Snowpack characteristics found in Hakuba, Northern Alps, Japan

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Abstract: Snowpack properties aiming at avalanche safety for backcountry recreations were investigated at Hakuba, NORTHAN ALPS, JAPAN. Snow profile results of this study (total 111 pit), which was from December 1999 to March 2002 at Hakuba region delineated the following snowpack characteristics for that region.

- Maximal snow-depth is around 4m and maritime characteristics predominate.
- Although the most commonly identified weak-layers consist of large new snow crystals without rime, on a relative scale the grains are not so large (2-3mm) size, and layers not so weak.
- Surface hoar and faceted crystals near the snow surface are rare.
- Rains in high winter is not uncommon and often results in a hard layer (pencil or higher) and weak bond interface with new snow layers.
- In areas of shallow coverage due to wind transportation often caused by strong seasonal Northwest winds, depth hoar growth is prevalent near the ground. Also a tendency for rapid change was also seen between wet grains to depth hoar and back.

Keywords: snow cover structure, snow cover distribution, avalanche, JAPAN NORTHAN ALPS

1. Introduction

In Japan, it has become popular to enjoy winter back country recreations in recent years, and possibility of avalanche accidents by them rise. In the country, the snowpack characteristics aiming at avalanche safety for backcountry recreations are largely unknown, and this is mainly due to the fact that there are no avalanche programs which utilize modern snow-profile assessment techniques. It is a purpose of this study to find snow-pack characteristic in Hakuba for avalanche safety.

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2. Study area

The mountain area known as HAKUBA is located in the Northern end of the NORTH ALPS of JAPAN and covers an area roughly 20 by 15 km. This area is located in approximately 20km with distance in a straight line from the Sea of Japan, and heavy snowfall is brought by moist northwest seasonal wind. By the abundant snow and the steep terrain, the region is the most popular mountain resort area in the country. It boasts six 2000+ meter peaks (highest is 2900m), over 10 ski resorts and was location for many of the 1998 Winter Olympic Games. In Hakuba Avalanche victims recorded from the period from 1957 to present are 41.

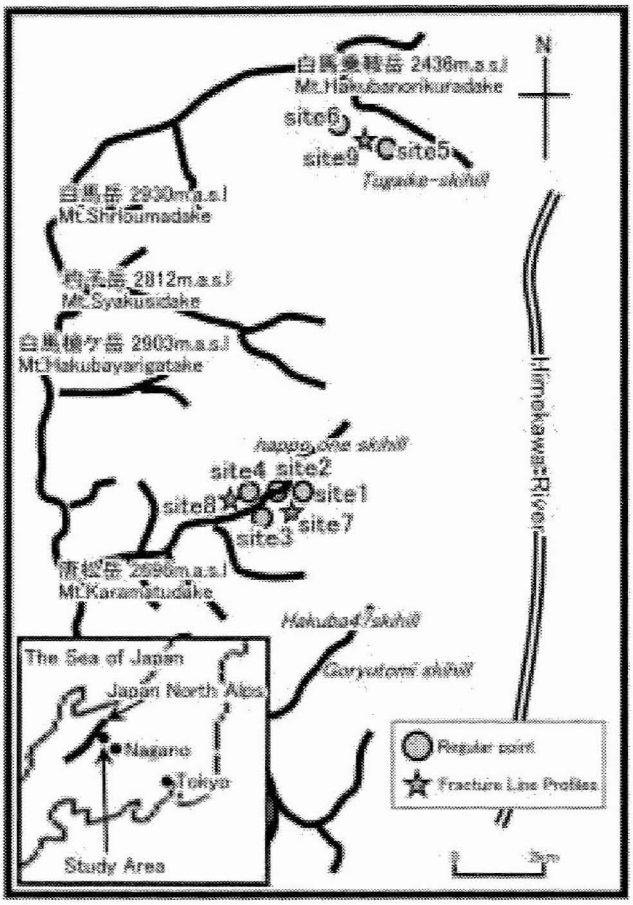

Fig.1: Study area map

3. Method

At 6 fixed point and 3 avalanche fracture line, totally 111 pits were dug (fig 1, table 1). Each pit was dug to 150cm from the snow surface to the ground. The grain shape, grain size, hand hardness and snow temperature (every 0.1m) were measured. Shovel compression test or shovel shear test was used to measure strength of weak layer or weak interface. All data are observed following "CAA Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches". Snow height was measured just snow pit (collapsible avalanche probe was used when over 150cm), and it was not measured using the snow stake on fixed point. Thereof the data of snow height include some error by a difference of an observation point so that 2-10m move every time.

Table 1: Observation site

	Aspect	Elevation	Slope(°)	Observation type	Period	Attributes	No. of data
Site1	S	1350m	20-30	Regular	00-01	Lee side of Happouone ridge. No trees.	15
Site2	E	1650m	0	Regular	99-00	Flat land on Happouone ridge. No trees.	9
Site3	S	1850m	20-30	Regular	01-02	Lee side of Happouone ridge. No trees.	12
Site4	N	1850m	20-30	Regular	00-02	Windward side of Happouone ridge. No trees.	22
Site5	SW	1650m	20-30	Regular	99-02	Flat land on Fir and Mt.birch forests	38
Site6	SW	1900m	20-30	Regular	99-02	Timber line	12
Site7	S	1690m	38	Fracture line	02.1.6	Lee side of Happouone ridge. No trees.	1
Site8	NE	1900m	30	Fracture line	00.2.23	Windward side of Happouone ridge. No trees.	1
Site9	SW	1700m	30	Fracture line	01.2.25	Fir and Mt.birch forests	1

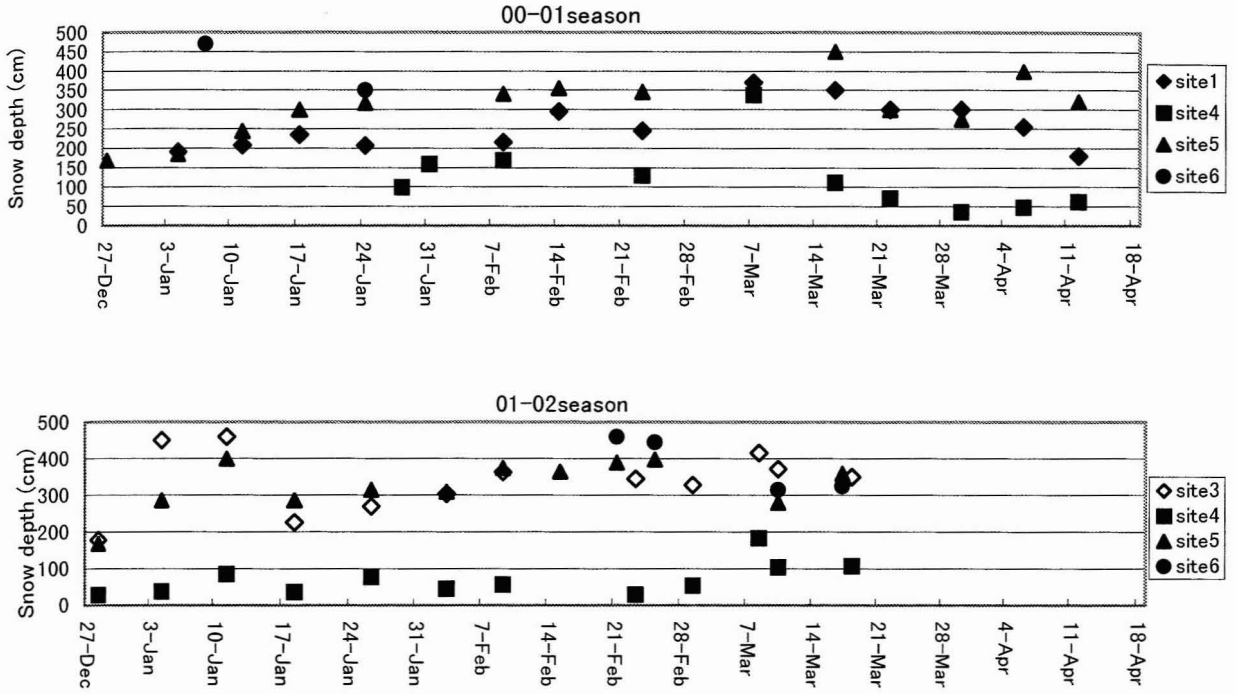

Fig. 2: Snow depth in 00-01and 01-02 season

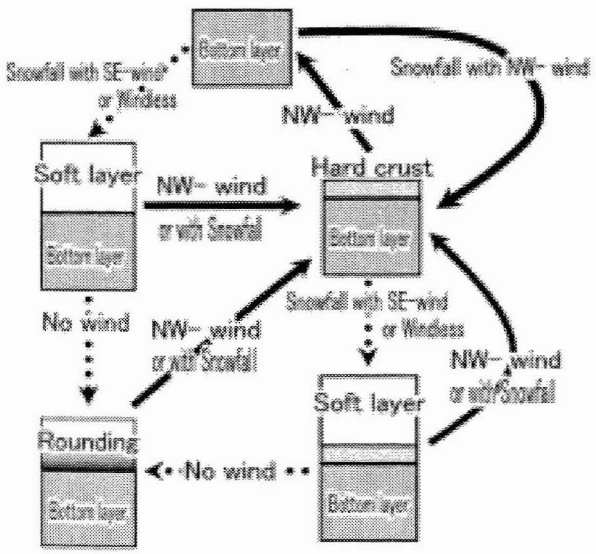

Fig. 3: Change of snow depth in site 4

4. Results

4.1 Snow depth

Snow depth were measured at 79 pits in 00-01 and 01-02 seasons. Those data are shown in fig 2.

Maximal snow depth was over 3 m on each site except site4. Site4 is a lee side against SW seasonal wind and usually snowpack is erode, but sometimes low-pressure front passing sea of Japan cause SE wind and snow depth change rapidly (fig. 3).

4.2 Hardness profiles

Hand hardness profiles were classified into 4 types shown in fig 4. The typical hardness profile in study area is A type (41%). B type was found in 19% of the profiles. Most of B types are caused by rain or warm temperature (over 0℃) in high winter, they are not uncommon in this area. Site4 is characterized by depth hoar growth near the ground like Colorado Rocky. But they differ in that Hakuba is warmer than Colorado Rocky. In Hakuba often depth hoar growth near the ground is changed into wet-grain by warm weather even high winter (Fig. 7).

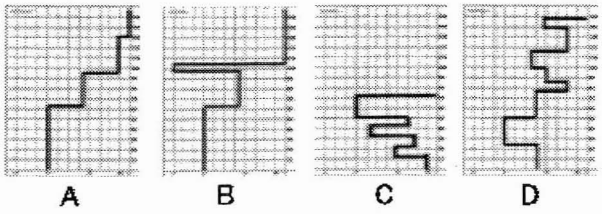

Fig. 4: Classification of hardness profiles

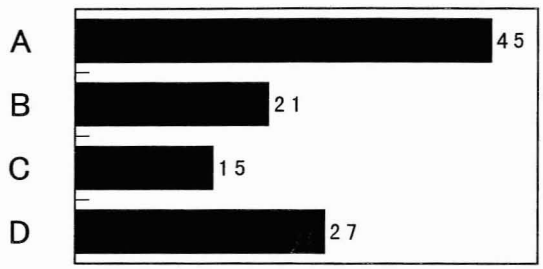

Fig. 5: Number of hardness profiles

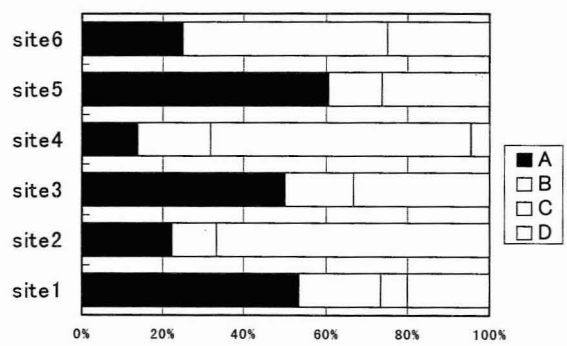

Fig. 6: Percentage of hardness profiles

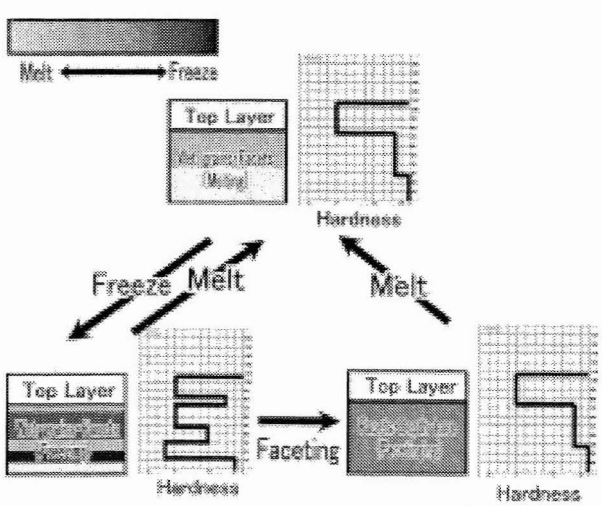

Fig. 7: Melt-Freeze-Faceting cycle in site 4

4.3 Weak layer and interface

Totally 173 failures plane were observed, when doing Shovel compression test or shovel shear test, and 126 failures of them are known source of failures plane. 100 failures in 126 failures were caused by weak layer, and rest were weak interface.

Typical grain types in weak layers are precipitation particles consists of rime less stellars, irregular crystals and graupel (66%). Almost observed stellars are spatial (only 1 failure caused by planner) and small (2-3mm). For that reason they are not very weak (VE rating of test are not find). Faceted grains and surface hoar, most popular weak layer invite avalanche accidents in Swiss and Canada, are not common (facets: 13, surface hoar:1). 12 failures of facets in 13 failures were find in 01-02 season, it show existence of seasonal difference. Often, surface hore crystals are find on the snow surface but it is rare to find in snowpack.

69% of failures plane were observed at shallower than 60cm from surface. 88% of failures plane with easy rating of tests were observed at shallower than 40cm from surface. They suggest that the lifetime of weak layers or interfaces in this area are short.

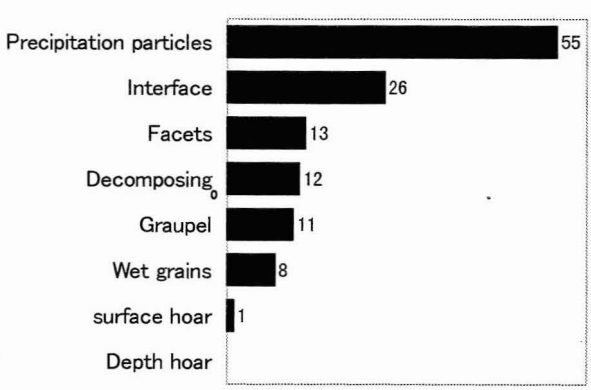

Fig. 8: Grain type in weak layer

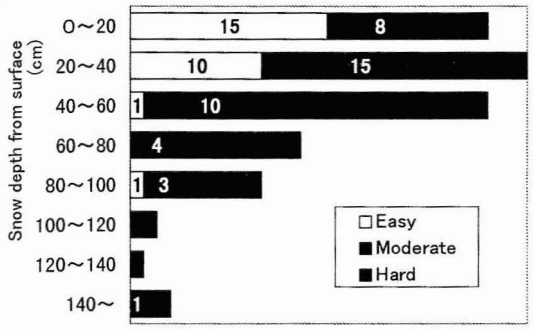

Fig. 9: Depth of failure plane

4.4 Examples of avalanche

Snow pits were dug on the fracture line at 3 cases of avalanches. Avalanche summaries are shown in table 2.

The avalanche occurred at site 7 was caused by heavy snow storm continued all week long. In that period 270cm increase of snow depth was observed at study site 3 in a week.

The factor of the avalanche occurred at site 8 was weak bottom layer consist from wet facets, and thin breakable surface layer. Formations of those layers are shown in fig.3 and 7.

50cm depth storm snow on the hard melt-freeze(K) crust caused by raining in high winter invited the avalanche at site 9.

These 3 avalanches hereinbefore are typical avalanches in this area.

Table 2: Example of avalanche

	Site7	Site8	Site9
Date	02.1.5	00.2.19	01.2.15
Type	Dry slab	Dry slab	Dry slab
Elevation of starting zone (m a.s.l)	1690	1900	1700
Trigger	Natural	Snow boader	Test skiing
Max.width(m)	200	300	20
Vertical drop (m)	1000	1000	-
Horizontal length (m)	1500	1700	50
Slab thickness (cm)	200	50-100	50
Hardness profile	D	C	B
Weak layer	Facet/wet-grain	Facet/wet-grain	Interface

5. Conclusion

In Japan there are many beautiful place to winter backcountry recreations. Hakuba is just one of them. We need more understanding snowpack characteristics of each region in Japan. And I hope that winter backcountry recreations will be familiar more and more with right knowledge in Japan.

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