BLASTING GLACIAL ICE AND SNOW

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ABSTRACT

This presentation, with the aid of slides, is about methods of blasting large quantities of glacial ice and snow. The project illustrated here involved blasting sections of a hanging glacier and a full year`s snow pack threatening a work site. It was carried out by Mountain Consultants Inc. of Whistler, B.C. under contract to Omni Resources Inc. of Vancouver, B.C. in the period of September 1978 to October 1979. The reason for this project was the discovery of a Molybdenum ore body in the north Coast Mountains (Boundary Ranges) near the Alaska/BC border. The exact location was 40 km east of the Juneau Icefields above the abandoned mining town of Tulsequah, B.C. The exploration company attempted to complete a feasibility study to bring the mining property into production. Also discussed are methods of controlling ice falls by helicopter, blasting lake ice and the Yokullhaup phenomena.

INTRODUCTION

The removal of large quantities if ice from a hanging glacier can present problems or may be impossible to achieve with existing techniques and approved methods. To be able to relate to existing snow avalanche control methods and snow properties, and to demonstrate decision making during this project, I will explain a few facts about glacial ice. We are dealing with a temperate glacier whose ice is very near the pressure melting point throughout, except for a surface layer that is chilled below freezing each winter. Unlike some sub-polar glaciers and the polar glaciers, the temperate glaciers are not frozen to the bed rock. The mode of flow of temperate glaciers is affected by the presence of liquid water throughout most of their mass. The ice deforms, fractures and slides readily and the regelation process is able to assist sliding over the bedrock. The velocity of the flow of a temperate glacier increases significantly during the summer months.

The mountains of the north coast can experience weather that produce 50 cm snow falls as late as end of June and as early as mid September.

ILLUSTRATIONS

Slide

1 LONGYEAR 38 diamond drill used in exploration work. Expected weather conditions. Photo september 1979.

2 Drilling site on ridge above Sittakany and Wright glaciers. Hazards from avalanches, exposure, high winds etc. Mountaineering expertise necessary to establish and manage site.

3 Site for proposed exploration adit located on the Sittakany glacier, at the base of 500 meter high buttress. Above the buttress is a hanging glacier that regularly calves off. Above the hanging glacier is a large and steep slope with an avalanche hazard. Photo taken end of June.

4 We recommended to establish the working platform with compressors, light plant, water tanks and mechanics shop at the base of buttress on glacial ice.

5 During the months of greatest glacier activity (July & August) this ice fall produced 1 avalanche per hour at fairly regular intervals, day and night. Obviously we had to improve the safety margin at this site.

6 The section of hanging glacier to be removed was an ice block of 50'000 cubic meters or ca. 40'000 tons. We attempted to bring it down with one blasting operation. This was feasible since the whole block started to separate from the main glacier the year before.

7 Problems with safe access to crevasse behind ice block. Hazard from new snow avalanches.

8 Conventional helicopter bombing of slope above crevasse. Mountaineering techniques to access crevasse from saddle.

9 Helicopter bombing to collapse snowbridge covering entire crevasse. Method used: 5 kg bomb dropped on surface of snow bridge to create initial hole, subsequent 5 kg charges dropped through hole. Entire crevasse opens immediately with blast initiated in confined space of crevasse.

10 Rigging to access bottom of crevasse. Methods used: rappelling, ascenders, ACMG crevasse rescue setup, quickly convertible into lowering or raising system if need be.

11 Long-lining explosives into crevasse by helicopter.

12 Two 650 kg charges in improvised nets placed in strategic points in crevasse. The two loads were connected and each load was connected with the fuse site on the saddle 200 meters above, with the heaviest type of explosives cord available. Two 15 minute fuses were lit and we left by helicopter to the site where the next series of slides were taken.

13 - 18 Blast sequence, July 8. 1979

19 Results: new terminal face and fracture line across slope above.

20 Crown fracture of entire 1978/79 snow pack down to 1978 firn layer 6-8 meter high and several hundred meters long. Total of ice and snow removed was ca. 60'000 tons.

21 Aerial shot of adit site as the miners started to drift into granite buttress.

22 Run-out of ice avalanche.

23 Observations suggest that ice or ice and snow avalanches behave similarly to wet snow avalanches. They may attain greater speed than wet snow avalanches when falling over cliffs and steep terrain but due to their density and some free water the run-out distance and the shape of the debris is similar, as is the speed in the runout zone.

24 Toe if debris of avalanche.

25 Cleanup blasts in the ice fall.

26 The charges had to be placed accurately in fractures and behind seracs. They had to be of a size too large to deliver by hand from a helicopter. The terrain was also of a nature that made it impossible to maneuver the helicopter into close proximity of the ice faces.

These factors forced us to come up with a safe method of long-lining the bombs into place. The setup was a charge in a disposable net, on a disposable long line carried on the cargo hook. We then devised a system where the bombardier could only ignite the fuses after the load released from the cargo hook.

27 Preparation of tunnel entrance in accumulation zone of glacier. Blasting to a level that could be maintained during ablation period. The firn line sank ca. 12 meters during the summer.

28 Adit entrance during underground diamond drilling phase.

29 Aerial shot of adit.

30 Blasting to collapse snow bridges and bergschrunds to expose mineralized zones for sampling purposes.

31 The charges were usually placed on foot rather than by helicopter.

32 Blasting to speed up the breakup of lake ice to facilitate float plane support traffic.

33 High alpine, sterile lake not supporting fish population.

34 - 36 The phenomena known by the Norwegian word YOKULLHAUP: The sudden discharge of it's water by a glacier-dammed lake.

REFERENCES

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Field, W., Mountain Glaciers of the Northern Hemisphere, 1975 U.S.Army Corps of Engineers