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SHORT NOTE

ELECTRONIC DETECTION OF SERAC AVALANCHES AND GLACIER NOISE AT VAUGHAN LEWIS ICEFALL, ALASKA

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ABSTRACT. Design details of a portable, light-weight, seismic recording system are presented together with data concerning sensitivity and frequency response. Field procedures and methods are described with emphasis on coupling the hydrophone detector to waves propagating in the glacier ice. Two of the field-recorded signals are reproduced here: the first resulted from a small serac avalanche in the ice fall and the second was produced by an unusual, local source of glacier noise.

RÉSUMÉ. *Détection électrique d'avalanches de sérac et du bruit du glacier au Vaughan Lewis Icefall, Alaska.* On présente un projet détaillé d'un système portatif léger d'enregistrement sismique ainsi que des données concernant sa sensibilité et sa fréquence de réponse. Les méthodes et procédés d'emploi sont décrits en insistant sur la possibilité de brancher le détecteur hydrophone sur des ondes se propageant dans la glace de glacier. Deux des signaux enregistrés sur le terrain sont reproduits ici: le premier résultait d'une petite avalanche de sérac dans le rapide et le second était produit par une source locale inhabituelle de bruit de glacier.

ZUSAMMENFASSUNG. *Elektronischer Nachweis von Serak-Lawinen und Gletscher-Geräuschen am Vaughan Lewis-Icefall, Alaska.* Konstruktionseinzelheiten eines tragbaren, leichten seismischen Registriersystems werden zusammen mit Daten über seine Empfindlichkeit und sein Ansprechen auf verschiedene Frequenzen mitgeteilt. Arbeitsverfahren und Methoden werden unter besonderer Berücksichtigung der Kopplung zwischen dem Hydrophondetektor und den im Gletschereis sich ausbreitenden Wellen beschrieben. Zwei der im Feld beobachteten Signale werden hier wiedergegeben: Das erste stammt von einer kleinen Seraklawine im Eisfall, das zweite von einer ungewöhnlichen, lokalen Quelle von Gletscher-Geräusch.

INTRODUCTION

Ice falls are regions of enhanced glacial activity because of serac avalanches and the extreme deformation and crevasse formation attendant with the ice flow. Vaughan Lewis Icefall of the Juneau Icefield, Alaska, has all of these features and an outstanding set of wave ogives at its base (Miller, 1963). Avalanche activity on Vaughan Lewis Icefall has been investigated by the author and his associates* (Pinchak, 1968). As a result of this work, it was decided to construct a simple, economical, automatic, light-weight system for electronically detecting the seismic disturbances caused by serac avalanches in the ice fall. In addition, it was anticipated that monitoring the background glacial noises would provide information regarding ice-flow phenomena and the flow of supraglacial melt water (Neave and Savage, 1970).

METHODS AND MATERIALS

A single hydrophone system was utilized in these preliminary experiments so as to simplify field logistics during the June–July 1971 field season. The hydrophone was lowered into water-filled crevasses or supraglacial pools and care was taken to avoid hydrophone–ice contact. Hydrophone depth was set in the range from 2–10 ft (0.6–3 m). The associated electronic amplifier and tape recorder were located on an insulated pad on the edge of the crevasse or pool. The hydrophone signals were monitored on the tape recorder input at the beginning and end of each tape. Due to the sensitivity of the system, it was necessary for the operator to remain very still during the recording period or to move to a position distant from the hydrophone. Serac avalanches were also observed visually and acoustically by the operator and recorded in a field notebook to facilitate review of the tape recording. Tapes were replayed in the field and later monitored visually on a cathode-ray oscilloscope and a light-beam oscillograph at Case Western Reserve University.

* A paper by A. C. Pinchak and W. M. Lokey, "Variations of avalanche frequency on the Vaughan Lewis Icefall, Alaska", is in progress.

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The hydrophone was the type commonly used in sono-buoys with a sensing element having a sensitivity of −87 db referenced to 1 V/μbar. The sensing element was a right-circular cylinder $1\frac{3}{8}$ in by $1\frac{3}{4}$ in (3.5 cm by 4.5 cm) diameter. An integral, potted pre-amplifier was connected close to the sensing element (7 in or 18 cm) and had a gain of 15 db. Frequency response of the hydrophone and pre-amp increased from 5 Hz at 6 db/octave up to 15 Hz (personal communication from F. Hess, Woods Hole Oceanographic Institution, 1970).

25 ft (7.6 m) of no. 24 AWG two-conductor, insulated wire connected a separate amplifier to the hydrophone pre-amplifier. The weight (0.5 lb; 0.23 kg) of the hydrophone and its pre-amplifier was supported by a nylon parachute cord attached to a coarse nylon net which held these units. Two integrated circuits (FU6A 7741393 and 2N5306) were utilized in an amplifier designed to produce an additional 40 db voltage gain for the hydrophone signal and to provide a low output impedance. The gain characteristic of this amplifier was found to be flat from 0 Hz and decreased 6 db at approximately 5 000 Hz.

From this amplifier the signal was fed to a portable cassette-tape recorder (Ampex Corporation, Model "Micro 70"). Overall response of the tape recorder varied from −6 db at 50 Hz, +7 db at 125 Hz to −6 db at 7 500 Hz. The *entire system* was powered by three 6 V and one 9 V batteries. Back-packing was facilitated as the complete system weighed less than 20 lb (9.1 kg) with batteries included. Total cost of this system is less than $230.00. A qualitative idea of the system's sensitivity is its ability to detect a man walking on the glacier at a distance of approximately 200 ft (60 m).

Results and discussion

When the hydrophone was located in the lower regions of the ice fall, the signal intensities were markedly reduced as compared to signals received from crevasse pools in the ogive region. This difference was attributed to the poor transmission of waves through broken surface ice in the lower ice fall as compared to the improved wave conduction through the compacted, solid ice which extends to the surface in the wave-ogive region (Miller, unpublished).

A typical signal produced by a serac avalanche is shown in Figure 1. By comparison with the background noise it is seen that the avalanche is readily detected with a signal-to-noise ratio of approximately 20 db. This particular avalanche was estimated to have a magnitude of 0.5/5, according to the scale set by Pinchak (1968). This is the lowest magnitude avalanche which may be consistently recorded by acoustic or visual observation (Pinchak, 1968).

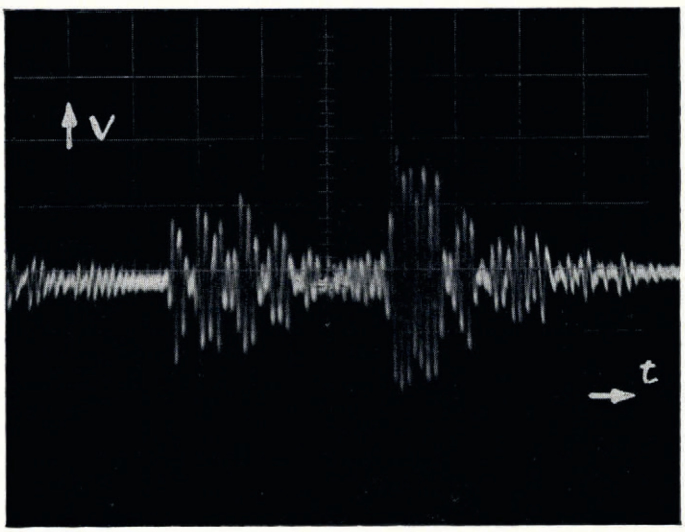

Fig. 1. Recorded hydrophone signal produced by very small magnitude serac avalanche. Hydrophone located in water-filled crevasse in wave-ogive region below ice fall. Depth of hydrophone 1.75 mV. Vertical scale 500 m/division. Horizontal scale 100 ms/division.

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In addition to the continuous background noise due to nearby supraglacial streams, there were intermittent periods with repetitive pulsatile signals having the form shown in Figure 2. Because of the high frequency content of these signals, it was concluded that they were due to a local disturbance in the region of the ogives. This type of signal was noted at several locations in the water-filled crevasses of the ice fall–ogive region but was not heard in a glacial lake on another glacier on the Juneau Icefield. The source of this peculiar signal remains unknown at present but will be the object of investigation in future field work.

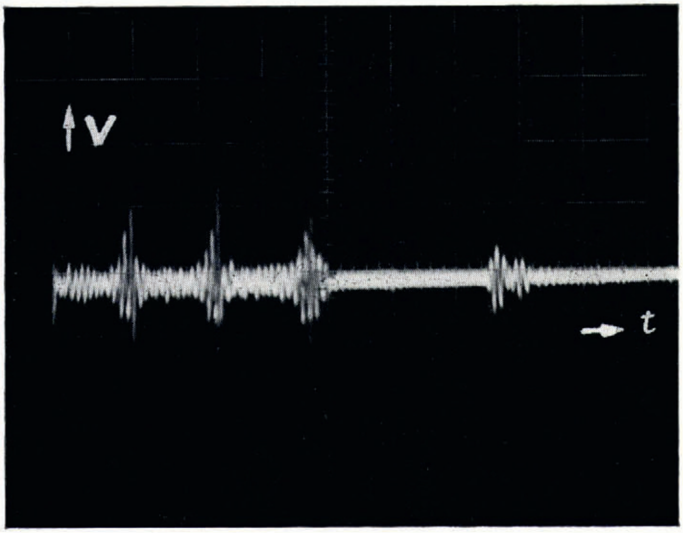

Fig. 2. Periodic signal attributed to local source of glacier noise. All other parameters and scales identical to Figure 1. Data for Figures 1 and 2 both recorded 1 July 1971 between 17.30 and 18.30 h.

Conclusion

A simple, inexpensive, light-weight hydrophone–amplifier–tape-recorder system has been developed which is capable of detecting serac avalanches in an ice fall. In addition, the system is capable of recording noise related to glacier flow and deformation as well as hydrological phenomena in the supra glacial melt water.

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