The melting of the Siachen glacier

Siachen (5Q131084), the 74 km long valley glacier is located in the eastern Karakoram region of northern Ladakh, India (Figure 1). This is the largest glacier in the Karakoram and second largest glacier known outside the polar and sub-polar regions. Siachen lies between the Saltoro Range immediately to the west and the main Karakoram Range to the east (Figures 1 and 2). It ranges from an altitude of 5753 m (18,875 ft) above sea level at its source at Indira Col (pass) on the Indo-China border, to its snout at 3620 m (11,875 ft) in the Nubra Valley, northern Ladakh. In Survey of India Toposheet No. 52 E, it is situated[1] within the coordinates 35°12′–35°41′N and 76°47′–77°11′E. The word 'Siachen' ironically means 'the place of wild roses' or specifically refers to the thorny wild plants which grow on the rocky outcrops near the snout. The melting waters of the glacier are the main source of the Nubra River, which drains into the Shyok River of northern Ladakh. The Shyok in turn joins the Indus River; thus the glacier is a major source of water for the Indus.

In 1821, Moorcroft reported for the first time the existence of Siachen glacier in the Karakoram region. It was Strachey[2] who stepped on the Siachen glacier in 1848 and later Drew in 1949. Subsequently, Ryall from the Survey of India sketched the lower part of the Siachen glacier in 1861 and estimated its length as 16 miles. In 1909, Longstaff[3] alongwith Neve and Lt. Slingsby were the first to traverse the length and breadth of the Siachen glacier. They further established the size of the glacier up to the Turkestan La, its northern limit[4].

The global climate change has a significant impact on the high mountain environment. The Himalayan glaciers are in the state of general retreat[5] since 1850 and the average air temperature of the Himalayan region[6] has risen by 1°C since mid-1970. The trend in the recession of the Himalayan glaciers is expected to continue this century[7–10]. The Himalayan glaciers are retreating faster than glaciers in other parts of the world[11]. Because of climatic and topographical factors, the rate of recession and amount of volume change are irregular for glaciers across the Himalayan arc[12].

The 74-km-long Siachen glacier is an example of the nature and size of glaciers that must have once existed in the Himalaya towards the end of the Last Ice Age[1]. In 2005, the WWF[13] warned that the Himalayan glaciers, which regulate the water supply to the Ganges, Indus, Brahmaputra, Mekong, Thanlwin, Yangtze and the Yellow rivers, are believed to be retreating at a rate of about 10–15 m (33–49 ft) each year. The concern over the melting of the Siachen glacier and its melting process have classified it amongst the fastest receding glaciers in the world[14]. Its retreat is evident from the snout (base of the glacier) and through the continuous thinning of ice along its entire length. According to Hasnain[14], the melting of ice in the Siachen glacier is accelerated by military presence from both India and China. If the region is not demilitarized now, the glacier will vanish by 2050. According to Taylor[15], however, glaciers are growing in the Himalayan Mountains, confounding global warming alarmists who have recently claimed that the glaciers are shrinking and that global warming was to blame. Researchers have found that cooler summers are failing to melt winter snows, which are themselves becoming more frequent, resulting in advancing ice sheets[15]. Similarly, Raina and Sangewar[1] observed that the snout front of the Siachen glacier from AD 1862 till date has revealed that there may have been a rapid advance of 700 m or so between 1862 and 1909, which was subsequently neutralized by relatively faster retreat between AD 1929 and 1958. The Siachen glacier along its snout front has since been in 'rest mode' or with very low or practically nil retreat, and one cannot expect any sensational retreat in the future, unless a catastrophic climatic change takes place[1].

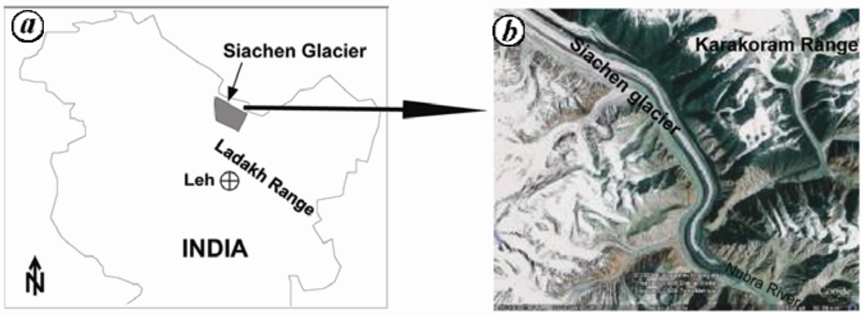

Figure 1. ***a***, Location of the Siachen glacier in northern India. ***b***, Satellite image of Siachen glacier, Nubra Valley and adjoining Karakoram Range (source: Google Earth).

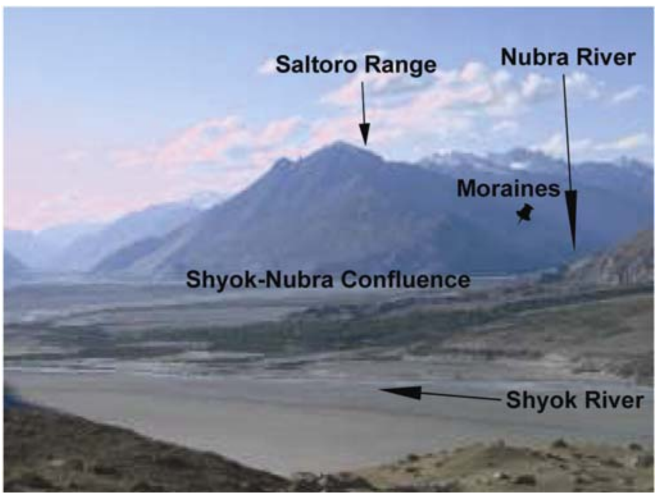

Figure 2. Confluence of Nubra–Shyok rivers and Saltoro Range in northern Ladakh.

Figure 3. Very thick and well-preserved lateral moraines and erratics resting over Saltoro Molasse near the village of Charasa and Burma, located along the right bank of Nubra River.

Figure 4. Rouche montanees and polished surfaces between the villages of Murgi and Charasa on the right bank of Nubra River.

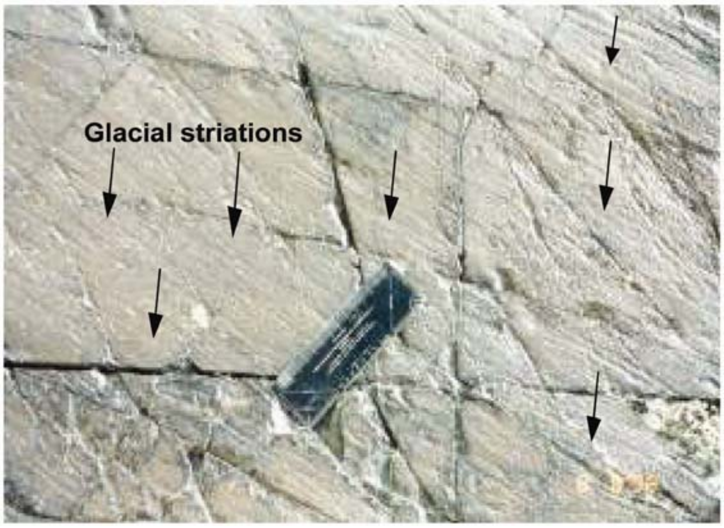

Figure 5. Prominent glacial striation marks are well preserved on the sandstone of Saltoro Molasse as seen between the villages of Charasa and Burma. This location is about 75–80 km south of the present snout of the Siachen glacier.

Whether the Himalayan glaciers are retreating/advancing or are in 'rest mode', it is a well-known fact that the last glacial period ended more than 8000 years ago and its effects can still be felt today. The typical geological evidence for ice ages comes in various forms and features left behind by the glaciers, e.g. moving-ice carved-out landscape, including rock scouring and scratching, glacial moraines, drumlins, valley cutting, deposition of till or tillites and glacial erratics, etc.

During four exploratory geological excursions in 1995, 1996, 2002 and 2008 in the Nubra–Shyok river valleys and the adjoining Karakoram Mountains, the present author came across some exciting geological evidences which suggest that (beginning of inter-glacial period) the extent of the Siachen glacier was once more than 150 km long, and extending at least up to the Nubra and Shyok river confluence point in the Nubra Valley, northern Ladakh (Figures 2–6). This is evident by the fact that the entire Nubra Valley is witnessing the presence of various glacial landforms, including moraines spread all along the valley. The perched of glacial moraines and erratics can be seen along a straight line within the walls of the valley up to a height of 600 m above the present valley floor of the Nubra River (Figure 3). The volcanic and volcano-sedimentary rocks exposed around the villages of Burma, Charasa and Tircha are carved out as rouche montanees along with polished surfaces (Figure 4). Prominent glacial striation marks on the outcrops of sandstone of the Saltoro Molasse, exposed between the village of Charasa and Burma, located near the Nubra–Shyok confluence (Figure 5), further testify that these bedrocks were once overlain by a thick cover of Siachen glacier. Similarly, between Sasoma and Changlung, a large hump of old morainic material could be observed, as if representing the glacier front of the present snout of the Siachen glacier (Figure 6). Thus all these evidences suggest that once in the Holocene period the entire Nubra Valley, which is more than 150 km long, was filled up by at least 600 m thick ice cover of the Siachen glacier. According to Raina and Sangewar[1], the present length of the Siachen glacier is 74 km. This suggests that since past inter-glacial period, the Siachen glacier has receded more than half of its original length or at least about 76 km. Keeping in mind the critical positioning of the

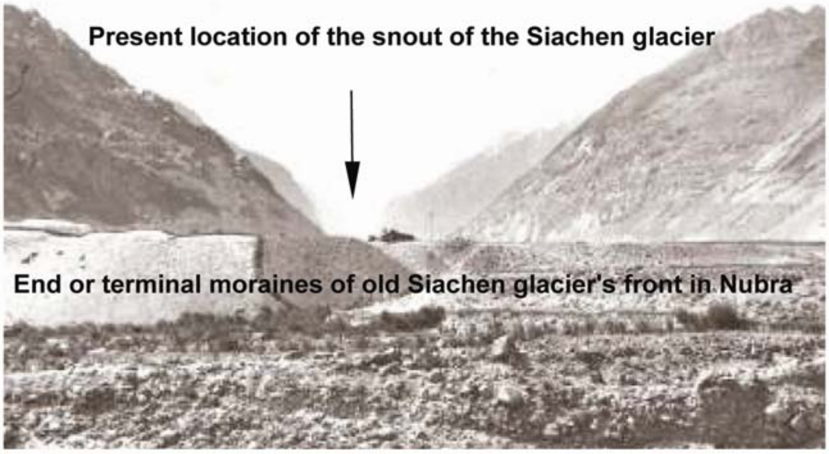

Figure 6. Photograph showing a thick accumulation of end or terminal moraines of the snout front of the Siachen glacier, formed sometime during the inter-glacial period, as seen between the villages of Sasoma and Changlung in the Nubra Valley. The present snout of the glacier is situated about 40–45 km north of this point.

Siachen glacier between North India, Central Asia and the adjoining Tibetan Plateau, further detailed multidisciplinary work is required to understand the periodicity of advance/retreat or 'rest mode', if any, of the Siachen glacier since the beginning of last inter-glacial period. Thus a well-constrained palaeoclimatic data-based model would definitely help towards better understanding the climatic change vis-à-vis monsoonal variation in the Indian subcontinent, Tibetan Plateau and adjoining Central Asian region.

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Present state of the three tidal inlets of the Pulicat Lake: facts from remote sensing and field surveys

A recent scientific correspondence in these columns noted with concern that one of the tidal inlets of the Pulicat Lake has been considerably narrowed, which could be detrimental to the lake[1]. But a more recent satellite image of the area, which is presented here, does not indicate any reason for raising such an alarm. Our intention is to provide a realistic picture of the conditions prevailing at the Pulicat Lake, based on the remote sensing image analysis and more importantly, enquiries in the field.

The Pulicat Lake is the second largest coastal lagoon after the Chilika Lake along the east coast of India. The lake appears to have occupied a natural depression bound by major lineaments on its three landward margins[2], while on the east, a prominent barrier spit (linear shore-parallel sand bank deposited by wave/longshore current activity), known as the Sriharikota Island (where the satellite launching station is located), separates it from the sea (Bay of Bengal). The lake spreads over an area of about 620 km^2 (measured within its boundary traced from the topographic maps), excluding the 120 km^2 area of numerous islands that lie in it[2]. Out of the total area of the lake, about 360 km^2 in the southern part is active, whereas the rest of the lake area in its northern part is desiccated due apparently to tectonic upliftment, which is evident from the displacement of subsurface sediment sequences of recent origin[3]. At present, the northern part of the lake appears more or less like a mudflat (Figure 1 *a*) with a thin water column, if any, especially during the monsoon.

The Pulicat Lake is connected to the sea through three tidal inlets, one each at Tupilipalem, Rayadoruvu and Pulicat villages respectively, from north to south (Figure 1 *a*). The inlets near the first two locations enter the northern part of the lake, while the third one is at the extreme southeastern end of the lake. We present