TABLE 2.—*Snow density by 1-foot layers ground up at Summit, Calif.*

(Percentage of equivalent water.)

Year.	Ground to 1 foot.	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	12 to 13	13 to 14
1916–17.														
November	21													
December	37	37	29	27	13									
January	42	38	40	36	32	28	18	18						
February	43	44	42	40	38	34	34	31	29	28	25	31	13	
March	43	42	44	43	40	38	40	41	37	38	26	19	17	10
April	55	45	48	51	55	53	55	55	50					
May	61	50	62											
1917–18.														
November	43													
December														
January	36													
February	43	32	28	24	24	22	16							
March	52	49	54	48	46	47								
April	46	54												
1918–19.														
December	30	25												
January	34	30	28	24										
February														
March	37	34	39	37	39	37	30	25	26	22				
April	43	44	47	45	50	50	47							
May	50	49	48											
1919–20.														
December	36	32	35											
January														
February														
March	47	45	53	32	28	20								
April	51	48	52	45	48	41								
May	55	58	54											
1920–21.														
January	41	47	49	44	33	24								
February														
March	48	51	48	42	49	46	46	43						
April	46	52	52	47	53									

During the season of 1918–19 five trips to Summit were made, the first being on Decebmer 31, when the depth of snow was 23 inches. The January snowfall was light, but the snowfall during February was heavy and a depth of 122 inches was measured on March 5, which was the greatest of the season.

Four trips were made to Summit during the season of 1919–20, the first being on December 31, when the depth of snow was 39 inches, and the ground was frozen to a depth of 1 inch. As the snowfall was light in January and the first half of February, the next trip was delayed until March 5, when there was a depth of 68 inches on the ground. At this time the ground was well moistened and not frozen. On April 13 the depth was 66 inches, and it was 36 inches on May 13.

Only three trips to Summit were made during the season of 1920–21. The first measurements for this season were made on January 14, when the snow cover was 64 inches. The maximum depth of the season was 97 inches on March 17, and a depth of 63 inches of snow remained on the ground on April 29. The density of the snow cover in January was much greater than usual.

The layer measurements prove that it is impossible to determine the density of the whole snow cover from the density of a layer on the surface. Wengler himself stated that in deep snow there are such breaks in uniformity that a perfect law can not be established. This lack of uniformity in density is due to weather conditions during the accumulation of the snow cover. In the interval between storms crusts of varying thickness and density are invariably formed, and such crusts were encountered each season in the work at Summit. These crusts varied from a fraction of an inch to 10 inches in thickness, and some of them were almost solid ice in formation. The density of a layer of snow where incrustation was found was considerably greater than adjacent layers with no incrustation. By noting the relative position of certain crusts at different times, *it was proved that the snow disappears simultaneously from the top and the bottom.*

The mean density for the whole snow cover at Summit, Calif., as determined by the five seasons of investigations, is as follows:

December.	January.	February.	March.	April.	May.
32	34	34	40	49	54

Five years is a short period to establish accurate means, yet it is believed that records covering a longer period of time would not change these values materially. Therefore, it is believed the water content of the snow cover at Summit, Calif., and adjacent regions can be determined approximately at any time of the season by applying these average densities to the depth. Whether or not these values would hold good for other regions could be determined only by investigations in those regions.

This is the first detailed study of a snow cover during several consecutive seasons that has been made in this country, and the records obtained should add much to our limited knowledge of snow densities.

A SIMPLE SNOW-DENSITY MEASURER.[1]

By W. W. KORHONEN.

[Translation by H. C. Frankenfield.]

With the cooperation of Prof. G. Melander, I have constructed for the determination of snow density a new measurer with which observations can be made much more rapidly and simply than hitherto, and the measurements can be made in the open air. It consists of a cylinder 50 cm. in height, with a cross section of 100 cm.^{2}, a shovel, a sliding weight balance, and a hook by which the cylinder is attached to the balance. The balance has an arm 48 cm. in length, and the prisms, which are 4 cm. apart, can be pressed together for transportation by means of two screws. The sliding weight weighs 200 g., wherefore a snow mass of 10 g. (=1mm. water depth) corresponds to a length of 2 mm. on the scale. The balance arm can be brought into a horizontal plane by means of an indicator fastened to one of the prisms, whereupon the reading will be found at the end of the sliding weight. The balance turns the scale distinctly for a weight of 2 g., which corresponds to the water content of a layer of snow about 1 mm. in thickness. For transport the balance and hook are placed in the cylinder and this, together with the shovel, are packed into a narrow sack. The observation is so carried out that the cylinder, after the snow sample has been cut in the prescribed manner, is overturned, fastened with the hook to the balance, and weighed, so that the lid of the cylinder serves as a bottom.

There was freedom from the earlier errors of evaporation by reason of careless melting of the snow, the adhe-

[1] Meteorologische Zeitschrift, June, 1922.

sion of melting snow to the walls of the vessel, as well as the possibility of accident during transport and the later handling of the sample. The composition of the different snow layers was also easily studied with the new instrument. The measurer constructed by Polis for this purpose did not give good results, inasmuch as the sinking of the snow by reason of the simultaneous cutting out of the samples worked badly.

At the end of January I made measurements with the new instrument, part of the time northward from Helsinki in a wide, unprotected field, part of the time in thick woods or in larger clearings. Everywhere the snow was granular and the snow cover consisted of several layers. Beneath lay a thick layer of coarse snow with a maximum thickness of 15 cm. that offered strong resistance to the measuring cylinder. This occurred very generally in the woods, but was encountered only sporadically in the field. Then followed several thinner layers of finer or coarser snow, and above lay a fairly uniform stratum of from 10 to 25 cm. thickness which was covered with a thin crust of smooth ice.

When the thin intermediate layers were summarized we obtained the following results for all of the places in which separate measurements were made:

	Open field.			Woods and clearings.			All places.		
	Depth.	Water content.	Density.	Depth.	Water content.	Density.	Depth.	Water content.	Density.
	cm.	*mm.*		*cm.*	*mm.*		*cm.*	*mm.*	
Upper layer	12.9	33.4	0.262	20.9	43.8	0.210	17.8	39.7	0.223
Intermediate layer	15.0	39.7	0.265	16.9	47.7	0.282	16.2	44.8	0.276
Surface layer	1.7	5.5	0.322	11.2	31.4	0.278	7.6	21.5	0.283
Entire snow cover	29.6	78.6	0.265	49.0	122.9	0.251	41.6	106.0	0.255

The increase in snow density from above downward shows here no such regularity as could be demonstrated mathematically, for example, but nevertheless the mean for a number of years was computed. In single instances these stand out, as, for example, in a clearing where six layers were measured, whose depth and density from above downward were as follows:

	1	2	3	4	5	6
Depth (cm.)	21.0	4.0	4.0	2.8	5.5	10.0
Density	0.220	0.343	0.250	0.253	0.282	0.238

To a certain extent the snow cover reveals a history of the weather during the presence of the snow. The layers, 2, 4, and 6 fell and existed during thawing weather, with very large grains, except the last. It should be noted that the density of the lower, quite hard layer was only a little greater than that of the moderately soft upper ones. Thus the structure of the snows in this respect appears to play a more important rôle than the absolute differences in density.

The maxima and minima of the entire snow cover were as follows:

	Open field.			Woods and clearings.		
	Depth.	Water content.	Density.	Depth.	Water content.	Density.
	cm.	*mm.*		*cm.*	*mm.*	
Maximum	39.5	110.7	0.287	57.5	140.7	0.260
Minimum	24.0	61.6	0.222	19.5	69.5	0.193

The measurements in the clearings show the most uniform results, as was to be expected. There the density varied only from 0.260 to 0.241, and the mean differed but little from the general means.

That the density in the field was greater than in the protected places is entirely due to the packing together of the snow by the wind, and it is most significantly marked in the upper layers, because the hard surface layer is almost entirely absent. However, the influence of the age of the snow cover is apparent in the woods, because in those places where the surface layer was thickest as a whole, the density of the whole snow cover reached a higher value than otherwise. Because of the much smaller snow depth the water content in the field was less than in the protected places, despite the greater density.

The difference between the protected and unprotected places of observation, namely, 19.4 cm. (depth) and 44.3 mm. (water content) distributed themselves in the upper, middle, and lower layers in the following manner: Upper layer, 8.0 cm. and 10.4 mm.; middle layer, 1.9 cm. and 8.0 mm.; the lower layer generally 9.5 cm. and 25.9 mm. Since the differences between the various places of observation are such that the snow collects in one place better than in another, or the decrease of the snow through thawing weather occurs mainly because of the varied influence of the different winds, the highest and lowest layers here come under consideration. This becomes evident during a cold period, and the difference, corresponding mainly to the varied accumulation of the snows, dates from the first periods of the snow cover, where decided thaws eat up the snow in great measure. Their differences thus make essentially clear the last-mentioned viewpoint, wherein consideration must also be given to the fact that over the field less snow has fallen originally than over the protected areas, about in the same proportion as the upper layer yielded. The effect of the thawing weather is thus stronger than that of the remaining factors, although the air temperature during the existence of the snow cover has fallen below the normal. The average proportions result first from several years' observations. In mild winters the influence of thawing weather easily predominates, whereas in cold winters the different deposits of the snows become of more importance. In the Southwest the former, in the East and North the latter factor is the stronger, and after the early year the thawing weather and the sunshine play an increased part.