

POLLEN-ANALYSIS INVESTIGATION OF A 20 m. FIRN PIT ON THE KESSELWANDFERNER (ÖTZTAL ALPS)

By W. AMBACH, S. BORTENSCHLAGER and H. EISNER

(Physikalisches Institut der Universität Innsbruck, Innsbruck, Austria)

ABSTRACT. Firn samples from a 20 m. deep pit were examined by pollen analysis methods in order to confirm the stratigraphy of the annual net accumulation back to 1949. The late summer horizon separates the overlying winter layer with a small pollen content from a firn layer with a large pollen content. There are also differences in the spectra of the species which enable a seasonal separation of the layers. In addition, the mineral dust content was examined.

RÉSUMÉ. *Recherches polliniques d'un puits de 20 m dans le névé du Kesselwandferner (Alpes d'Ötztal).* Les échantillons de névé d'un puits de 20 m ont été soumis à l'analyse pollinique en vue de confirmer l'étude stratigraphique de l'accumulation nette annuelle jusqu'en 1949. L'horizon de fin d'été est séparé de la couche hivernale à faible teneur en pollens par une strate de névé à forte teneur en pollens. Il y a aussi des différences dans le spectre des espèces qui permettent une séparation saisonnière des couches. De plus, on a aussi examiné la teneur en poussières minérales.

ZUSAMMENFASSUNG. *Pollenanalytische Untersuchung eines 20 m tiefen Firnschachtes auf dem Kesselwandferner (Ötztaler Alpen).* Mit Hilfe der Pollenanalyse wurden Firnproben aus einem 20 m tiefen Schacht untersucht, um die jährlichen Firnrücklagen zurück bis 1949 zu prüfen. Der Herbsthorizont trennt die darüberliegende Winterschicht mit geringem Pollengehalt von einer Firnschicht mit grossem Pollengehalt. Es zeigen sich auch Unterschiede im Spektrum der Pollenarten, wodurch eine jahreszeitliche Trennung der Schichten möglich ist. Zusätzlich wurde der Staubgehalt der Proben untersucht.

INTRODUCTION

A detailed analysis of the firn stratigraphy of a 20 m. deep firn pit on the Kesselwandferner (Ötztal Alps, 3,240 m. a.s.l.) was carried out by Ambach and Eisner (1966). The site of this pit is designated L58 in the paper by Hoinkes and Rudolph (1962, fig. 1). In order to confirm the analysis of the annual net accumulation, 35 firn samples were examined by pollen analysis. The method of pollen analysis of firn samples, which was described by Vareschi (1935[a], [b], 1937, 1940, 1942), could thus be successfully revived. In this paper it is shown that summer and winter layers can be easily distinguished by pollen analysis.

SAMPLING TECHNIQUE

The samples were collected from the pit wall by means of an ice-axe or an auger in the summers of 1963 and 1964. The outermost layer of approximately 10 cm. thickness was not used. The layer thickness of each sample is approximately represented in Figure 1. One litre of water from the melted firn sample was used for the determination of the pollen content, following Erdtman's (1936) method of acetolysis. Because it is impossible to separate all pollen grains from the water sample by centrifuging, the number of pollen grains per litre represents only a value for comparison with the total number of pollen grains.

RESULTS

The total number of pollen grains in each sample is represented in Figure 1, which also gives the site of each sample at the pit wall. The symbols denote the amounts of some species. The significantly large difference between the pollen content in the winter and summer samples can be seen very clearly.

The pollen content is usually small except in a thin layer just below the late summer horizon which shows the highest pollen numbers, up to 7,000 per litre. The large amount of pollen in this layer can be taken as a criterion of the late summer horizon and the maximum in the pollen content just below the late summer horizon can be explained easily. The pollen content increases during the melting of the snow which has accumulated after March. The

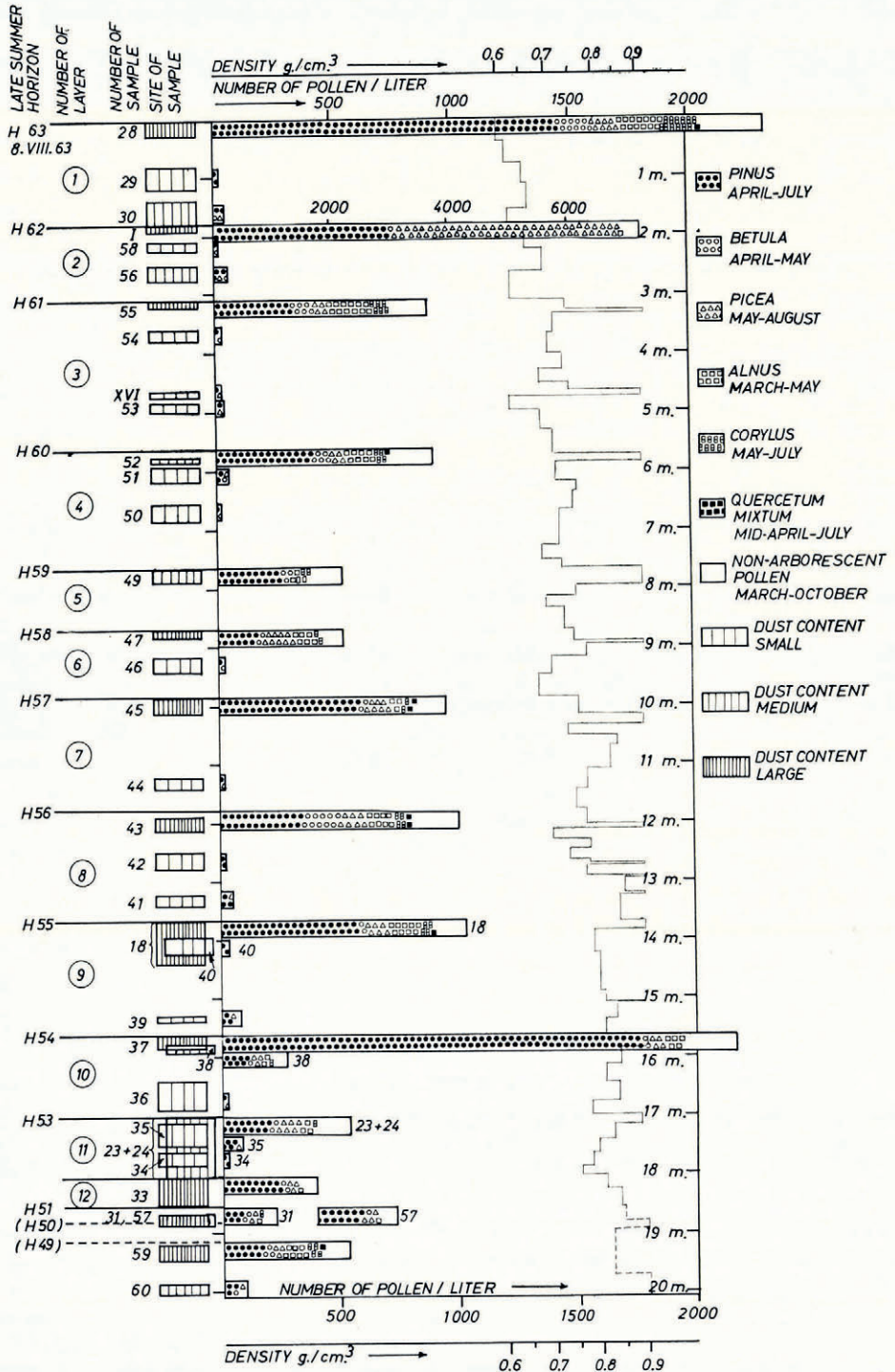


Fig. 1. Pollen-analysis profile of the 20 m. deep firn pit. Thin lines indicate the density profile. For sample I the scale (number of pollen grains per litre) is different as indicated

pollen grains remain on the surface as a residue, thus concentrating the pollen content of the snow just below the surface. In addition, new pollen grains are deposited during this period. All late summer horizons which have been determined by firn stratigraphy and density measurements (Ambach and Eisner, 1966) show a pollen maximum, thus confirming the earlier analysis of annual net accumulation. Samples 31 and 57 may indicate the late summer horizon of 1950 and the large amounts of pollen and dust in these samples result from the fact that the samples still contain the main pollen horizon.

Samples I and XVI (Fig. 1) were taken in the summer of 1964. Sample I confirms the late summer horizon of 1962. It was taken from a small pit situated 22 m. from the 20 m. deep pit. Sample I shows the largest pollen content of all the samples. One-eighth of the sample was examined and 916 pollen grains were counted in it. The main contribution is that of *Picea* (55 per cent), thus the year 1962 seems to have been a good year for *Picea*. Due to this fact, the late summer horizon of 1962 could be used for pollen-analysis dating in this area.

Sample XVI was taken from the thick ice layer in the horizon H61–H60 in the 20 m. deep pit. It was confirmed that this layer is not a late summer horizon because of the low pollen content and the species of pollen grains present. It contains only 28 pollen grains per litre. The spectrum of species corresponds to an autumn sample, because 20 per cent of the pollen grains are autumn pollen. This demonstrates that the displacement of pollen by melt-water incursion cannot be significant. This result is very important, because it demonstrates that a thick ice layer is not necessarily related to a late summer horizon.

Samples 37 and 38, and 52 and 51 demonstrate that by pollen analysis a sharp separation into a summer layer with a large amount of pollen and a winter layer with little pollen is possible, if closely adjacent samples are taken. Sample 33 and the mixed samples 23 and 24 were taken from a complete layer of annual net accumulation. As this layer is composed of the summer layer as well as the winter layer, the pollen content is relatively high. Sample 18 contains the pollen of a summer layer but it also contains part of the winter layer which is represented by sample 40. Sample 31 was taken from the opposite wall of the pit but it shows the same pollen content as sample 57.

The relative distribution of pollen and spore species was determined for each of the samples, and pollen grains and spores of 57 different species were counted. These results, which are not given here in detail, enable a more exact statement of the stratigraphy to be made in some cases. At first sight, the pollen contents of the summer and winter layers appear to be similar, because pollen grains had been displaced, probably during collection of the samples or by melt-water incursion. A more thorough examination of the pollen-grain numbers and the spectra of pollen species shows, however, that there are differences according to which a sub-division into spring, summer, autumn and winter layers is possible. For instance, samples 59 and 58 have similar tree-pollen compositions and therefore sub-division into summer and winter layers would normally be impossible. However, on the basis of a careful examination for herb pollen and absolute pollen content, samples 59 and 58 can be clearly assigned to summer and winter layers, respectively. The same is true for spring samples, in which pollen of late-flowering plants predominates.

Pollen grains are deposited on the surface of a glacier relatively early, i.e. usually one week or, at the latest, two weeks after the beginning of flowering. This discussion shows that the layer of annual net accumulation is composed primarily of the winter accumulation, which had been deposited up to March. Accumulation after that period melts during the ablation period.

To examine the accumulation of the different seasons, the samples have to be taken at very close intervals of about 10 cm. If only a separation between summer and winter layers is needed, no detailed examination of the pollen species is necessary, because of the significant difference in the amount of pollen and spores in the summer and the winter layers.

The number of mineral dust particles was also estimated under the microscope and the

relative particle content is shown in Figure 1. The summer layers contain more dust than the winter layers but quantitative dust analysis has not been carried out.

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REFERENCES

- Ambach, W., and Eisner, H. 1966. Analysis of a 20 m. firn pit on the Kesselwandferner (Ötztal Alps). *Journal of Glaciology*, Vol. 6, No. 44, p. 223-31.
- Erdtman, G. 1936. Neue pollenanalytische Untersuchungsmethoden. *Bericht über das Geobotanische Forschungsinstitut Rübel in Zürich*, 1935, p. 38-46.
- Hoinkes, H. C., and Rudolph, R. 1962. Mass balance studies on the Hintereisferner, Ötztal Alps, 1952-1961. *Journal of Glaciology*, Vol. 4, No. 33, p. 266-80.
- Vareschi, V. 1935[a]. Blütenpollen im Gletschereis, eine neue glaziologische Methode. *Zeitschrift für Gletscherkunde*, Bd. 23, Ht. 4-5, p. 255-76.
- Vareschi, V. 1935[b]. Pollenanalysen aus Gletschereis. Vorläufige Mitteilung mit besonderer Berücksichtigung des Problems der Pollenstreuung. *Bericht über das Geobotanische Forschungsinstitut Rübel in Zürich*, 1934, p. 81-99.
- Vareschi, V. 1937. Prüfung der neuen pollenanalytischen Methode der Gletscherforschung an Hand eines Firnprofils bekannter Entstehungszeit. *Zeitschrift für Gletscherkunde*, Bd. 25, p. 17-35.
- Vareschi, V. 1940. Pollenniederschlag in den Hochalpen. *Zeitschrift für die gesamte Naturwissenschaft*, Bd. 6, Ht. 3-4, p. 62-74.
- Vareschi, V. 1942. Die pollenanalytische Untersuchung der Gletscherbewegung. *Veröffentlichungen des Geobotanischen Instituts Rübel*, Bd. 19.