the streams at Chakra Tith and Chandra Kund, but always boiled water we drank from the tal; none of us were unwell on the expedition although that does not mean the streams are reliably sanitary.

Mostly, ablutions are conducted on the ground surface in unofficially designated spots. At Chakra Tith, this is between two large boulders directly behind the open-topped shelter at the bottom (northern) corner, at Satopanth Tal it is behind boulders on the north-east of the terrace the campsite is on, and at Chandra Kund it is behind a boulder at the bottom of the hillslope in the southern corner. At Kunalin, semi-permanent long-drops are maintained by the logistics support team to the scientific project. At the other camps, we dug small holes for solid waste. The ground is moraine gravel and difficult to dig. Locals do not use toilet paper, which is advisable as it must biodegrade very slowly in the holes and unless very well covered, could provide food for rodents.

The glacier itself is covered by a thick landslide-debris carapace that we think is up to 4m thick in places. Walking across it is more like boulder hopping than glacier travel, and the challenges it presents are somewhat different to debris-free glaciers. The gradient of the surface is very low on average, but picking a route through the supraglacial ponds and ice-cliffs that outcrop from the debris would be very difficult without an experienced guide – it would be very easy to lose your track and waste daylight hours searching for a way through the hummocky topography. The ice-cliffs are susceptible to collapse and there is thermo-karst erosion of ice channels that are invisible from the surface but present a hazard. Having said that, our guides knew exactly where to take us, to access the campsites and to access the parts of the glacier we needed for our research.

There is a path from Kunalin behind the Little Ice Age moraine at least half way up the debris-covered area of the glacier that, we were told, leads to a cave that is permanently occupied by a holy man. That path is lovely, but runs below a very high cliff that clearly fails sometimes and the risk of being hit by a falling rock is probably quite high; I would not want to take that path again in hindsight and would not recommend it.

Our collaborators have on automatic weather station (AWS) installed at the toe of Satopanth and on a previous expedition we set up a second one near the centre of the glacier at the elevation of the tal (lake), but with only one tripod it was too heavily laden with

instruments and we needed to set up a second tripod and rearrange the instruments. The weather stations were (and are) logging measurements of air temperature, relative atmospheric humidity, air pressure, incoming and outgoing solar and longwave radiation, wind direction and wind speed. With those measurements we are able to calculate the energy balance at the glacier surface, which can then be related to the measured ice melt rate. We installed 12 rain + temperature gauges in the valley leading from Srinagar to Mana on a previous trip, which we collected on the way up on this trip for re-deployment in the glaciated valley itself, to derive a high-resolution precipitation lapse rate in order to calculate the energy supplied to the glacier by rain as well as the quantity of snowfall in winter. On the previous expedition we also installed soil temperature probes in pits dug into the rock debris overlying the glacier ice, to measure the transfer of heat from the surface to the ice and on this trip we moved them to new locations to sample a wider range of debris thicknesses and sedimentary characteristics.

The most time consuming and labour intensive activity, though, was using the GPR. GPR measures the return time of radar waves transmitted into the ground from the surface, which can be used to glean insight into subsurface material properties. Our purpose was to measure the thickness of the debris. Using first 100MHz and then 1000MHz transmitters, the GPR has multiple components connected by delicate wires and our assistants were required to lift, carry and replace, lift carry and replace every two meters along a total of twelve transects across the glacier width. Back-breaking work! They were absolute champions and the dataset is priceless.

There are many fascinating areas of potential research in the valley, some of which will no doubt be conducted by the existing research team. These include the impact of the supraglacial debris on the hydrological system of the proglacial stream; quantification of debris supply to the glacier by different processes; temporal evolution of the surface topography; the rate of paraglacial relaxation of the glacier valley; high resolution variation of surface albedo; isotopic trace analysis of hydrological components; temporal evolution of the glacier drainage system; the cultural impact of glacier retreat on the local population and tourist population; temporal trends in flash flooding of the Alaknanda and its tributaries; variation of the sedimentological regime of the Alaknanda with glacier retreat and geomorphological implications; the cultural or spiritual impact (if any) of scientific field work on a site of cultural and religious significance.

To the best of my knowledge, locally generated rubbish and sewerage is disposed of directly into the Alaknanda River or piled high and burned. Neither option is satisfying for those of us accustomed to having rubbish removed from our field of view, but it is how rubbish disposal is organised in this locale. Many locals and tourists walking the paths around Satopanth leave rubbish where it falls; we carried ours back to Badrinath to at least minimise our disturbance to the immediate environment, in full knowledge that it was nevertheless destined for the river. I am aware there is a cultural shift taking place in India and (arguably) more environmentally sound methods of rubbish disposal are becoming more widespread.

The Google Earth images we accessed for this trip were more than adequate and we did not notice any inaccuracies.

SUMMARY FINAL ACCOUNTS

INCOME

FROM	TO	AMOUNT (CA$)
Alex Winter-Billington	NA	500.00
Michele Koppes	NA	1,000.00
National Sciences and Engineering Research Council of Canada (NSERC)	Prof. M. Koppes	9,903.42
Government of India Grant	Prof. R. Shankar	4,289.41
Mount Everest Foundation	A. Winter-Billington	2,292.12
TOTAL		**17,984.95**

EXPENDITURE

CATEGORY	DATE	PAID TO	FOR	AMOUNT	
				IRP	CA$
Transport	02/02/2017	Indian High Commission to Canada	Research visas, Michele and Alex		310.00
	12/05/2017	Air India	Argha flight Pune-Derhadun return	6,569.00	
	12/05/2017	Spice Jet	Shankar flight Chennai-Dehradun return	14,320.00	
	12/05/2017	Flight Network	Alex, Michele return flights Vancouver to Delhi		3,290.00
	14/05/2017	World Nomads	Travel insurance		732.00
	14/05/2017	Yellow Cabs	Taxi from home to airport Alex		60.60
	14/05/2017	Yellow Cabs	Taxi from home to airport		54.00

			Michele		
	14/05/2017	Delta Airlines	Excess baggage Vancouver to Delhi		1,420.00
	17/05/2017	MakeMyTrip India	Flight Delhi- Dehradun	12,600.00	
	17/05/2017	Delhi airport	Parking	100.00	
	24/05/2017	Dehradun taxi driver	Dehradun - Srinagar - van	15,000.00	
	06/06/2017	Badrinath taxi driver	Mana to Joshimath for petrol	2,000.00	
	14/06/2017	Badrinath taxi driver	Mana to Joshimath for petrol	2,000.00	
	18/06/2017	Badrinath taxi driver	Mana to Joshimath for rain gauges	2,000.00	
	26/06/2017	Badrinath taxi driver	Mana to Srinagar - van	15,000.00	
	27/06/2017	Combine Tour and Travel	Taxi van Dehradun to Srinagar return	41,689.00	
	28/06/2017	Spicejet	Flight Dehradun to Delhi	3,326.00	
	28/06/2017	Dehradun taxi driver	Taxi to airport	1,500.00	
	28/06/2017	Spicejet	Excess baggage Dehradun to Delhi	2,400.00	
	29/06/2017	Michele	Excess baggage - return Delhi to Vancouver with GPR		1,250.50
TRANSPORT TOTAL				**118,504.00**	**5,866.60**
Porters, food, camping and permits	22/05/2017	Wildlife Warden Office, Uttarakhand	Chief Wildlife Warden Research permit fee	13,000.00	
	25/05/2017	Eskimo Adventure	Camping permits and service fee	10,280.20	
	26/06/2017	Porters	Alex, Michele and equipment to Kunalin	3,000.00	
		Porters-cum research assistants	Wages for 6 assistants	225,000.00	

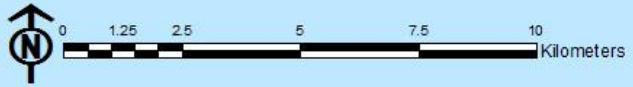
	26/06/2017	Surendra	Total food - us and staff	23,041.20	
	26/06/2017	Surendra	1/2 wages and tips for 10 porters and two cooks, tips for Gudju and Surendra	135,850.00	
TOTAL CAMPING EXPENSES				**410,171.40**	
Reusable equipment	20/05/2017	Sorya	Lightening rod	885.00	
	20/05/2017	Arora	Gionee mobile phone	2,300.00	
	20/05/2017	Ludhiana Power Tools	Reuseable hardware	11,804.00	
	26/05/2017	Argha Banerjee	Tripod and its delivery	15,500.00	
TOTAL REUSABLE EQUIPMENT				**30,489.00**	
Wages for rain gauge maintenance man	26/05/2017	Gudjendra Tiwari	Rain gauge maintenance	40,000.00	
TOTAL WAGES				**40,000.00**	
Consumable equipment & supplies	21/05/2017	Cona	Consumable hardware	2,480.00	
	21/05/2017	Marketing profile	Internet and printing	1,590.00	
	04/06/2017	Parvat filling station	Petrol	361.85	
	04/06/2017	Surendra	Batteries	420.00	
	06/06/2017	Surendra	Petrol can	80.00	
	06/06/2017	Surendra	Petrol	730.00	
	14/06/2017	Surendra	Petrol	1,091.28	

TOTAL CONSUMABLES				**6,753.13**	
				IRP	**CA$**
GRAND TOTALS				**605,917.53**	**5,866.60**
TOTAL EXPENDITURE					**17,984.95**

PLEASE NOTE:

The NSERC grant to Prof. Koppes is allocated by her discretion for her research projects including other graduate student projects. Funds specifically granted for this campaign were used for it and the NSERC grant to Prof. Koppes covered the shortfall. We did not go into profit.

Unofficial routes and campsites in the upper Alaknanda and Satopanth valleys



Background image Aster GDEM V0.2
Source: NASA/METI/AIST/Japan
Spacesystems, and U.S./Japan ASTER Science Team (2009).
ASTER Global Digital Elevation Model [Data set].
NASA EOSDIS Land Processes DAAC.
doi: 10.5067/ASTER/ASTGTM.002

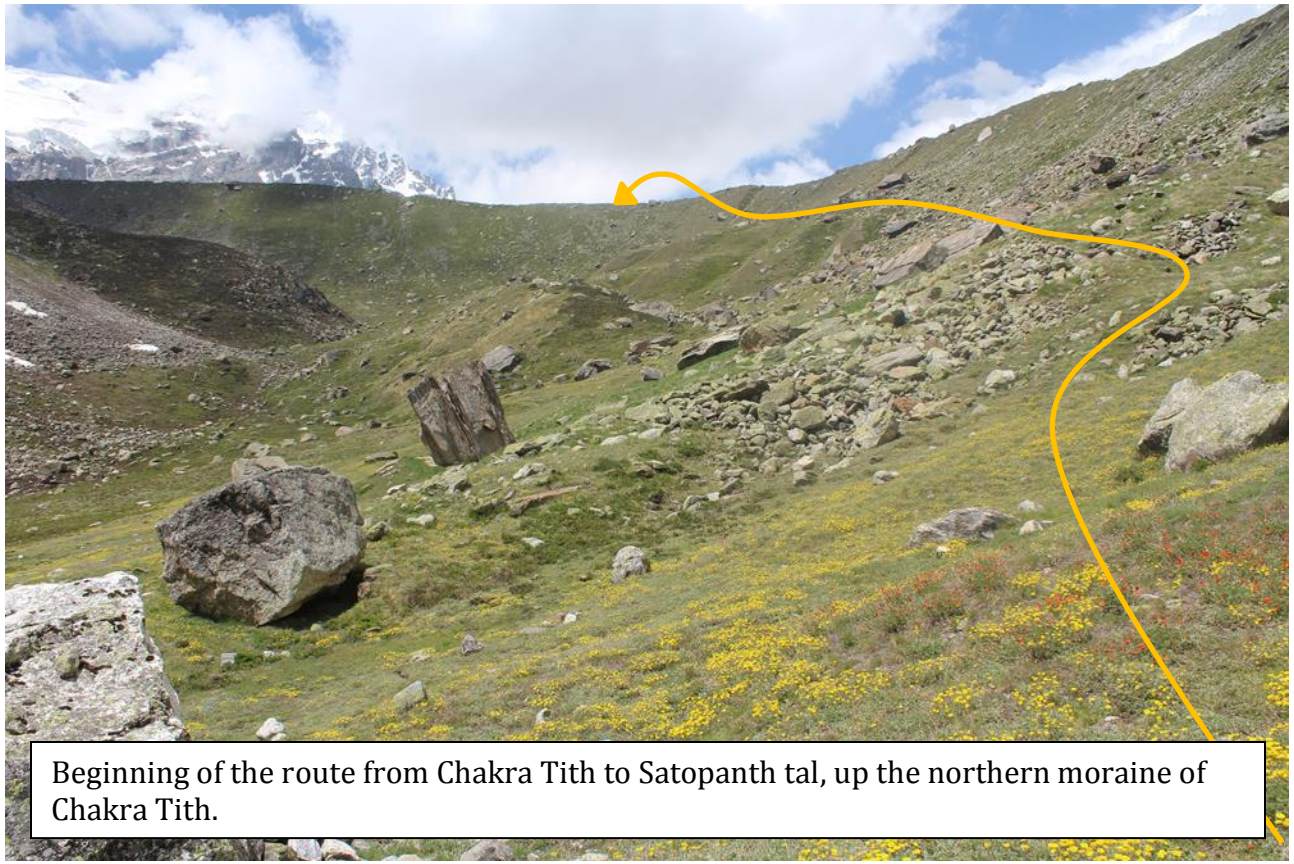
Legend

- Campsite
- Our route to Swagarohine
- Route true right
- Route true left
- 500m contours
- Approximate glacier outline

A “sketch” of the area and the routes we took.

Route along Alaknanda river terrace on true left of the valley.

Route across the glacier from Kunalin to get to the trail on the true right of the glacier to access Chakra Tith.



Beginning of the route from Chakra Tith to Satopanth tal, up the northern moraine of Chakra Tith.

Route from Chakra Tith moraine, across tributary, to Satopanth tal.

Route from northern Satopanth tal moraine to Chandra Kund, and from Chandra Kund to Swagarohine (the icefall).

Satopanth bamak terminus, adjacent to Kunalin campsite behind the moraine on the right of the photo.

An example of the ice cliffs and ponds that pepper the debris-covered area of the glacier.

Digging holes in the debris to measure its thickness!