Pre-Wisconsin interglacial pollen spectra from Washington State, USA

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Introduction and discussion of data

Pleistocene deposits in the southeastern part of the Puget Sound lowland in western Washington have been mapped by Crandell and his associates (Mullineaux, Crandell, and Waldron, 1957); their stratigraphic sequence includes drift from four major glacial advances. Pollen analysis of pre-Wisconsin sediments at 12 localities shows both warming and cooling trends in the interglacial intervals; this paper is restricted to a discussion of pollen stratigraphy in sediments at two localities, both deposited during Puyallup time, which was the second interglacial interval in their sequence.

At the first locality near Enumclaw, Wash., nineteen feet of peat and clay, which rest directly upon drift of the second glaciation, are exposed and are disconformably overlain by drift of the third glaciation. Analysis of samples taken from intervals of 2 to 8 inches through the peat and clay yielded a pollen diagram (fig. 1) that records four major pollen phases; these are, starting with the oldest:

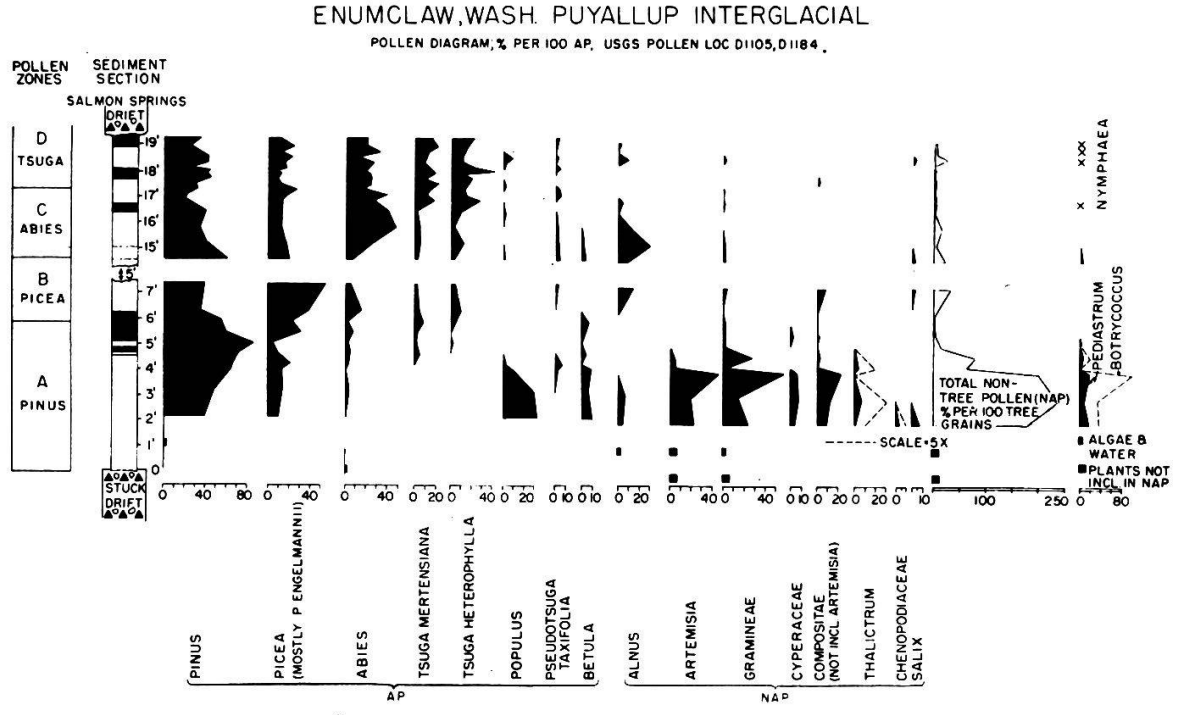

Fig. 1

[1] Publication authorized by the Director, U. S. Geological Survey.

A) an early dominance of non-arboreal pollen (NAP) types, including *Artemisia* and Compositae, grasses, sedges, *Thalictrum,* Chenopodiaceae, and *Salix.* This NAP maximum, associated with pine, *Populus,* and water plants, is followed by a great increase of pine.

B) a maximum of *Picea* pollen, mostly of the high altitude species, *P. engelmannii.*

C) prominence of *Abies* associated with *Alnus.*

D) as *Abies,* wanes, a rising importance of *Tsuga* (2 species): *T. heterophylla,* the lowland species, and *T. mertensiana,* the montane species.

The second diagram (fig. 2) from Zenith, Wash., is also based on pollen from sediments of the second interglacial interval. At the base of these sediments is a volcanic mudflow deposit of interglacial age. Fifty feet of laminated silt and clay that lie above the mudflow deposit are overlain by drift of the third glaciation. Only the lower half of the fine-grained sediments was sampled; the upper half is inaccessible owing to its vertical outcrop.

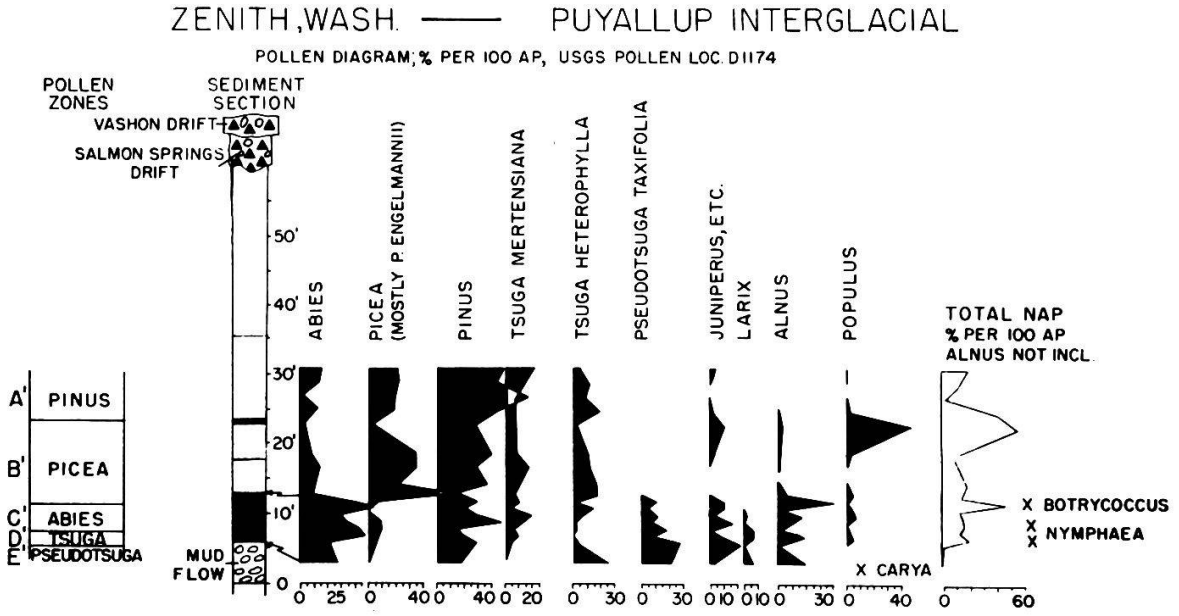

Fig. 2

The sequence at Zenith shows pollen zones similar to those in the Enumclaw section, but here they occur in a reverse order, and an additional zone (E') is present at the base (fig. 2). A pre-Wisconsin pollen chronology comparable to that in the Zenith section has been described from interglacial sediments of undetermined age in the Puget Sound lowland by Hansen and Mackin (1949).

Climate inferred from the pollen sequences

The Enumclaw pollen sequence, which begins with pine and cold-loving montane forms such as *Picea engelmannii* and ends with lowland forms such as *Tsuga heterophylla*, appears to record forest development during a warming climate early in the second interglacial. *Abies*, which characterized the middle phase (pollen zone C) now occupies areas of heavy rainfall in a wide range of altitudes in the mountains of this region; its importance in pollen zone C probably signifies a cool, moist phase of the second interglacial.

The Zenith profile shows in a general way the same sequence in a reverse order, and appears for that reason to reflect a cooling climate. The warmest assemblage in these pollen diagrams occurs in pollen zone E' of figure 2, and is in all respects like the modern pollen rain at this site.

Since the upper part of the Zenith section was not sampled, it is not certain whether the cooling trend recorded here represents the final one near the end of the interglacial, or only a part of some climatic oscillation during the interglacial.

Comparison with forest succession of postglacial

The forest development accompanying a climatic warming of the second interglacial includes at least a four-fold forest succession based on the Enumclaw profile, and probably a five-fold succession if pollen zone E' at Zenith follows. Vegetation stages are enumerated below showing characteristic trees and inferred climate:

A) NAP and *Pinus*	cold
B) *Picea engelmannii*	cold (moist?)
C) *Abies*	cool, moist
D) *Tsuga mertensiana* and *T. heterophylla*	cool, moist
E') *Tsuga heterophylla* and *Pseudotsuga taxifolia*	warmer and drier like present climate

In contrast, the pollen chronology of postglacial time (an interval of at least 14 000 radiocarbon years; WALDRON, MULLINEAUX, and CRANDELL, 1957) in the Puget Sound lowland (HANSEN, 1938) shows a succession of only three dominant forest types: 1) an early pine phase (cool and moist), 2) a dominance of *Pseudotsuga* (warmer and drier), and 3) a final dominance of *Tsuga heterophylla* (cooler and moister). Only the first two of these phases record a climatic warming.

In contrast to postglacial pollen diagrams from the region, the interglacial diagrams reported here have 1) a much greater importance of *Abies* and *Picea,* and 2) no record of any prolonged dominance of *Pseudotsuga.*

The warming of the second interglacial as recorded at Enumclaw, involved a far more complex forest succession than did the warming of the early postglacial in the Puget Sound lowland. Because it contained more major cool phases, this interglacial warming probably was more gradual, occurred over a longer period of time, and was accompanied by higher rainfall than that of the postglacial interval.

In Europe, major differences in pollen chronology are known to exist between different interglacials and the postglacial interval, e. g., in East Anglia, *Abies* zones are present in the Hoxnian Interglacial, absent in the Cromerian Interglacial and in the postglacial (West, 1955). Hence, comparable differences are not surprising in the present material.

Exotic trees which were important in the late Tertiary vegetation of Europe and the western New World (e. g., *Sequoia, Zelkova, Pterocarya),* and which are known to have existed in Europe until middle Quaternary time, were looked for but not observed in assemblages from the second interglacial of the Puget Sound lowland.

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