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"SUN SPIRALS" ON MELTING SNOW

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Abstract. The light oblong elements like blades of grass and wooden sticks resting on the surface of melting snow change their position and arrangement (direction). They turn under the direct influence of the varying angle of the Sun's rays due to the movement of the Sun. Turning of the elements gives a circular form of arrangement that has been termed ablation "sun spirals".

Résumé. *"Spirales solaires" sur neige fondante.* Position et orientation des éléments légers et allongés (brins d'herbe et brindilles) reposant sur la neige fondante évoluent au cours du temps. Les variations d'incidence de la lumière du Soleil provoquent une rotation de ces éléments. Cela conduit à des arrangements circulaires que l'on a baptisés "spirales solaires" d'ablation.

Zusammenfassung. *"Sonnenspiralen" auf schmelzendem Schnee.* Leichte, längliche Elemente wie Grashalme und Holzstückchen, die auf der Oberfläche schmelzenden Schnees liegen, ändern ihre Lage, Anordnung und Ausrichtung. Sie drehen sich unter dem direkten Einfluss des wechselnden Einfallswinkels der Sonnenstrahlen infolge der Wanderung der Sonne. Die Drehung der Elemente führt zu kreisförmigen Anordnungen, die als "Sonnenspiralen" der Ablation bezeichnet werden.

In the study on ablation hollows on snow (Jahn and Kłapa, 1968) published in this *Journal*, we called attention to the characteristic, concentric arrangements of material on snow. We wrote then: "It is worth noting that in the course of dirt concentration due to ablation elongated dirt particles, e.g. grass blades or conifer needles, are arranged in such a way that their long axes follow the ridge line", and further on: "Dirt particles are accordingly arranged along these lines to form a system of concentric rings" (Jahn and Kłapa, 1968, p. 306 and 307).

At that time I did not have a clear view of the problem. In subsequent years, however, I have performed a series of field experiments on the Juneau Icefield in Alaska (lat. 58°30'N.) as well as in the Kebnekaise mountains in Swedish Lappland (lat. 68°N.). The research conducted at both of these glacio-nival field stations lasted several months. This note covers a fragment of these investigations, which will receive a full description in a later article.

The first place of observations was in the vicinity of Camp 10 of the Summer Institute of Glaciological and Arctic Sciences on Juneau Icefield. The site of the station is marked on the map published in Miller (1969), and the climatic conditions have been given in the paper by Marcus (1964). This is on an extensive nunatak in the large ice field, the peak of which reaches 1200 m. The rocks are covered with a thick layer of firn and snow. In such a snow-field, 0.5 km from the camp, observations were carried out in August 1970. At the time the weather was fine and sunny, and the snow underwent rapid ablation at a

sunny, and the snow underwent rapid ablation at a daily mean rate of 5-10 cm.

The place of the other experiments was a snow-field near the glaciological station of Stockholm University at Tarfala in the Kebnekaise mountains at a height of 1140 m (Schytt, 1979). At the time of the observations, July 1982, the sky was cloudless and the air temperature reached 18°C. The daily ablation rate reached 10 cm. It is worth mentioning that it was in this region of Sweden that Ashwell and Hannell (1966) carried out their studies on snow ablation processes.

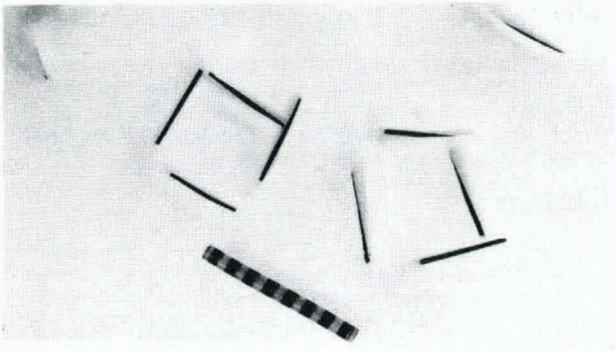

Fig. 1. Black-coloured wooden sticks arranged on the snow in the shape of squares, and their characteristic change of position after 3 h. Rule - 15 cm.

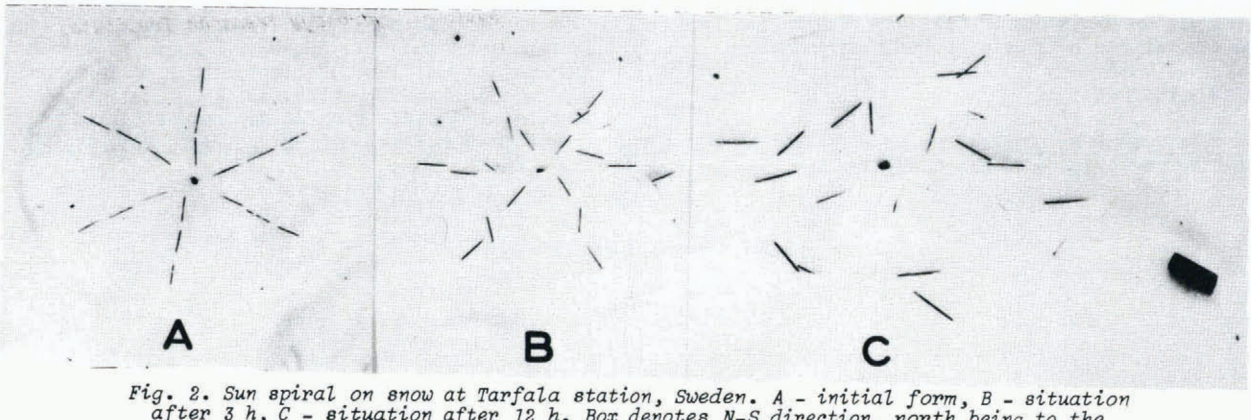

Fig. 2. Sun spiral on snow at Tarfala station, Sweden. A - initial form, B - situation after 3 h, C - situation after 12 h. Box denotes N-S direction, north being to the right. Tarfala, July 1982.

Thus for both experiments the meteorological conditions were very similar. Similar too was the structure of the crystallized snow, its density being 0.4 - 0.5 Mg m^{-3}. The experiments were very simple and consisted in placing light, oblong elements on the snow, that is objects such as blades of grass, small wooden sticks, or, most often, matches. These were arranged in different ways, e.g. in squares, circles or star-like shapes. Every few hours any changes, i.e. deformations in the arrangement were recorded. The result was unmistakable in all the cases. The objects placed on the snow had sunk into its surface and simultaneously turned in the direction corresponding or opposite to the movement of the Sun. Three hours were sufficient for a turn to be noticed (Fig. 1), and within a 24 h period a form had developed on the snow, which has here been called a "sun spiral".

The result was most easily noticeable where the original shape had been that of a star, e.g. matches arranged radially (Fig. 2). While the particular stages of the turn were being traced, it was found that the process took place either in one direction only or in two directions. This fact is illustrated in Figures 3 and 4.

An element placed on the snow gradually warmed and, emitting its heat, sank into the snow. If the element did not warm up evenly, if one of its ends got warm earlier, then the element sank into the snow

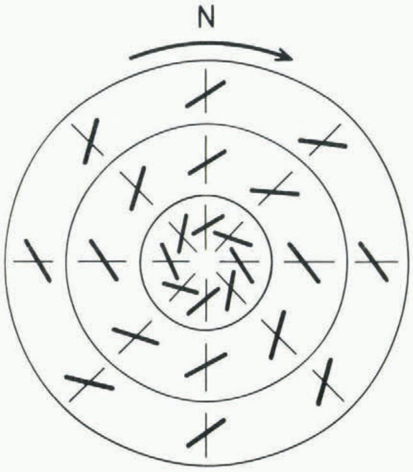

Fig. 3. Sun spiral developed from a one-directional turn.

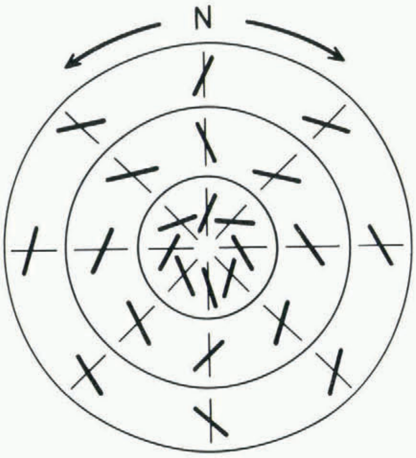

Fig. 4. Sun spiral developed from a two-directional turn.

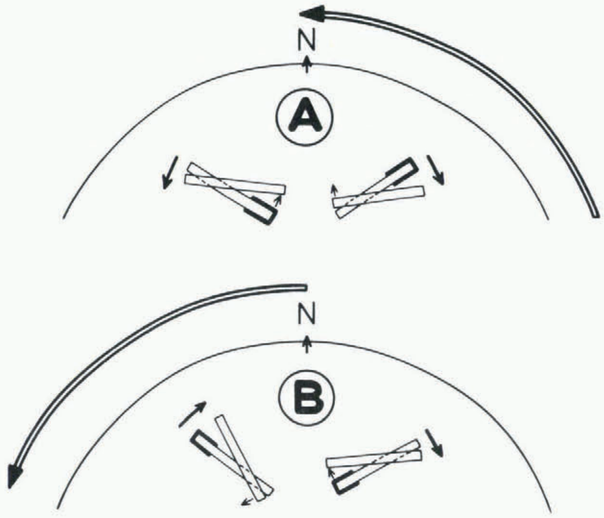

Fig. 5. Diagram showing the directions in which the elongated elements turned on the snow under the influence of the Sun's rays. A - two-directional turn, B - one-directional turn. The black-rimmed ends of the elements denote earlier and more intensive warming than the opposite ends. Arrows show the turn of the elements. The double arrow on the edge shows the Sun's movement before and after noon.

slantwise (Fig. 5) and with a simultaneous change of direction. With the Sun turning from east to west, there exist conditions for the element to turn in accordance with the Sun's movement or against it. Different conditions appear before and after Sun culmination (Figs 3, 4). When the sky was clear all day, the prevailing turn was against the Sun's movement. Morning sunshine caused a turn in two directions. When, however, the sky was partly clouded, the elements started to sink into the snow at different times of the day, a fact that had a decisive effect on the direction the turn was to take.

Simultaneously with the turn, a longitudinal shift of the elements may take place (Fig. 1). Below the element which had sunk into the snow there developed a trough-like depression inclined towards the warmer end. In this trough the element shifted horizontally in accordance with the direction of its axis.

At Tarfala station many of the experiments included strewing the snow surface with mineral dust. This type of thermal accelerator increased the melt-

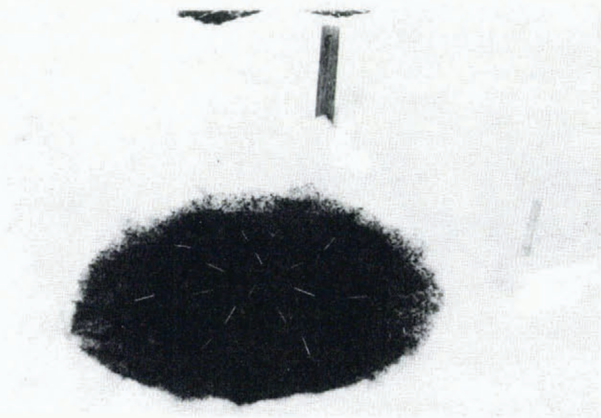

Fig. 6. Ablation hollow developed on snow surface after application of accelerator. Radially arranged match sticks show distinct turn after 12 h. Tarfala, July 1982.

ing rate of the snow. In the resulting hollows the elongated wooden elements (matches) were subjected to horizontal turns which, however, did not occur earlier than did the turns on clean, unsprinkled snow surfaces (Fig. 6).

The problem of ablation forms on snow has always aroused great interest. These are ablation hollows (sun cups) or ablation hillocks (dirt cones). Apart from the form of the snow surface itself, there exists the problem of regular forms developed from material deposited on the snow by wind action. This material is mostly of organic origin such as grass, leaves, twigs (Fig. 7), which often form in regular shapes. This phenomenon has most often been linked with turbulent, whirling air movement over the snow surface.

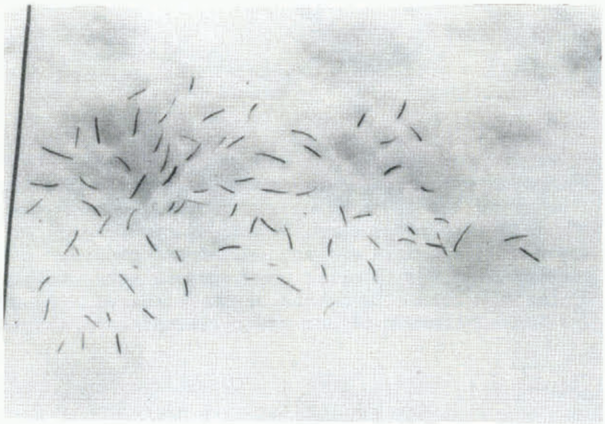

Fig. 7. Blades of grass scattered on snow begin to arrange into "sun spiral" after several hours. Juneau Icefield, August 1970.

The experimental results presented here prove that independently of the turbulence factor many of these forms are derived from the direct action of the Sun's rays, which with their varying angle of incidence and their changes of direction corresponding to the Sun's movement may by themselves suffice to initiate the development of forms that have here been termed "sun spirals" of ablation.

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REFERENCES

Ashwell, I.Y., *and* Hannell, F.G. 1966. Experiments on a snow-patch in the mountains of Sweden. *Journal of Glaciology*, Vol. 6, No. 43, p. 135-44.

Jahn, A., *and* Kłapa, M. 1968. On the origin of ablation hollows (polygons) on snow. *Journal of Glaciology*, Vol. 7, No. 50, p. 299-312.

Marcus, M.G. 1964. *Climate-glacier studies in the Juneau Ice Field region, Alaska.* Chicago, Dept. of Geography, University of Chicago. (University of Chicago. Dept. of Geography. Research Paper No. 88.)

Miller, M.M. 1969. The Alaskan glacier commemorative project, phase 1. *National Geographic Society Research Reports, 1964, Projects*, p. 135-52.

Schytt, V. 1979. *Tarfala and its research activities.* Stockholm, Research Station for Physical Geography, University of Stockholm.

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