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ACCELERATING STRAIN PRECEDING AN AVALANCHE

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ABSTRACT. Strain gages set in the snow on an avalanche track recorded accelerating strain for four hours preceeding a naturally released avalanche. On a second occasion when the strain-rate was similar, the strain decelerated and no avalanche occured.

RÉSUMÉ. *Accélération du fluage précédant une avalanche.* Un capteur de déformation placé dans la neige dans un couloir d'avalanches a enregistré une accélération du fluage pendant les quatre heures précédant un déclenchement naturel d'avalanche. En une seconde occasion qui présentait un diagramme de fluage analogue, a déformation s'est ralentie et il n'y a pas eu d'avalanche.

ZUSAMMENFASSUNG. *Beschleunigte Dehnung vor dem Abgang einer Lawine.* Dehnungsmesser im Schnee einer Lawinenbahn zeichneten eine beschleunigte Dehnung wahrend vier Stunden vor dem natürlichen Abgang einer Lawine auf. In einem zweiten Fall mit ähnlichen Dehnungsraten wurde die Dehnung verzögert und keine Lawine ging ab.

On 23 January 1975 two slope-parallel deformation gages (Sommerfeld, [1975]) were installed in the Cliffs avalanche path at Berthoud Pass, Colorado, just prior to a large storm. A 24 h period was allowed for the gages to bond to the snow. They were connected to a recorder on 24 January, about 19.00 U.T. (zone time + 7 h). On 25 January about 02.30 U.T., a natural avalanche released in the area. It tore out the down-slope gage (H-6) but left the up-slope gage (H-7) in place. Figure 1 shows a highly schematic representation of the snow stratigraphy determined at the crown, about 19.00 U.T. 26 January, and the approximate gage location.

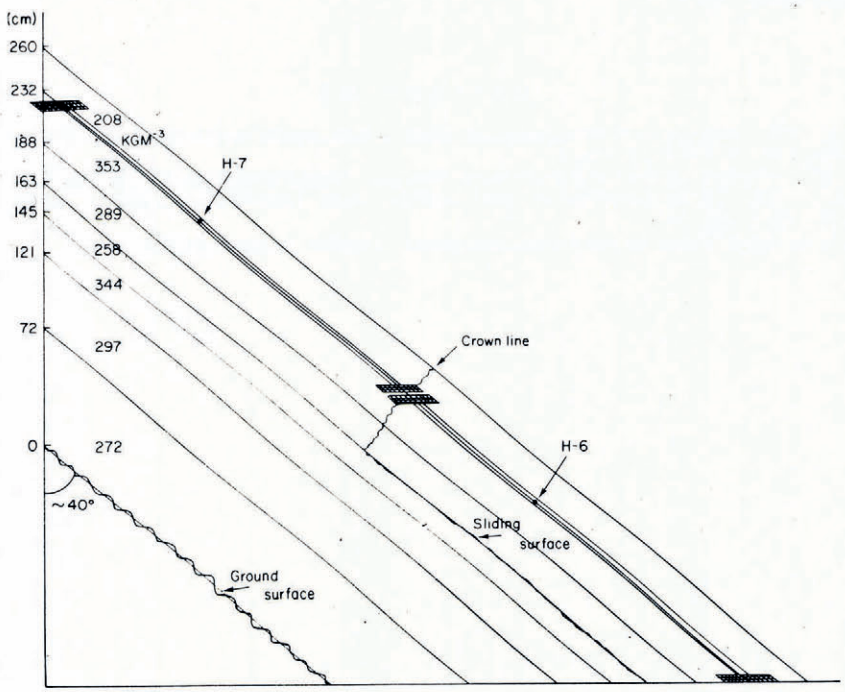

Fig. 1. Schematic representation of the snow-pack and gage locations 25 January 1977.

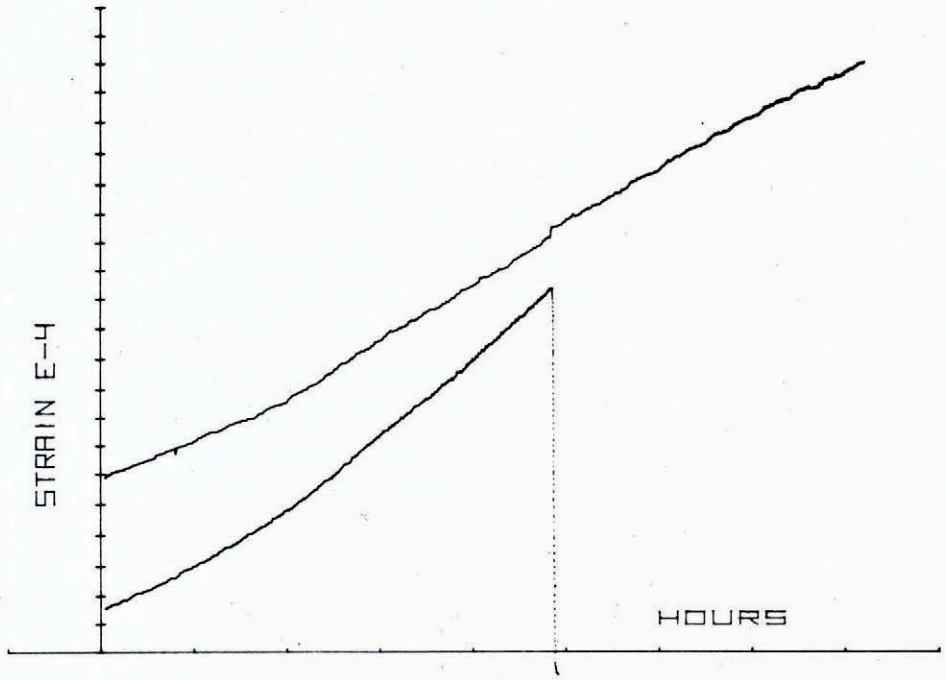

Fig. 2. Strain in units of 10^{-4} versus time in hours on 25 January 1977.

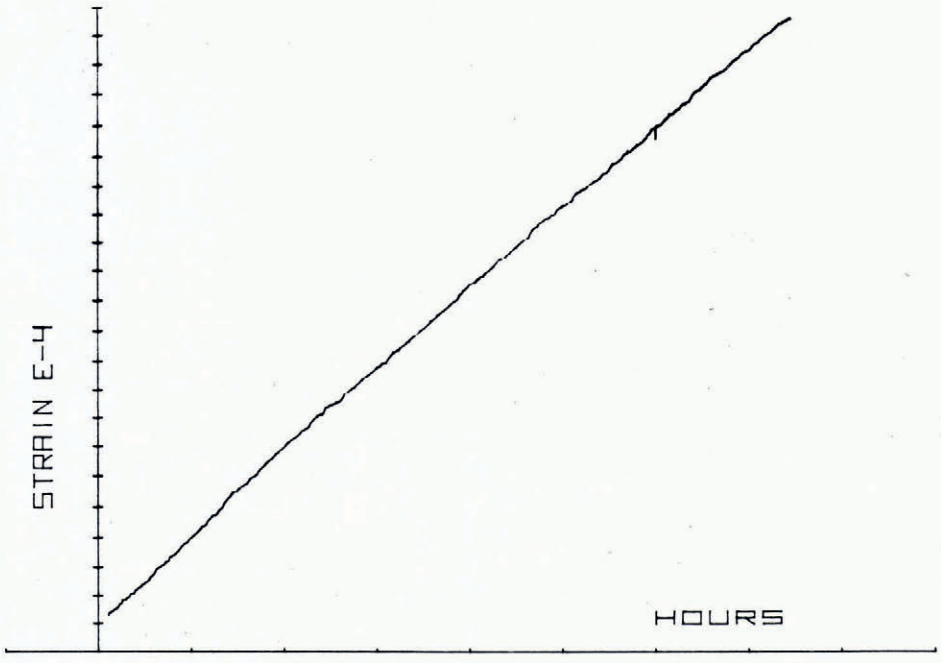

Fig. 3. Strain in units of 10^{-4} versus time in hours on 21 February 1977.

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Figure 2 shows deformation records from these two gages. The positive Y-axis indicates gage extension. Because of the recording techniques, there are 10 s running means of the deformations. The deformation rate on each gage *increases* for almost 5 h preceding the avalanche. After the avalanche the rate on H-7 *decreases* slightly. Also note that the strain-rate on H-6 averages 2.3×10^{-4} h^{-1} and does not exceed 3.9×10^{-4} h^{-1} (the strain-rate just prior to failure) at any time.

On 12 February 1975 another gage (H-4) was placed vertically above the previous position of H-6 on about 40 cm of additional snow. A storm during the period 20–21 February resulted in the deformation shown in Figure 3. There was no avalanche during the second storm. The average strain-rate was 2.8×10^{-4} h^{-1} but at no time was there an *increasing* strain-rate.

It is impossible to draw any sweeping conclusions from one pair of observations. However, it has been shown in the laboratory that snow exhibits accelerating strain before failure (personal communication from W. St. Lawrence). Figure 2 shows that snow in the field also exhibits accelerating strain prior to failure, at least under some circumstances. If this phenomenon is typical of snow it could form the basis for a short-term avalanche warning system.

Another interesting point is that the strain, as measured by the 3 m long gage, never exceeded 3.9×10^{-4} h^{-1}. R. L. Brown (personal communication) found that a strain-rate of at least 10^{-2} h^{-1} was necessary to achieve snow failure in tension: 1.5 orders of magnitude higher than measured by H-6. Therefore, the strain leading to failure must have been concentrated over a much shorter distance than that sampled by the strain gage. This observation supports the idea that snow fails at flaws which concentrate the stress and the strain.

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REFERENCE

Sommerfeld, R. A. [1975.] Continuous measurements of deformations on an avalanche slope. [*Union Géodésique et Géophysique Internationale. Association Internationale des Sciences Hydrologiques. Commission des Neiges et Glaces.*] *Symposium. Mécanique de la neige. Actes du colloque de Grindelwald, avril 1974*, p. 293–97. (IAHS–AISH Publication No. 114.)