CHARACTERISTICS OF WEAK LAYERS OF SLAB AVALANCHES THAT OCCURRED IN HOKKAIDO IN THE DECADE FROM 2007 TO 2017

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ABSTRACT: The Hokkaido branch of the Japanese Society of Snow and Ice (JSSI) has organized its Snow Damage Research Team since 2007. In cooperation with mountain guides, the research team ascended to the avalanche starting zone and observed the mountain snowpack to obtain information pertaining to any weak layers. It contributed to an avalanche society in Japan by acquiring data on the starting zone, for which little information had existed previously in Japan. The research team investigates both the avalanche accident and also the behavior of the party involved in the accident. In this paper, we describe the characteristics of the weak layers that caused the major avalanche accidents observed in the past 10 years. Faceted crystals and depth hoar were the most common weak layers, accounting for two-thirds of the total. These hoar crystals formed near the surface layer and were subsequently buried. There were also four cases in which precipitation particles (snow crystals without riming) formed a weak layer. This type of weak layer made up one-third of the total, which is larger than the proportion for weak layers of surface avalanches occurring in Europe or North America. This trend may depend on the snowfall system in Japan, so it is necessary to pay attention to the precipitation pattern.

KEYWORDS: slab avalanche, weak layer, snowfall system, Hokkaido

1. INTRODUCTION

The Hokkaido branch of the Japanese Society of Snow and Ice (JSSI) has organized its Snow Damage Research Team since 2007 (Ozeki et al., 2008). This team investigates avalanche damage as well as heavy snowfall events, snowdrifts, etc. For example, the research team investigated two accidents caused by heavy snowfall in Hokkaido in the past 10 years. One was an investigation of a heavy snowfall event at Sapporo and Ebetsu on January 17, 2010, and the other was a snow survey of heavy snow damage in the Sorachi region in 2012. However, investigation of avalanches is the main task for the research team. The research team investigates both the avalanche accident itself and also the behavior of the party involved in the accident. In cooperation with mountain guides, the research team ascended to the avalanche starting zone (Figures 1 and 2) and observed the mountain snowpack to obtain information pertaining to any weak layers (Figure 3).

Figure 1. Ascending to the avalanche starting zone in cooperation with the mountain guides. Photo: Mt. Kamihorokamettoku on November 17, 2007.

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One of the noteworthy aspects of the activity is an agreement with the Community Police Affairs Planning Division of the Hokkaido Prefectural Police to obtain avalanche accident information quickly. Information on mountain weather conditions during field investigations is provided by the Japan Weather Association.

In this paper, we describe the characteristics of the weak layers that caused the major avalanche accidents observed in the past 10 years.

2. FIELD INVESTIGATIONS

The research team investigated with a focus on slab avalanches that caused serious accidents such as fatality or serious injury. The team ascended from the debris to the crown, measured the avalanche size, and observed the mountain snowpack and debris.

Table 1 shows the observational data of the slab avalanches investigated by the research team in the past 10 years. The third column indicates the name of each respective mountain. The locations of these mountains are shown in Figure 4. The avalanche data do not include avalanche accidents that occurred around roads. Data pertaining to avalanches that reach national routes are collected at the Hokkaido Road Management Engineering Center.

2.1 Locations

The avalanches investigated occurred in Hokkaido, except for avalanche number 6 in Table 1. It is noteworthy that these avalanches occurred in two areas. One is the Niseko area, including Mt. Niseko Annupuri and Mt. Yotei. The Niseko area is located in the southwestern part of Hokkaido. The area is known as a premiere ski resort in the world. It is particularly popular with snowboarders and backcountry

Figure 2. Observation at an avalanche starting zone. Photo: Mt. Asahidake on December 31, 2015.

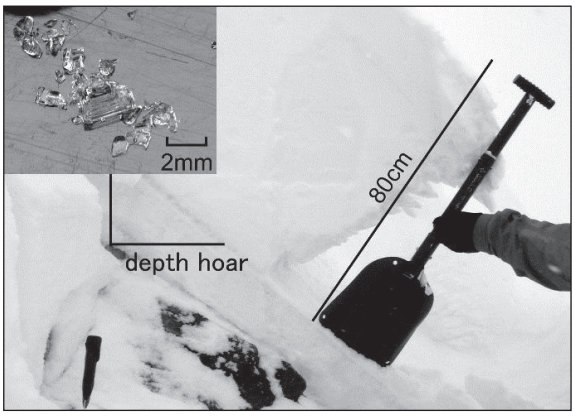

Figure 3. Crown surface of the avalanche (No.2 in Table 1) and grain shape of the weak layer. Photo: Mt. Kamihorokamettoku on December 11, 2007. (Ozeki et al., 2008)

Table 1 Weak layer data of the slab avalanches that investigated in the past 10 years.

No.	Date	Place	Grain shape & size (mm) of weak layer		Type
1	'07.Nov.17	Mt. Kamihoro*	□∧	1–2	Hoar crystals
2	'07.Nov.23	Mt. Kamihoro*	∧∧	1–5	Hoar crystals
3	'09.Feb.08	Mt. Nitonupuri	□□	0.5–1	Hoar crystals
4	'09.Mar.02	Mt. Yotei	＋＋	–1	PP w/o riming
5	'10.Jan.16	Mt. Shiribetsu	□□	0.2–1	Hoar crystals
6	'10.Nov.30	Mt. Kunimidake	□□	0.5–1	Hoar crystals
7	'11.Jan.01	Mt. Niseko Annupuri	○□	0.5–1	Hoar crystals
8	'12.Dec.16	Mt. Sandanyama	／＋	1–2	PP w/o riming
9	'13.Apr.22	Mt. Furanodake	／＋	0.5–1	PP w/o riming
10	'14.Jan.16	Mt. Niseko Annupuri	／＋	0.5–1	PP w/o riming
11	'15.Dec.30	Mt. Asahidake	●□	0.2–1	Hoar crystals
12	'16.Mar.26	Mt. Yotei	□□	0.2–0.5	Hoar crystals
13	'17.Feb.25	Mt. Niseko Annupuri	WL1: ／＋	0.5–1	PP w/o riming
			WL2: □／	0.2–1	Hoar crystals

*Kamihoro: Kamihorokamettoku

skiers who enjoy the off-piste areas because of their powdery snow.

The other is the Daisetuzan area, including the Tokachi Montain Range and Mt. Asahidake. The Daisetsuzan area, which is designated a national park, is located at the center of Hokkaido. This area is one of the best places to observe snow crystals in Japan. In addition, the number of skiers and snowboarders climbing the Tokachi Mountain Range and Mt. Asahidake has tended to increase in recent years, and there is an increasing risk of occurrence of avalanche.

2.2 Weak layers

Weak layers in the starting zone were observed through 13 avalanche surveys. The team contributed to an avalanche society in Japan by acquiring data on the starting zone, for which little information had existed in Japan previously.

There were nine cases in which faceted crystals or depth hoar formed a weak layer. Hoar crystals were the most common weak layers, accounting for two-thirds of the total. These hoar crystals formed near the surface layer and then were buried. There were also five cases in which precipitation particles (snow crystals without riming) formed a weak layer.

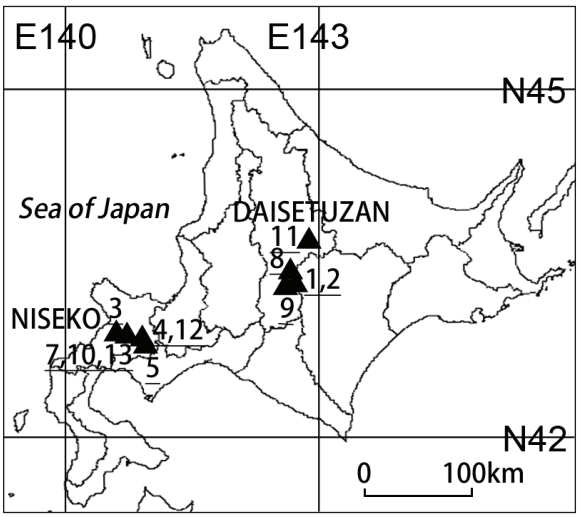

Figure 4 Locations of investigated avalanches. The numbers indicate the locations of mountains in Table 1. Location of avalanche number 6 is in Toyama Prefecture, Honshu. Southwest: Niseko area, center: Daisetuzan area.

3. DISCUSSION

According to Table 1, hoar crystal layers were the most common type of weak layer in Hokkaido. Fukuzawa and Akitaya (1993) reported that the faceted crystals and depth hoar grow rapidly near the surface. They also pointed out that a large temperature gradient is produced by radiative cooling. On the other hand, Schweizer and Jamieson (2000) investigated the weak layer of skier-triggered avalanches in Switzerland and Canada. They reported that 82 % of the weak layers consisted of surface hoar, faceted crystals, and depth hoar. Therefore, it can be stated that the proportion of hoar crystal weak layers, two-thirds of the total in Hokkaido, is slightly smaller than that in Europe or North America.

Weak layers consisting of snow crystals without riming, which means clear snow crystals, were characteristic in the investigation at Hokkaido. This type of weak layer made up one-third of the total, which is larger than the proportion for weak layers of slab avalanches occurring in Europe or North America. Schweizer and Jamieson (2000) reported that only 6 % of the weak layers in Switzerland and Canada consisted of precipitation particles. This trend may depend on the snowfall system in Japan. Snow crystals without riming often form in front of cyclonic systems. Cyclones migrate eastward across Japan and the prevailing northwesterly winds then cause advection of cold air from Siberia to Japan and bring heavy snowfall, which usually consists of precipitation particles with riming, to the west coast of Japan. Therefore, it is necessary to pay attention to the precipitation pattern.

4. CONCLUSIONS

The Snow Damage Research Team of the JSSI Hokkaido branch investigated 13 major slab avalanche accidents in the past 10 years. The avalanches were located in two areas: the Niseko area including Mt. Niseko Annupuri and Mt. Yotei and the Daisetuzan area including the Tokachi Mountain Range and Mt. Asahidake. Both areas are very popular with snowboarders and backcountry skiers.

The research team ascended to the avalanche starting zone and observed the weak layers of slab avalanches. Faceted crystals and depth hoar were the most common types of weak layers, accounting for two-thirds of the total. Weak layers consisting of precipitation particles (snow crystals without riming) made up one-third of the total, which is larger than the proportion for weak layers of surface avalanches occurring in Europe or North America. This type of weak layer, which may depend on the snowfall system in Japan, is characteristic of the investigation at Hokkaido.

ACKNOWLEDGEMENTS

We express our gratitude to Ms. M. Aoki, Mr. R. Furuichi, Mr. K. Higuchi, Mr. M. Kikuchi, Mr. S. Nakagawa, Mr. W. Nara, Mr. K. Oda, Mr. H. Onishi, Mr. D. Sasaki, Mr. M. Takahashi and Mr. Y. Yamamoto for their field support during observations. We thank

to the Japan Avalanche Network, NPO Hokkaido Institute of Avalanche Research and Education, and Sandan Yama Backcountry Ski Tour Club for their cooperation in the field observations. We acknowledge the useful support provided by the Community Police Affairs Planning Division of the Hokkaido Prefectural Police. This research activity was supported by donations from Hokuyaku Co., Ltd., Toppii Co. Ltd., Kinotoya Co., Ltd., Shugakuso Co., Ltd., and Daitou-Kohgyo Co., Ltd.

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