Deuterium variations related to snow pit stratigraphy in the Thiel Mountains, Antarctica

By Björn G. Andersen, University of Oslo, Norway *)

Deuterium analysis by Professor W. Dansgaard, Biofysiske Laboratoriet, University of Kopenhagen

Abstract: The walls of a 5 m deep snow pit displayed layers of porous coarse-grained snow and hard packed fine-grained snow. The coarse snow grains were formed through recrystallization mainly in summer, and most of the thickest layers of fine-grained wind transported snow were deposited during the long winter season. According to the stratigraphic interpretation the 5 m deep section was deposited during the last 12 years (1949—1962).

Deuterium analysis of snow samples collected at 7 cm intervals were made by Professor Dansgaard who also interpreted the results. The summer snow has a considerably higher deuterium content than the winter snow. In general the isotope interpretation corresponds well with the stratigraphic interpretation, and it also gives much supplementary information of great interest.

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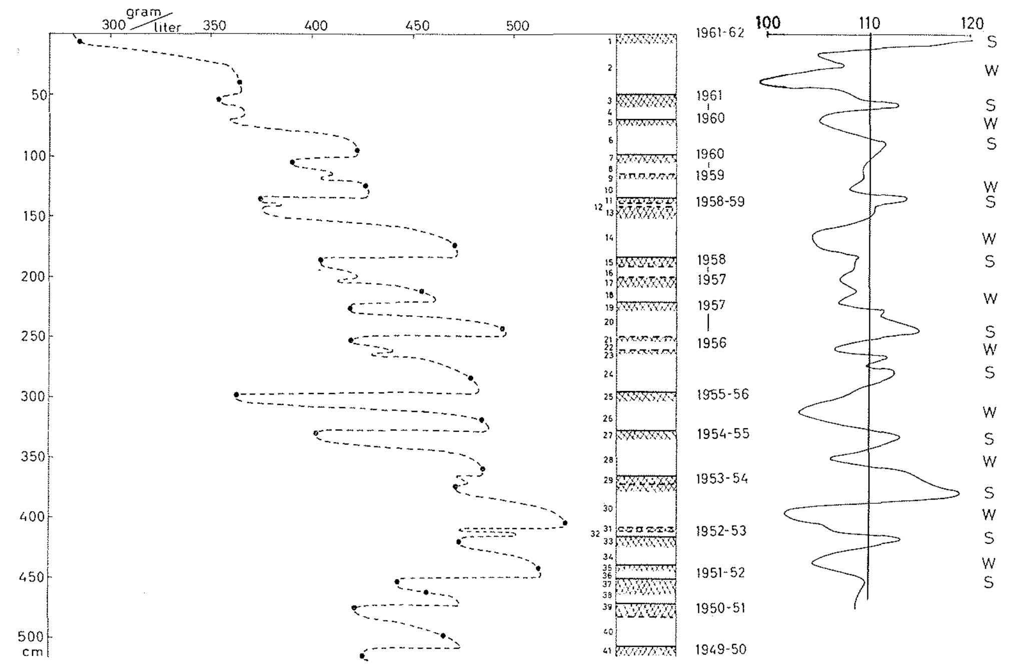
Snow pit studies were part of the glaciologic program conducted during the U.S. Geological Survey's study of the Thiel Mountains in the summers of 1960—61 and 1961—62. The investigated snow pit was located on the ice sheet about 1800 m above sea level and 6 km from the foot of the Thiel Mountains, at about lat. 85 ° 08′ S and long. 89 ° 40′ W. The highest recorded air temperature was —9 ° C, and the annual snow accumulation was approximately 45 cm (16 cm water). The snow accumulation during the warmest part of the summer (between November 8, 1961 and January 20, 1962) averaged 10—15 cm, and light snow fell 20 days of this period. The wind blew mainly from the south, and wind velocities were usually moderate. No melting of snow took place at this locality, but during the warmest part of the summer considerable recrystallization by sublimation occurred. Most of the accumulated snow was wind transported, and differential wind erosion and accumulation caused considerable local variations in the thickness of a snow layer.

The walls of the 5 m deep pit displayed distinct alternating layers of porous coarse-grained snow and hard packed fine-grained the density of the coarse-grained snow was much less than that of the fine-grained snow *(fig. 1)*. Most of the coarse-grained snow beds had a distinct upper boundary and graded downward into fine-grained snow beds. The coarse snow grains were undoubtedly formed through recrystallization, mainly by sublimation in summer. The thick, porous coarse-grained layers probably represented most of the total summer recrystallization, and thin layers probably represented only smaller parts of the total summer recrystallization. The hard packed fine-grained snow was wind transported, and wind transport of snow took place both in winter and in summer. However, the „winter season" was very long, and in general most snow accumulated during this season. Therefore the thick layers of fine-grained snow supposedly represented most of the winter accumulation. Based mainly on these principles the stratigraphy was rather easily interpreted, except for the part between layer nr. 20 and layer nr. 24 *(fig. 1)*. Here the two coarse-grained layers 21 and 23 were so thin that they must represent only a fraction of the total summer recrystallization. They were assumed to represent the recrystallization during an early phase of the summer season. Consequently the thick fine-grained layer 20 had to be a summer layer. The stratigraphic interpretation shown in fig. 1 was done before the results of the isotope analysis were known.

Snow samples collected at about 7 cm intervals were analyzed for their deuterium content by Professor Dansgaard. The results of the analysis are presented in the graph on *fig. 1*. The deuterium content is considerably higher in the summer than in the winter snow, and thus it is possible to distinguish between summer and winter

*) Dr. Björn G. Andersen, Blindern/Oslo, Institutt for Geologi.



Figur 1:
From left to right:
Snow density: dots: observed densities.
Dashed line: infered densities.
Snow stratigraphy: hatched: porous coarse-grained snow.
no hatching: hard packed relatively fine-grained snow.
heavy lines: distinct break.
dashed lines: less distinct break.
no lines: gradational transition.
All layers are numbered.
Stratigraphic interpretation: 1955—56: recrystallization took place the summer 1955—56.
Deuterium graph: samples from about every 7 cm were analyzed by Professor W. Dansgaard.
Deuterium content in parts per million.
Interpretation of deuterium gra by Professor W. Dansgaard.
The interpretation was madeph: W: winter. S: summer.

snow. Density variations were also distinct; snow. An interpretation made by Professor Dansgaard is shown in *fig. 1.* This interpretation corresponds in general with the stratigraphic interpretation, and by both methods the snow in the upper 4.6 m of the profile was estimated to represent 11 year's accumulation. But the isotope analysis also gave much supplementary information of great interest. For instance, the coarse-grained layers 5,9,21 and 25 have a low isotope content, which indicate that they consisted of snow from the previous winters which had been recrystallized during the early part of the summers. The thick, fine-grained layers 6,10,14,26 and 28 have a high isotope content in the lowest parts, which suggest an accumulation of wind transported summer snow during the early part of the winter seasons. The isotope analysis also show that the stratigraphic interpretation of the layers between 20 and 24 was partly incorrect. The two thick beds 20 and 24 both seem to represent summer accumulation and the thin bed 22 the winter accumulation. Therefore the thickness of the fine-grained beds is no reliable indicator in distinguishing between summer and winter snow.

For areas with a climate similar to that at the Thiel Mountains, the results of this investigation suggest caution in basing conclusions solely on stratigraphy. Isotope analysis is a very good supplement to the stratigraphic interpretation, and the two methods combined give the best results, as has also previously been realized by other scientists.