ROCKFACE GLIDE AVALANCHE DETECTION

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A smooth rock slab, known as Rock Face, is exposed 2.5 km north-northwest of Snoqualmie Pass, Washington adjacent to the Alpental Ski Area. Rock Face, at an elevation of 1055 m, has a slope angle of approximately 35° and a northeast aspect. During the winter of 2003-2004, a continuous recording station was installed at the top of the Rock Face slope. Instrumentation for data collection at the site includes air temperature, snow temperature, solar intensity, a cable-extension transducer for measuring glide rate and a geophone that will record the precise time of an avalanche. A limited number of events have been documented. We present an overview of the glide events and examine possible mechanisms for the glide failures. Our goal is to characterize avalanche processes and weather variables that influence the onset and eventual release of full-depth avalanches.

Keywords: Avalanche Detection, Glide avalanche, Forecasting

1. INTRODUCTION

An ongoing glide avalanche study was initiated during the winter of 2003-2004 on a smooth rock slab known as Rock face. This smooth rock slab is located 2.5 km north-northwest of Snoqualmie Pass, WA adjacent to the Alpental Ski Area. Rock face, at an elevation of 1055m, has an average steepness of 35°, and a northeast aspect. The local climate is Maritime; it is characterized by relatively heavy snowfall and relatively mild temperatures (McClung and Schaerer, 2006). Annual snowfall exceeds 1150 cm and the area experiences several rain-on-snow events each winter.

During the first year of study (2003-2004), several meteorological instruments and one strain meter that measures movement or glide of the snowpack were installed at Rock Face. Data were collected using a Campbell Scientific CR-10X datalogger with a collection interval of 15 minutes for meteorological data and 5 minutes for glide information. A Ref-Tek datalogger and Mark L-28 geophone were installed to collect timing of snowpack failure at a resolution of 50 samples per second. Additional meteorological and snowpack data are available from local weather stations and study plots.

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Alpental station #304 is located 0.6 km from Rock Face and Snoqualmie Pass station #342 is located 2.5 km from *Rock Face* (Stimberis and Rubin, 2004)

Data has been collected from the Rock Face site during each of the past four winters with varying success. Instrumentation problems, lack of snow, excessive snowfall and vandalism have all interfered with the study. At the beginning of the 2007-2008 winter season, the authors improved the study parameters, collection techniques, and expectations. The following paper and corresponding poster presentation provide an overview of the changes and challenges for characterizing glide processes and avalanches and highlight a few glide events that have been captured.

2. METHODS

Meteorological and snowpack data collected at the Rock Face site include: air temperature, solar intensity (as measured by a simple solar cell), temperature at the snow/rock interface, glide rate (utilizing a cable-extension transducer), and seismic data from a geophone. Additional information from the nearby weather stations at Alpental and Snoqualmie Pass include: air temperature, humidity, precipitation, 24 hour and total snow, water outflow from a snow lysimeter, and subjective snow observations (Stimberis and Rubin, 2004).

On-site data were collected at a resolution of 15 minutes for meteorological data and 5 minutes for glide rate. Since the data rate of 5 minutes was insufficient to characterize glide events, we increased the resolution ten-fold and now collect 30 second data output. This data rate provides better resolution for documenting glide rates and capturing catastrophic events, while maintaining a reasonable balance for data retrieval. Meteorological data collection continues at a 15-minute resolution, with the exception at the Alpental base station. Here, the meteorological data is collected at 60-minute intervals.

3. RESULTS

The authors reviewed data collected from 24-Jan-2008 through 29-May-2008. A particularly active period from 20-Feb 2008 through 3-March 2008 was examined. Over this thirteen-day period, about 3.5 meters of glide was recorded. Temperatures ranged from -3.1° C to 9.7° C and 39.6 mm of precipitation was recorded, including 24 cm of snowfall. We discuss three individual glide events that occurred during this period and their potential glide triggers. The individual events occurred on 23-Febuary 2008, 29-Febuary 2008, and 1-March 2008. In all three events, rising temperatures appear to trigger or contribute to glide failure. Rapid loading, in the form of precipitation, also appears to be a factor in one of the events.

Data for the glide events include snowpack glide movement (as measured by a strain meter), air temperature, precipitation, new and total snow amounts, and subjective snowpack analysis. Meteorological and snowpack data are derived from the Alpental Study plot (station #304). Snow/rock interface temperatures, geophone data and on-site air temperature were not recorded due to equipment damage and malfunctions.

The 23-Febuary event was the first significant event during the 13-day sample period. The glide event began around 0200 PST, during the early morning hours of 23-Febuary 2008. The initial glide event was short-lived as ambient air temperatures dropped below freezing. The drop in temperature resulted in surface crust formation, as observed at the local snow study plots. Glide was again initiated a few hours later, following sunrise, with ambient air temperatures rising shortly thereafter. Solar intensity values increased and correspond to the increasing glide rates. Glide continued through most of the day with air temperatures reaching a peak of 8° C at the Snoqualmie Pass station. By late afternoon glide rates decreased considerably and a corresponding drop in air temperature was recorded.

The second reviewed glide event occurred on 29-Febuary and is again largely attributable to an increase in air temperature. Precipitation may have influenced the amount of free water available, as 4mm of rain was recorded on 27-Febuary at the Alpental weather station. Temperatures increased rapidly during the morning of 29-Febuary and an initiation of glide followed the rise in temperature and remained relatively consistent through the day. Two small spikes in glide rate were recorded and they correspond to rapid increases in temperature. Here, temperatures rose more than 1° C/ hour. As with the 23-February event, glide rates began to decline and stopped as the air temperature decreased. Additional precipitation began on the evening of 29-Febuary and continued through the day on 1-March.

The third event that the authors reviewed occurred on the following day (1-March) and is perhaps triggered by an increase in temperature and loading from recent precipitation. This event is characterized by a rapid release on the test slope. An adjacent section of the snowpack released completely, causing an avalanche.

In detail, precipitation began after 1700 (PST) on 29-Febuary and continued through the day on 1-March, ending by 2200 (PDT). During this period, a total of 28 mm precipitation was recorded; 22.1 mm of precipitation recorded prior to the glide event. Temperatures also increased rapidly prior to the glide event, with an increase of nearly 1° C in the 15-minute collection interval from 1200-1215 (PDT). Glide initiated at approximately 1145 (PDT) and about 10 cm of movement occurred by 1200 (PDT). Over the next few minutes, glide increased rapidly with 9.9 cm of motion recorded in four minutes and an additional 99.3 cm of motion recorded during the following 30-second interval. On-site observers report a large section of snow releasing as an avalanche, though the test segment did not completely fail; the test section of snowpack was anchored by the surrounding snowpack and underlying rock structure.

4. DISCUSSION

Data collection at the Rock Face study site continues to improve. Equipment repairs and upgrades will certainly be implemented prior to the 2008-2009 winter. Collection intervals and methods will also be improved, with the addition of radio telemetry, and possible changes to data resolution at nearby weather stations. We plan to add a strain gauge to measure snowpack settlement at the Snoqualmie Pass study plot as well. The authors will continue to analyze data for additional glide events and related weather or snow variables and their corresponding significance.

Weather factors such as temperature and precipitation appear to be driving factors relating to glide. Rapid increases in temperature were observed to have a significant effect upon glide initiation and continuation. This supports observations by Reardon et al. (2006) and is likely due to the presence of liquid water at the snow/rock interface. Liquid water at the snow/rock interface contributes to glide initiation (McClung and Schaerer, 2006). In addition, increases in temperature increase creep within the snowpack (McClung and Schaerer, 2006). Snowpack creep and settlement may also contribute to glide initiation and avalanching. Based on our analysis, it might be possible to determine the critical shear stress on the rock surface for glide initiation. Further data collection and analysis is required to fully characterize glide and avalanche processes.

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