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CONTRIBUTIONS TO THE EUROPEAN POLLEN DATABASE

75. Lake Tenndammen, Colesdalen, Nordenskiöld Land, western Svalbard (Spitsbergen) archipelago

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Site details

The study site, small (0.15 ha), shallow (mean depth of 1.5 m; for details see Poliakova et al. 2024) lake Tenndammen (N 78°06.118′; E 15°02.024′, altitude 5 m above sea level [a.s.l.]) is located about 1 km away from the Greenland Sea shore in the Colesdalen (Coles valley), Svalbard (Spitsbergen, Шпицберген). The research area is known as one of Svalbard's biodiversity hotspots, with the highest number and concentration of rare, relatively thermophilous species (Engelskjøn et al. 2003; Arnesen et al. 2014). *Salix polaris* Wahlenb., *Carex* and Poaceae species make up most of the vegetation cover of the Coles valley. Bryophytes, including submerged taxa, are common as well.

Sediment description

Five sedimentary units were defined based on the lithological description of core Te2019 as follows:

Unit L1 (85–75.5 cm)

Consists of grey-brown, structureless clayey peat with clasts in the lower 2 cm. Loss on ignition at 550 °C (LOI_{550}) ranges between 8.5% and 21.8%. The clay-rich peat and the relatively low LOI_{550} suggest deposition in a shallow lacustrine environment with continuous inflow of minerogenic sediment.

Unit L2 (75.5–47.5 cm)

Dark brown peat. From *c.* 75.5–68 cm, the unit contains rounded sand-gravel sized clasts which are discoidal. The LOI_{550} of the core shows the largest fluctuations and also peaks in L2. The peat indicates deposition in a shallow lacustrine environment, and the clayey peat layers suggest episodic inflow of minerogenic sediment.

Unit L3 (47.5–30 cm)

Olive-brown to brown, laminae consist of pale-brown to greyish-brown laminated clay with layers of gyttja of 0.3–0.5 cm; each lamina is about 0.1–0.6 cm thick. LOI_{550} varies between 6% and 7%, showing its minimum value of 2% at 32 cm and maximum value (10.5%) at 36 cm. The lithology indicates a shallow lacustrine environment with strong variations in clastic input.

Unit L4 (30–20 cm)

Consists of massive, structureless olive-brown clay. LOI_{550} is stable at *c.* 6.4% throughout L4. The clay indicates deposition in a low-energy lacustrine

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environment dominated by minerogenic sedimentation.

Unit L5 (20–0 cm)

Olive-brown clayey gyttja. LOI_{550} ranges between 1.0% and 18.6%. The clay and gyttja suggest deposition in a low-energy lacustrine environment.

Based on the multiproxy Te2019 core investigation that involved sediment ancient DNA studies, botanical microfossil (pollen, spore and non-pollen palynomorphs) and macrofossil (seeds and tissue fragments), as well as X-ray fluorescence (XRF), LOI_{550}, grain size and portable optically stimulated luminescence (pOSL), four composite palaeo-units (Te2019-I –Te2019-IV) are presented in Figure 1, Supplementary material S1, and further described in Poliakova et al. (2024)

Dating

To establish a chronology from the Tenndammen sedimentary record, 13 radiocarbon ages (see Supplementary material S2) were converted into calibrated years (cal. yr) before present (BP; BP = before CE 1950) using OxCal (v4.3.2; Bronk Ramsey 2017), and the IntCal13 calibration curve (Reimer

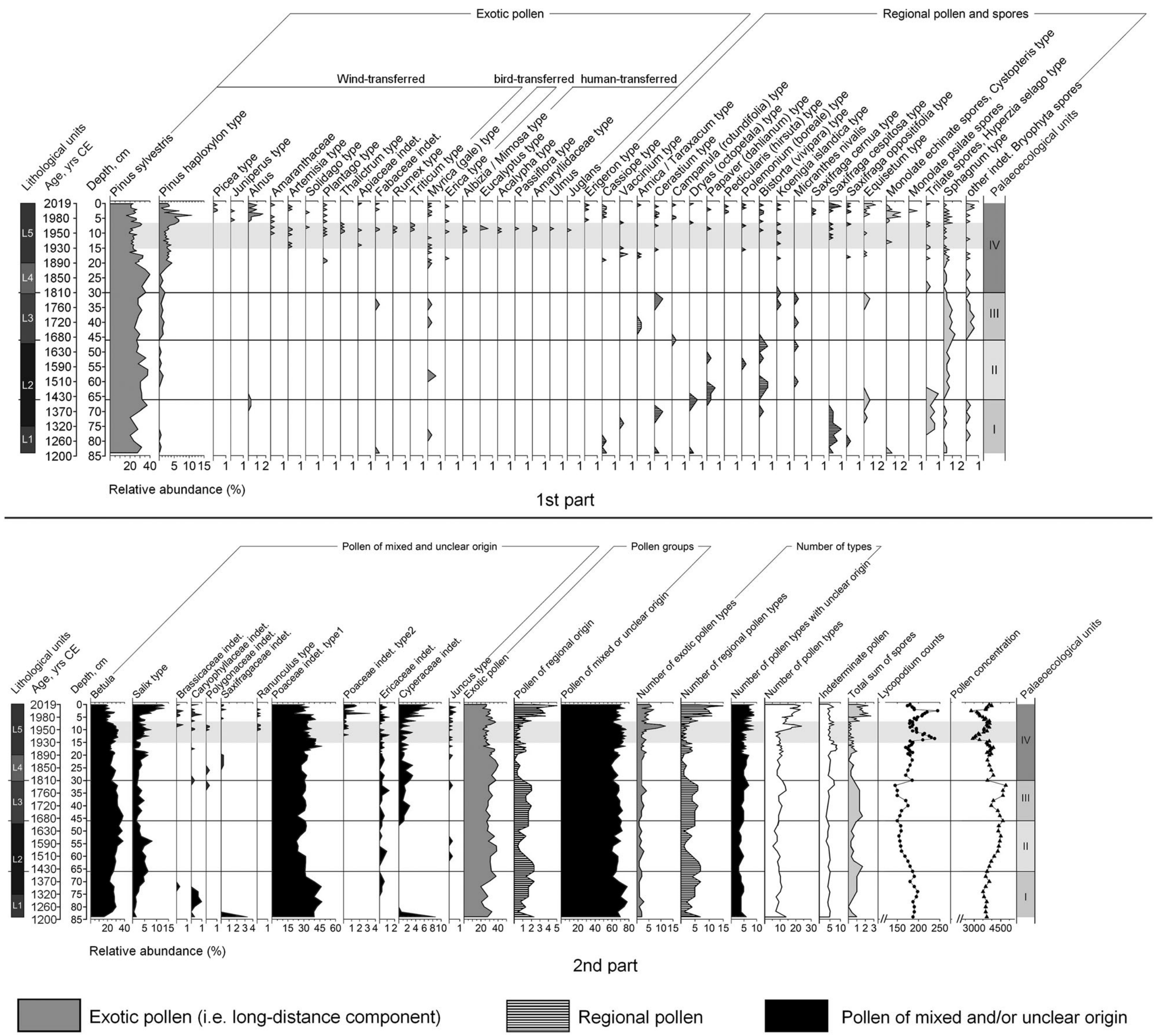

Figure 1. Pollen diagram showing relative abundances of the individual pollen types; sums of exotic pollen, regional pollen and pollen mixed or unclear origin; numbers of exotic pollen types, pollen types of regional and mixed or unclear origin; general numbers of pollen types, *Lycopodium* marker counts and pollen concentrations. Timeframe between 1929 and 1962 in the diagram is marked with grey shadow.

et al. 2013) was used in both cases. Faced with multiple reversals, we did not succeed in constructing an age-depth model using the BACON approach. There were a number of constraints that had to be considered: (1) the regional uplift curve indicates that the base of the sequence (marine sands) cannot be older than 1000 years BP and probably lie within the period of 700–1000 years (Landvik et al. 1987). This suggest that the lower two dates which are similar and overlap statistically are reliable but approximate. (2) The spheroidal carbonaceous particle (SCP) profile provides a robust model down to 26 cm. The curvilinear interpolation between this model and the basal dates also incorporates two of the other carbon 14 (^{14}C) accelerator mass spectrometry (AMS) dates suggesting that they could be correct. The result is a model similar in its estimated sediment accumulation rates (*c.* 1.1 mm yr^{-1}) to other models in the region (Farnsworth 2020). This composite age–depth relationship was then modelled by Bayesian statistics using the program MacBacon 2.2 with default settings (Blaaw 2011) (Supplementary material S1).

Interpretation

In 2019, an 85 cm long and 60 mm in diameter sediment core Te2019 was obtained from the lake with the modified Nesje sediment sampler (Nesje 1992). Sampling was performed at every 2 cm throughout the core except the top most 20 cm, where sampling was performed at every 0.5 cm. In total, 73 samples were analysed according to the standard methods (Fægri & Iversen 1989). As initial pollen content was as low as 10–50 grains per slide, each sample was sieved several times over a nylon 10-µm filter in order to concentrate pollen material. The pollen sum includes all pollen taxa, i.e. (1) regional (sourcing specifically from Colesdalen or from larger areas of Svalbard), (2) exotic (clearly extra-regional pollen) and (3) pollen of mixed and/or unclear, both regional and extra-regional origin (see Poliakova et al. [2024] for details on the pollen group specification). Spores were not included. No aquatic taxa except microalgae were registered. Four pollen zones were defined (Figure 1):

Zone Te2019-I (66–84 cm; c. *1202–*c. *1370/1430 yr* CE*)*

Dominated by Poaceae indet. type 1 (~40% of total pollen sum), *Pinus sylvestris* (about 26%), *Betula* (~25%) and *Salix* type (~3%). Total contribution of regional pollen that is represented by eight pollen types and five spore types is *c.* 2% of the total pollen sum (Figure 1). Exotic pollen contributes ~27%, five pollen types.

Zone Te2019-II (48–64 cm; c. *1418/1668–* c. *1630/1680 yr* CE*)*

Pollen of mixed or unclear origin (~67% of total pollen sum) comprises five types with *Betula* representing ~32%, Poaceae indet. type 1 ~28%, and *Salix* type up to ~5%. The exotic pollen component

Table I. Radiocarbon dates for Lake Tenndammen.

Depth (cm)	Laboratory ID	^{14}C age	Cal. W. mean	Cal. median	Cal. 2σ range	Sample content
4.0	**Poz-121134**	**500 ± 30**	**1395**	**1450**	**1399–1450**	**Moss (*Caliergon, Warnstorfia*)**
7.0	**Poz-121135**	**1095 ± 30**	**924**	**1017**	**890–1017**	**Moss (*Caliergon, Warnstorfia*)**
9.0				1912	1911–1913	SCP
11.0	**Poz-121136**	**505 ± 30**	**1393**	**1450**	**1396–1450**	**Moss (*Caliergon, Warnstorfia*)**
12.0				1944	1941–1946	SCP
18.0				1955	1951–1958	SCP
20.0	**Poz-112299**	**845 ± 30**	**1183**	**1267**	**1159–1267**	**Moss (*Caliergon, Warnstorfia*)**
32.0	**Poz-121138**	**550 ± 30**	**1472**	**1607**	**1397–1607**	**Moss (Caliergon, Warnstorfia)**
34.0	**Poz-123841**	**470 ± 40**	**1336**	**1434**	**1318–1434**	***Salix polaris* leaves**
44.0	**Poz-121139**	**535 ± 30**	**1351**	**1439**	**1323–1439**	**Moss (*Caliergon, Warnstorfia*)**
54.0	**Poz-112300**	**445 ± 30**	**1423**	**1490**	**1416–1490**	**Moss (*Caliergon*)**
56.0	Poz-123842	290 ± 30	1551	1662	1499–1662	*Salix polaris* leaf fragments
64.0	Poz-112301	460 ± 30	1412	1471	1412–1471	Moss (*Caliergon*)
66.0	**Poz-123843**	**305 ± 30**	**1543**	**1653**	**1492–1653**	***Salix polaris* leaf fragments**
74.0	**Poz-112302**	**760 ± 30**	**1224**	**1285**	**1222–1285**	**Moss (*Caliergon, Warnstorfia*)**
80.0	Poz-112303	755 ± 30	1226	1288	1224–1288	Moss (*Caliergon, Warnstorfia*)

Note: Dates shown with their 1σ error, calibrated weighted (Cal. W.) mean, calibrated median and calibrated 95% confidence age ranges. Reversal dates are depicted in bold typeface. SCP, spheroidal carbonaceous particle.

includes three types with *Pinus sylvestris* being most abundant, ~32% (Figure 1), other types contribute less than 1% altogether. Pollen of regional origin makes up *c.* 1% of total pollen sum (Figure 1).

Zone Te2019-III (32–46 cm; c. *1630/1680–* c. *1810/1850 yr* CE*)*

Pollen of mixed or unclear origin (69%, Figure 1) is represented mainly by *Betula* (~34% of total pollen sum), Poaceae indet. type 1 (~30%), *Salix* type (~3%), and Cyperaceae indet. adding ~2%. Exotic pollen contributes *c.* 29% (four types). Pollen of regional origin is about 2% of total pollen sum.

Zone Te2019-IV (0–30 cm; c. *1810/1850–*c. *2019 yr* CE*)*

Pollen of mixed or unclear origin forms 69% of the total pollen sum and is composed of 21 pollen and spore types (Figure 1). Pollen of regional origin is most diverse: 15 pollen and six types of spores, but they form only 1% of the total pollen sum. Twenty-three exotic pollen types are recorded (Figure 1), among them *Acalypha* type, *Albizia*/*Mimosa* type, *Eucalyptus* type, Amaryllidaceae type, and *Juglans*, found exclusively in the time period *c.* 1938–1966 yr CE when the most intensive human activity and migration to and from Colesdalen is historically known (The ArctikUgol Mining Company 2020). Evidence for this period has also been provided by palaeoecological studies in Svalbard (Poliakova et al. 2024).

Since *c.* 1200 CE until modern times, the contributions of regional (including Svalbard) pollen, long-distance dispersed extra-regional pollen, and pollen with mixed and unclear origin in Colesdalen have been relatively stable and are about 1%, 29%, and 70%, respectively. Increasing taxonomic diversity of exotic pollen is strongly correlated with human activities in the region. Pollen spectra well reflect human industrial and post-industrial history of Colesdalen.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Supplemental data

Supplementary material for this article can be accessed online at https://doi.org/10.1080/00173134.2024.2407341.

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