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POLLEN DISPERSION AND THE DESTRUCTION DEGREE

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Abstract. Separate curves for the pollen types included within the *gradus destructionis* curve were calculated; they are discussed together with available information on pollen corrosion. The result is also compared with some aspects on differential pollen dispersion.

Working with pollen analysis the analyst often registers corroded pollen grains and spores. When the state of preservation is very bad, difficulties will appear in determining the pollen and spores into species or groups of species, and in older literature whole diagram sectors are often shown with only one message: Pollen content too corroded to be determined.

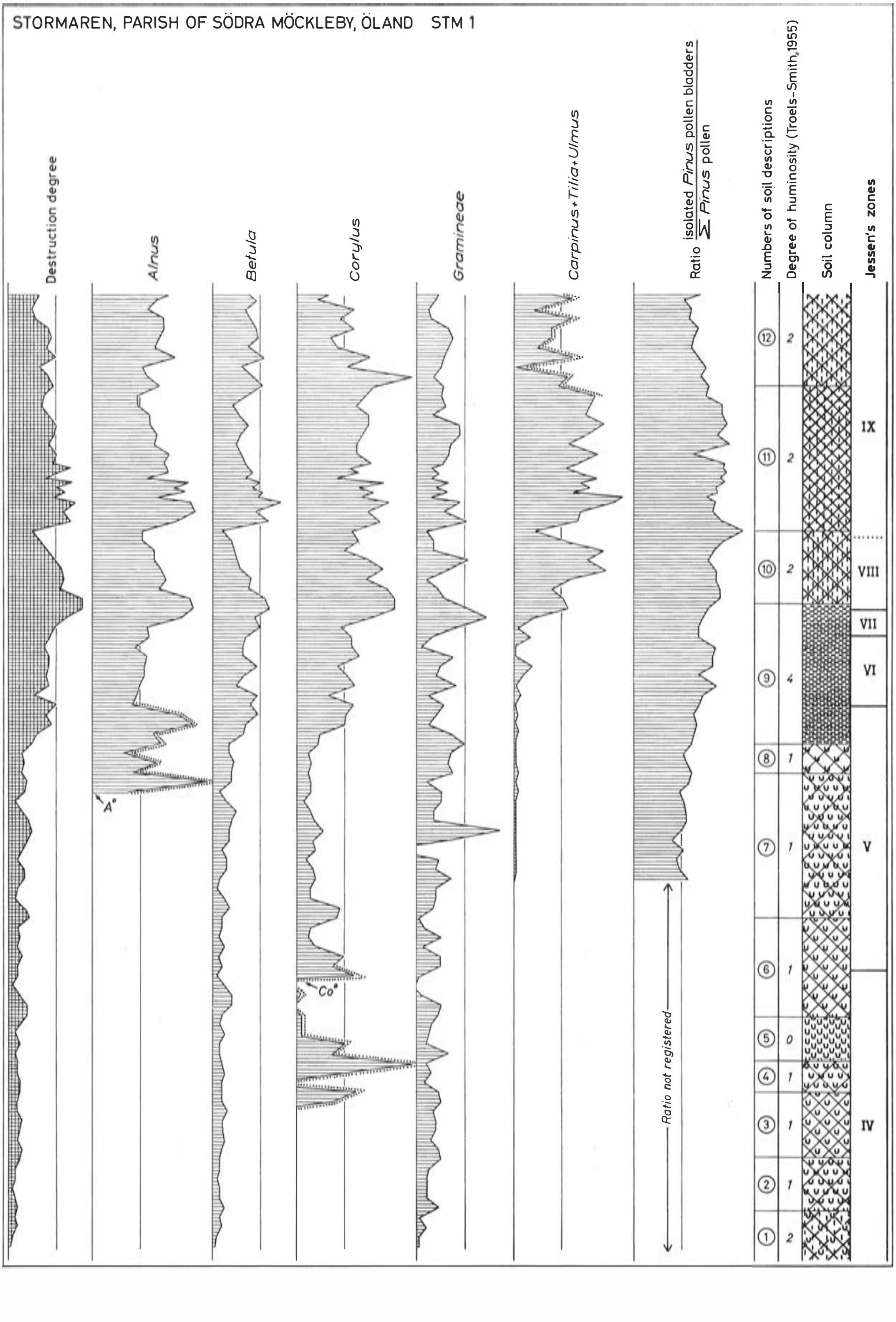
In "Textbook of pollen analysis", Faegri & Iversen (1964) mention the differential destruction of pollen grains among the classical sources of error within the pollen analytic method (p. 120). "As the composition of the exine and its resistance to corrosion differ from one group to the next, it goes without saying that if pollen grains are subject to any notable degree of corrosion during fossilisation or after, the composition of the pollen flora will change, the more resistant types will appear to accumulate owing to the disappearance of their counterparts, the less resistant pollen grains". It is also said that the sample should be discarded if more than half of the sum of the pollen grains of deciduous trees shows signs of any corrosion. "In normal diagrams, intended to be used as a standard for the area, corrosion should not be tolerated at all". In sediments, generally very little corrosion is said to be noticed while in aerated peats it is a grave source of error (p. 120).

Troels-Smith constructed a registration and calculation method for what he named "the destruction degree" (1941), when he worked with the pollen analytical dating of a reindeer antler hammer. The registration of pollen destruction as it was described by Jørgensen (1963) has ever since been a standard method of the Department of Science, Danish National Museum. Destruction, which was observed on pollen grains (Jørgensen 1963, p. 16) from *Alnus, Tilia, Ulmus, Betula, Corylus* and *Gramineae* was investigated in this respect. (In Jørgensen's paper *Alnus* was unfortunately omitted in the list.)

Berglund (1963) used the method too, but he only registered the observed destruction on pollen grains from *Alnus, Betula,* and *Corylus* in his curve (p. 420).

The present author has also used the method, and in a recent paper on the Holocene history of the Great Alvar of Öland (Königsson 1968) a curve for the destruction degree is given in most diagrams.

In this paper, the curve for the destruction degree in the diagram from Stormaren, an Alvar lake in the southernmost parts of the island, will be further treated. Separate curves for the pollen types included within the *gradus destructionis* curve were calculated together with a curve for the ratio between the registered isolated *Pinus* bladders and the sum of *Pinus* pollen total. They were drawn on a special diagram (Fig. 1). On the diagram the huminosity of the soils is given for each stratigraphical unit according to Troels-Smith (1955). Jessen's pollen zones (1935, 1938) have also been marked and the soil column has been constructed according to Troels-Smith's system (1955). The following soils have been described: 1. Peaty gyttja with calcareous gyttja substance. 2–4. Calcareous gyttja with gyttja substance. 5. Lake marl. 6–8. Calcareous gyttja with gyttja substance. 9. *Substantia humosa*. 10. Peaty gyttja. 11. Gyttja with peat substance. 12. Peaty gyttja.


STORMAREN, PARISH OF SÖDRA MÖCKLEBY, ÖLAND STM 1
Destruction degree
Alnus
A°
Betula
Corylus
Co°
Gramineae
Carpinus+Tilia+Ulmus
Ratio isolated Pinus pollen bladders / Σ Pinus pollen
Ratio not registered
Numbers of soil descriptions
Degree of huminosity (Troels-Smith, 1955)
Soil column
Jessen's zones
12 2
11 2
10 2
9 4
8 1
7 1
6 1
5 0
4 1
3 1
2 1
1 2
IX
VIII
VII
VI
V
IV

Sequence of increasing corrosion susceptibility compiled from older literature	Sequence of increasing oxidation susceptibility	Sporopollenine contents in pollen and spores	Observed pollen corrosion in moss humus pollen spectra	The proportions of the tested pollen and spore species in leaf mould and river clay in a greenhouse after 20 months, showing a more or less perforated exine Leaf mould	River clay
Lycopodium Conifers *Tilia* *Corylus* *Alnus, Betula* *Quercus* *Fagus*	*Lycopodium clavatum* *Polypodium vulgare* *Pinus silvestris* *Tilia* sp. *Alnus glutinosa, Corylus avellana, Myrica gale* *Betula* sp. *Carpinus betulus* *Populus* sp., *Quercus* sp., *Ulmus* sp. *Fagus silvatica, Fraxinus excelsior* *Acer pseudo-platanus* *Salix* sp.	*Lycopodium clavatum* *Pinus silvestris* *Tilia* sp. *Alnus incana* *Corylus avellana* *Betula verrucosa* *Carpinus betulus* *Ulmus* sp. *Acer negundo* *Quercus sessiliflora* *Populus alba*	*Fraxinus* *Quercus* *Betula* *Tilia* *Fagus* *Alnus* *Corylus*	*Lycopodium clavatum* *Polypodium vulgare* *Juniperus communis* *Taxus baccata* *Quercus robur* *Salix* sp. *Fraxinus excelsior* *Populus* sp. *Pinus silvestris* *Acer pseudo-platanus* *Betula verrucosa* *Fagus silvatica* *Carpinus betulus* *Alnus glutinosa* *Tilia* sp. *Ulmus carpinifolia* *Corylus avellana* *Myrica gale*	*Lycopodium clavatum* *Polypodium vulgare* *Juniperus communis* *Taxus baccata* *Quercus robur* *Salix* sp. *Fraxinus excelsior* *Populus* sp. *Acer pseudo-platanus* *Pinus silvestris* *Tilia* sp. *Betula verrucosa* *Fagus silvatica* *Carpinus betulus* *Ulmus carpinifolia* *Alnus glutinosa* *Myrica gale* *Corylus avellana*
HAVINGA 1964	HAVINGA 1964	KWIATKOWSKI and LUBLINER-MIANOWSKA 1957	ANDERSEN 1967	HAVINGA 1967	

Fig. 2. Table showing corrosion susceptibility and sporopollenine content in certain pollen and spore types.

For detailed information as to the soils and their composition, the information in Königsson (1968, p. 87) can be referred to.

On the diagram the line marking 40% has been drawn together with each curve. On the parts of the curve, where the calculation material is considered to be unsafe, a dotted line follows the curve. The area under the curve for the destruction degree is marked with a diamond pattern cover, those of the separate curves by horizontal lines.

On the whole there is very little destruction of the pollen content in the lower eight stratigraphical units of Stormaren. With the change to *Substantia humosa* the rate of destruction increases and just below the stratigraphical transition 9/10, it reaches a distinct maximum. The rate diminishes in the rest of the diagram from around 40% to 20%. In the upper part of the soil layer 10, however, corresponding to the later part of zon VIII, a minimum appears.

The different components of the curve of the destruction degree largely show the same trend. The total values of the curves, however, have diverging figures. *Alnus, Corylus,* and the collective curve for *Carpinus, Tilia,* and *Ulmus* all amount to 40% or more, while the *Gramineae* curve amounts to around 20% and that of *Betula* to slightly more. This picture is very interesting as most of the *Gramineae* and *Betula* pollen can be expected to be rather locally produced, while the others appear to have been transported relatively long distance to the Alvar lake (cf. Königsson 1968, pp. 158, 159). This will be further discussed below.

In an interesting paper on differential corrosion susceptibility of pollen and spores, Havinga (1964) compiled available literature and discussed it in relation to his own experiments, where the oxidation effect, and the effect of bacterial and fungial attacks were studied.

Many authors, according to Havinga, consider that the exine will oxidize in a natural aerobic environment, but he remarks that this was never proved accurately. Havinga's experiments showed that the oxidizing effects perhaps might not be as big as had been assumed before, but the oxidation effect, which was observed in the experiments, still proved to be a good indicator of corrosion resistance in a natural environment. As to bacterial attacks on pollen material, experiments with *Pinus* and *Populus* pollen in a nutrient solution, suitable for growth of bacteria and inoculated with some earth, showed very few traces of corrosion on the pollen. Experiments with yeasts gave same result. When, however, the pollen material in the experiments was first oxidized and then inoculated with bacteria and fungi, the corrosion effect became very heavy and very quick.

Fig. 1. Diagram showing the destruction degree in the pollen diagram from the Alvar lake Stormaren. For each curve the 40% line has been drawn.

The information on corrosion susceptibility available was collected in a table by Havinga (1964, p. 625); in this paper it can be found summarized on Fig. 2. Together with this, another series containing Havinga's own experimental observations on oxidation susceptibility is given and also a series with known sporopollenine contents in certain pollen and spores (Kwiatkowski and Lubliner-Miankowska 1957). Observed corrosion affinity for pollen in moss humus samples (Andersen 1967) is given together with the proportion of the tested pollen and spores in river clay and leaf mould which were stored in greenhouse experiments for 20 months. These showed a more or less perforated exine (Havinga 1967).

It is notable that the pollen and spores, which derive from rather primitive plants show greatest resistance to corrosion, and they also have the highest sporopollenine content in their exines.

In the Stormaren diagram the highest percentage of observed corrosion was registered on *Corylus, Alnus,* and the collective group: *Carpinus, Tilia* and *Ulmus.* In the literature compilation *Corylus* is said to show less susceptibility to corrosion than *Alnus* and *Betula.* In the list of observed corrosion susceptibility *Alnus* and *Corylus* are said to be more resistant than *Betula.* The sporopollenine content in the different types are: *Alnus incana* 8.8%, *Corylus avellana* 8.5%, *Betula verrucosa* 8.2%. Andersen's observations, however, indicate that *Alnus* and *Corylus* show less resistance to corrosion than *Betula* and in Havinga's greenhouse experiments *Corylus avellana* showed perforations in the exine in 96% and 92% of the investigated pollen (leaf mould and river clay samples) while the corresponding figures for *Alnus glutinosa* were 60% and 79% and for *Betula verrucosa* 25% and 15%.

According to the first three columns *Betula* seems to be more or less equal to *Alnus* and *Corylus* in its ability to resist corrosion, while the last three columns show that *Betula* can be expected to be better preserved than the other two. This may correspond with the Stormaren material, and would indicate similar qualities for *Gramineae* if the conclusion is correct.

If, however, the first three columns' information is correct, another interpretation of the Stormaren material has to be made. Havinga (1964, p. 628) emphasizes, as has been noted above, that bacterial and fungial attacks show a quicker corrosion response if the sample has been oxidized before the attack. This may then have been the case for the long distance transported *Alnus* and *Corylus* pollen in the Stormaren diagram, while the bulk of the pollen from *Betula* and *Gramineae* emanate from source communities more nearby. Tauber (1967) in his paper on the mode of pollen transfer in forested areas found that a considerable part of the pollen, which was deposited in his samplers during a test year, was deposited in the "refloatation" period (registration which was performed during the period August 1st to November 26th). The refloatation pollen was first captured on twigs and branches during the flowering period. It was then released and spread again later during the year.

The combination of long distance transport and the refloatation effect may yield enough time for the oxidation of the mentioned *Alnus* and *Corylus* pollen so that bacterial and fungial attacks upon the pollen will result in corrosion when the pollen is deposited in the central telmatic fen communities of the Alvar lake.

The curve for the ratio between the isolated *Pinus* pollen bladders and the total sum of registered *Pinus* pollen approximates to those of *Alnus* and *Corylus.* The general level of the curve, in its maximum parts, is around 40% and it may be discussed if this ratio can be expected to reflect corrosion effects to a greater extent. Mechanical destruction by the vigorous dispersion of the sample in connection with the preparation for pollen analysis is probably involved in the complex of reasons for the development of the ratio. It is also obvious that a natural corrosion factor is involved in the complex to a considerable extent. The curve for this ratio may therefore have some value for the discussion of the destruction degree. However very few pieces of real information as to these suppositions have been published and further investigation is necessary.

The necessity of general corrosion investigations is also obvious. In the near future pollen analysis will be used at an increasing rate in ecological and palaeo-ecological research. In these types of studies, environments where much corrosion of the pollen can be expected will be of essential interest to the future investigators; the importance of intensified work on pollen corrosion and of the significance of the destruction degree is great.

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