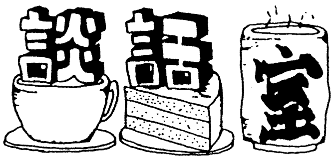

Avalanche Issue in Western Himalaya, India

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> Himalaya, having vast adornments, including gems, has only one blemish — avalanches. Though, even this stain is imperceptible among other values, as spots on the Moon do not reduce its shining light. . .
>
> Meghadūta, the Cloud Messenger
> (Kalidasa, ～500 AD)

Introduction

Avalanche research in the Indian Himalaya began because of the Sino-Indian Border Conflict (1962), a war between China and India. Crises in the 1960-s on the border with China and Pakistan had revealed an incredible vulnerability of military troops to avalanche hazards. Problems of survival in avalanche prone areas faced by the Armed Forces, literally reminded the Indian government about a fact: that enormous areas of India were affected so heavily by snow and avalanches (that was not considered before as an important issue). To combat this hazard and to enhance socio-economic growth of snowbound regions, later on, in 1969 a special organization was founded — *Snow and Avalanche Study Establishment* (or SASE), under the *Defense Research & Development Organization* (or DRDO). It had been started as a humble camp of tents, but soon turned into a large, world-known research facility with a number of buildings, observatories, laboratories, conference auditorium hall and helipad (Fig. 1), now which is issuing avalanche warnings for the region and conducting avalanche and snow research in Himalaya. Exactly this organization hosted the International Symposium on Snow and Avalanches 2009 (ISSA '09) (6–10 April 2009), the first ever IGS symposium in the Himalaya and in India (refer to some photo-highlights of the ISSA'09 at the Photo Studio of Snow and Ice Section —雪氷写真館— and the symposium section —シンポジウム報告— at the present issue, p. i-ii and p. 485–494).

The main conference hall for ISSA'09, Siachen Auditorium (Fig. 1), was named after the Siachen glacier, which symbolizes specifics of SASE research work. The 1984 Indian Military attack operation "*Meghdoot*" (name of a poem written by one of the greatest Sanskrit poets - Kalidasa), took place here over disputed with Pakistan territory, which is considered to be the world's highest battlefield (>6000 m; lasts for more than 20 yrs; death toll: 3,000–5,000 lives) at the Siachen Glacier (India largest, and world's second largest glacier outside of the polar regions, l=73 km, 541.7 km^2, 108.3 km^3, average annual retreat 5 m yr^{-1} (Raina and Srivastava, 2008, p. 71), Eastern Karakoram (33 km from the "K2")).

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Fig. 1 SASE HQ, Manali (the main conference hall — Siachen Auditorium is in the center of this panoramic photo). For more details about the deeply rooted meaning of the word “Siachen” refer to McGirk and Adiga (2005).

Indus River derives its runoff from this glacier. India has built here the world’s highest helipad (6400 m) to support permanent military personnel. Due to high average annual snow accumulation at high altitudes (10 m; Bhutiyani, 1999) and severe weather (minimum temperature −40℃; Bhutiyani, 1999) many Indian soldiers were killed by avalanches (*Avalanche Atlas,* 1991), thus reconnaissance, observational (at 8 stations), mapping and avalanche-triggering work of SASE was necessary at the Meghdoot area (1984–1987). Thanks to these manned observatories mass-balance studies were performed through 1986/87–1990/91 and described by Bhutiyani (1999). Interesting, that only for Karakoram region (in contrast to the Greater Himalaya) for 1984–2008 cooling trend by 3.0℃ was observed (Shekhar *et al.,* 2009), and that during the last 100 yrs. the Siachen glacier was retreating at a higher rates only in 1950-s (Raina and Srivastava, 2008, p. 205), when global temperature anomaly was negative (but according to another source, 914 m retreat was during 1929–58; Vohra, 1981).

Avalanches in Indian Himalaya

The idea for the IGS symposium in India can be illustrated without any comments by avalanche statistics in Asia. It is estimated, that about 10% of Asia is affected by avalanche activity (Akif’eva *et al.* 1992) and according to

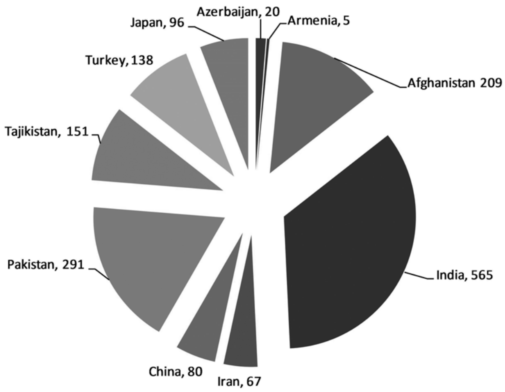

Fig. 2 Number of people killed by avalanches by countries in 1995–2006, Asia (data was extracted from Troshkina *et al.,* 2007; Podolskiy, 2009; Prof. K. Izumi (personal communication, 2009).

Troshkina *et al.* (2007), from 1995 through 2006 the largest number of avalanche accidents occurred in India, where in total more than 565 people were killed. Such a tragic figure makes India the unhappiest World leading country by number of deaths in avalanches (Fig. 2).

For a period 1971–2005 (only since 1970/71 have systematic records been started (Ganju *et al.,* 2002)) the estimated average annual death rate in India was equal to 49 persons a year, though even this figure is underestimated, due to a lack of communication and security factors (in general, reliability of statistical data from India is a hard question, for example, many births and deaths go unregistered, as well as marriages and divorces; after *Statesman's Year Book 2009*). The avalanche areas of India lay along the northern part of Himalayan states, namely: Jammu and Kashmir (or J&K, the most vulnerable state), Himchal Pradesh (or HP), Uttarakhand (or Uan, formerly Uttaranchal), and Sikkim. Total population of these states composes about 2.2% of India's population (25.23×10^6), accordingly, a smaller number of people live in avalanche prone areas (estimation based on *Statesman's Year Book 2009*). Moreover, Gunju *et al.* (2002) suggested that due to population growth and increasing number of activities in the Himalayas, the total number of avalanche accidents in the area should be growing as well. (2008 estimate population of India is 1.14bn - 2nd largest, 1/6 of world population. It is expected that by 2050 India would have a population of 1.66×10^9, and that it would overtake China as the world's most populous country around 2025. Density: 349 persons km^{-2} - larger than in Japan. In 2005, 52% of the population was aged under 25. Number of illiterate adults: 257 $\times10^6$ or 22.5% of all population; one-third of world number (after *Statesman's Year Book 2009*)). According to the same authors (Gunju *et al.,* 2002) the largest number of accidents occurs on the Greater-Himalaya range, the Pir Panjal range and in the Karakoram. In only three states, J&K, HP and Uan, there are 216 settlements and 11 major roads under avalanche prone slopes (*Technology Focus,* 2009). During the last decades the following winter seasons had maximum annual avalanche casualties in the Western Himalayan region of India: 1978/79–***285*** (plus hundreds of cattle and large property losses), 1982/83–***233,*** 1986–***60,*** 1987/88–***326,*** 1997/98–***69,*** 2001/02–***49,*** 2004/05→***230*** (Fig. 3; *OCHA Situation Report,* 2005; *Avalanche Atlas,* 1991). It is interesting to note, that the highest value of the death toll (326, 1987/88) is followed by the only registered positive mass-balance year at the Siachen glacier (hydrological years 1988/89; Bhutiyani, 1999). According to Gunju *et al.* (2002) one third of the total number of killed people were soldiers, about one third of avalanche accidents occurred in March (Fig. 4), and 46% of avalanche accidents were caused by heavy snowfalls. The latter phenomenon has extreme intensities — for example, during the avalanche disaster at the end of Feb 2005 in state J&K (Poonch and Anantnag districts) at the meteorological station of the Avalanche Forecast-

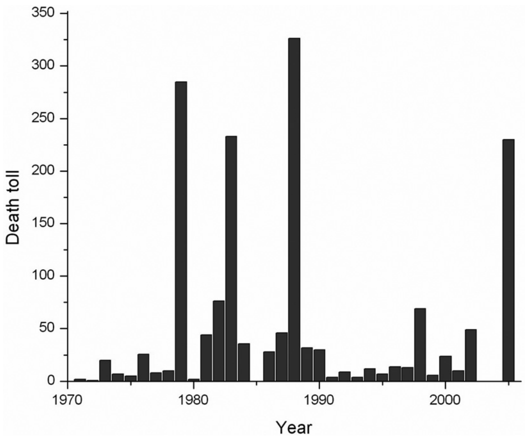

Fig. 3 Annual deaths in avalanches in the Western Himalayan region of India for 1970/71–2004/05 (data was extracted from Ganju *et al.,* 2002 and *OCHA Situation Report,* 2005).

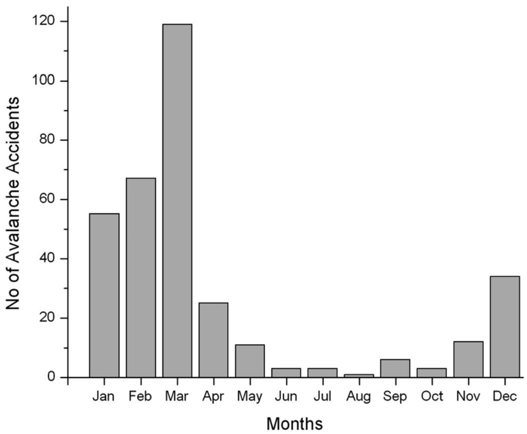

Fig. 4 Monthly distribution of avalanche accidents in the Himalaya (adapted from Ganju *et al.,* 2002).

ing Center at Srinagar (1587 m a.s.l.) about 4.5 m of snowfall precipitation was observed; it is estimated that the junction of Hindukush, Karakorum and Western Himalaya gains a total annual precipitation of 2650–3000 mm (after Troshkina *et al.,* 2007, and Winiger *et al.,* 2005) (though it decreases significantly in the Karakoram Range; on the Upper Himalayan range there is no liquid precipitation). To wrap up this section, it is interesting to remind ourselves, that in Sanskrit the word "*Himalaya*" means "*abode of snow*" and thus once again proves, that it was a great idea to hold the symposium in such an appropriate and fascinating place on the planet — beautiful, but hard and challenging for its people and researchers. For general information about avalanche climatic zones in Western Himalaya refer to Sharma and Ganju (2000).

Snow and Avalanche Study Establishment

Indian national safety and necessity to patrol and control situations at the border with Pakistan 12 months a year determined a need to keep major roads trafficable for the Army (mainly the highway connecting Leh with Srinagar and Leh with Manali). The initial function of SASE, minimization of snow avalanche hazard on these highways (11 major roads) and providing operational mobility for troops, has grown significantly and presently includes all kinds of research work. Namely: avalanche mapping (eg. *Avalanche Atlas,* 1991, for major roads and op. "Meghdoot" Area, GIS-based Avalanche Atlases), acquiring nival- and meteo-data (there is a 43 Automatic Weather Station network in operation in the north-western Himalayas with satellite relaying of data; up to an altitude of 6,500 m; started in 2002), high altitude manned observatories (52) in 3 states, avalanche forecasting (issuing bulletins, live broadcast), designing avalanche control structures (snow fences/nets/bridges, deflecting dams, snow galleries, jet roofs and etc.), artificial triggering of avalanches (explosives, thrown from helicopter or delivered by wire; guns; bombardment; hand bazooka; by helicopter air pressure and etc.) and other investigation work related to snow physics/mechanics/hydrology, de-icing of roads and etc (e.g. there is a cold laboratory (from 1990), a wind tunnel, a snow chute for avalanche dynamics studies (from 2002; see Fig. 6 at the symposium section —シンポジウム報告— of the present issue p. 485–494), an X-ray microtomography facility for a reconstruction of 3D snow microstructure (since 2008), terrestrial laser scanner and a MODIS Earth Receiving Station for snow cover mapping) (*Technology Focus,* 2009; *Souvenir,* 2009).

Moreover, SASE organizes regular training of troops on avalanche safety and rescue (besides, it uses 3D terrain visualization center to familiarize soldiers and personnel with avalanche prone areas), participates in the Indian Antarctic program (since 1996), and has an information exchange agreement with Cold Regions Research and Engineering Laboratory (or CRREL), USA (since 2007). Presently SASE has 2 main centers: headquarters in Manali and a Research and Development Center in Chandigarh (from 1996). Also it is worth noting that, snow & meteorological data for this inaccessible part of the world, which is possessed and produced by SASE, should be called unique, and that before ISSA '09, SASE has already held 5 national and 3 international workshops. As of now SASE has a 40-year history and about 90 employees. For more details about the Establishment and its work, refer to a special SASE publication, prepared on the occasion of the ISSA '09, and containing a welcome message to participants from the President of Republic of India, *Pratibha Devisingh Patil,* and other highly ranked Indians (*Souvenir,* 2009; or *Technology*

Focus, 2009).

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