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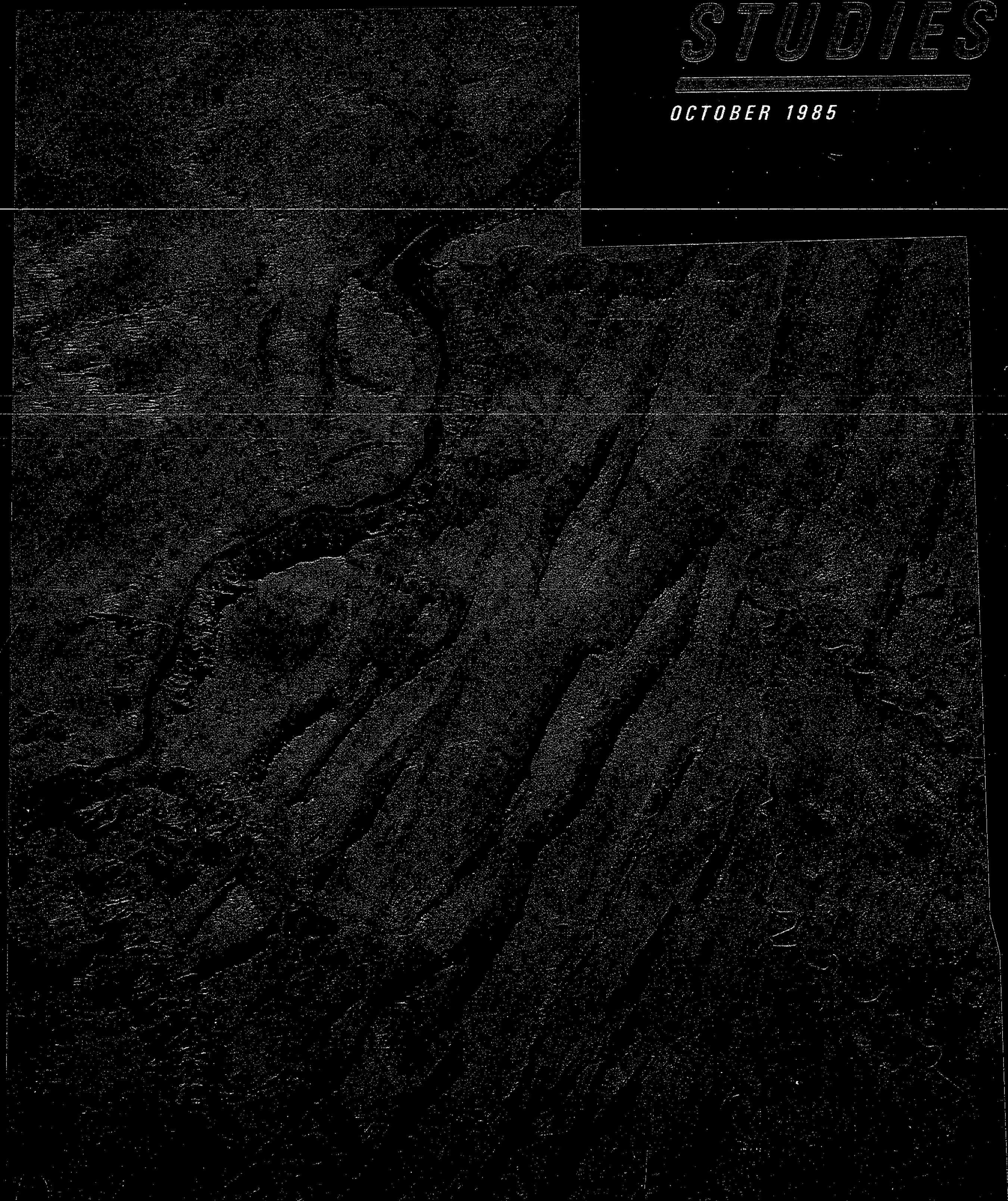
STUDIES

OCTOBER 1985



VOLUME 32, PART 1

BRIGHAM YOUNG UNIVERSITY
GEOLOGY STUDIES

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THE GLORY OF GOD IS INTELLIGENCE

A publication of the
Department of Geology
Brigham Young University
Provo, Utah 84602

Brigham Young University Geology Studies is published by the Department of Geology. This publication consists of graduate student and faculty research within the department as well as papers submitted by outside contributors. Each article submitted by BYU faculty and outside contributors is externally reviewed by at least two qualified persons.

Cover: High-altitude infrared aerial photograph of block faulting in the Permian Cutler-Rico formations near the junction of the Green and Colorado Rivers, Utah. Fall 1983. U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service. Salt Lake City, Utah: Aerial Photography Field Office.

ISSN 0068-1016
Distributed October 1985
10-85 600 76925

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A Pollen Study of Holocene Peat and Lake Sediments, Leidy Peak Area, Uinta Mountains, Utah

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ABSTRACT

Pollen data from a sediment core from a bog in the Leidy Peak area of the Uinta Mountains, Utah, yielded information concerning past climates. Radiocarbon dates indicate that a continuous record of the last 6,500 years is present in this core. Between 4,600 and 6,500 B.P. the climate appears to have been cooler than present. From 600 to 4,600 B.P., the climate appears to have been warmer than present, with the period of maximum warmth occurring between 2,100 and 4,600 B.P. From 100 to 600 B.P. the climate was the coolest represented in the core record. Forest fires, indicated by the presence of charcoal fragments in the sediment core, have been common in the past, but never had a major role in vegetational changes. This is indicated in the core by the fact that variations in pollen are unrelated to the abundance or absence of charcoal fragments. Furthermore, no sharp increases in the pollen of fire-indicator species are present in the core.

INTRODUCTION

Little is known about the Holocene vegetation and climate of the Uinta Mountains in Utah. To gain an understanding of past environments, sediment cores from a bog in the Leidy Peak area of the eastern Uinta Mountains were collected for pollen studies and radiocarbon dating.

The Uinta Mountains of northeastern Utah consist of a single east–west range of peaks. Numerous summits in the range exceed 3,950 m, the highest being Kings Peak (4,124 m). The range is eroded from a large anticlinal uplift whose axis is roughly the range crest. Exposed at the core of the anticline, and underlying the study site, is the Precambrian Uinta Mountain Group, a sequence of mostly red, medium-grained to coarse-grained siliceous sandstone, quartzite, and conglomerate about 7,300 m thick (Hansen 1965).

Despite the widespread occurrence of glacial deposits in the Uinta Mountains, few investigations of these deposits have been undertaken. Atwood (1909) identified deposits of two major glaciations ("earlier" and "later epochs") by their stratigraphic positions and morphological differences, such as degree of stream dissection and amount of kettle lake infilling. He estimated that, during these glaciations, the Uinta Mountains were covered by about 2,600 km^2 of glacial ice. In addition, Atwood recognized limited evidence for an even older glaciation. Bradley (1936) identified glacial deposits of three ages along the northern flank of the Uinta Mountains: from oldest to youngest, the Little Dry, Blacks Fork, and Smith Fork glaciations. Once again, these deposits were identified primarily by stratigraphic and morphological criteria. Bradley correlated the Blacks Fork glaciation with Atwood's "earlier epoch" and the Smith Fork glaciation with Atwood's "later epoch." In addition, Bradley correlated the three tills in the Uinta Mountains—Little Dry, Blacks Fork, and Smith Fork—with the Buffalo (pre–Bull Lake), Bull Lake, and Pinedale Tills, respectively, of the Wind River Range, Wyoming. Carrara (1980), in basic agreement with Bradley, identified tills of three ages in the eastern Uinta Mountains including the area encompassing the study site (fig. 1).

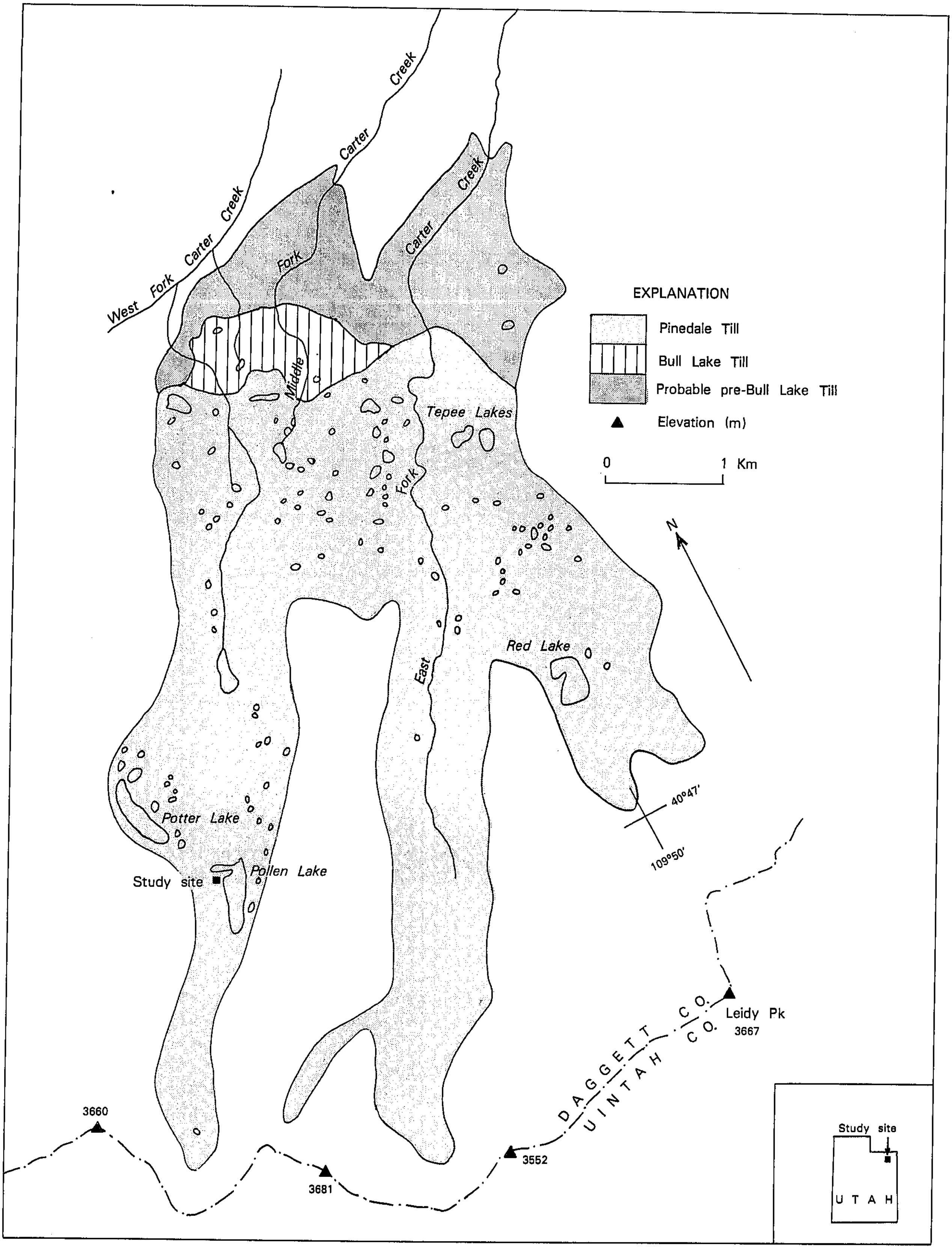

FIGURE 1.—*Generalized location map of the study area, eastern Uinta Mountains, Utah, showing the different age glacial deposits (after Carrara 1980).*

The study site is in the Leidy Peak area of the eastern Uinta Mountains in a poorly drained depression adjacent to Pollen Lake, about 3 km north of the range crest, in the headwaters of the Carter Creek drainage (fig. 1). During the Pinedale Glaciation this drainage was occupied by a valley glacier that was about 6.5 km long and terminated at an elevation of 2,800 m. The site is bounded on the downvalley side by a recessional moraine of Pinedale age. At an elevation of 3,135 m, the site is located in the upper subalpine forest, about 90 m below timberline (3,225 m). The surrounding forest consists mainly of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*), with some lodgepole pine (*Pinus contorta*), which is dominant below an elevation of 2,900 m.

ACKNOWLEDGMENTS

The authors thank the U.S. Forest Service, Ashley National Forest, Vernal, Utah, for helicopter support, which greatly helped in the collection and transport of the sediment cores. We also thank Leon Chamberlin and Andrew Godfrey of the U.S. Forest Service for assisting with the coring and for valuable comments and discussions. The senior author was ably assisted in the field by Cathy W. Barnosky. W. R. Hansen and J. P. Bradbury of the U.S. Geological Survey and S. A. Elias of the Institute of Arctic and Alpine Research kindly reviewed earlier drafts of this paper; their comments and suggestions were most helpful.

LITHOLOGY AND RADIOCARBON AGES

At the study site several sediment cores were taken within a radius of a few meters using a piston corer. The core selected for pollen study and radiocarbon dating was composed of 5 cm of peat overlying 87.5 cm of organic silt and clay, silt and clay, and sandy clay (fig. 2), indicating the gradual infilling of this site from a shallow pond to a bog.

Four radiocarbon ages were obtained from organic-rich material in the core (fig. 2). The ages range from 6,210±250 B.P. (W-3478) for organic sediments containing coniferous wood fragments near the base of the core to 1,350±400 B.P. (W-3479) for organic sediments near the top of the core. Sedimentation rates based on these radiocarbon dates yielded the approximate ages of the various pollen zones present in the core.

LABORATORY PROCEDURES

Samples for pollen analysis were collected at 2.5-cm intervals from the sediment core and processed in the pollen lab of the Institute of Arctic and Alpine Research, University of Colorado, using techniques modified from Faegri and Iversen (1975). The pollen samples were treated with caustic soda, hydrofluoric acid, and an acetolysis solution to remove organic and mineral matter. A total of 300 pollen grains, exclusive of the possible peat formers of Cyperaceae (sedge family) and Ericaceae (heath family), was counted for each sample. Pollen concentrations, grains per gram dry weight (gdw^{-1}), were determined by the "absolute" method of pollen preparation and counting. This method is based on the oven-dry sample weight before and after treatment (Jørgensen 1967) and the addition of a known amount of exotic pollen (Stockmarr 1971).

Fifty-one pollen types were identified in the samples prepared from the sediment core. Species identification of *Pinus* (pine) pollen was not attempted. The number of unknown and undeterminable grains was small, owing to the excellent preservation of the pollen.

MODERN POLLEN SPECTRA

Comparison of the modern and fossil pollen spectras allows the interpretation of past vegetation and climate. The pollen in the surface sample of the core is considered to be representative of the modern pollen spectra in this area. This sample is dominated by *Pinus* (41 percent), *Artemisia* (sagebrush, 25 percent), Gramineae (grass family, 16 percent) and Cyperaceae (26 percent). The pollen concentration in the surface sample is 590,000 grains gdw^{-1}.

POLLEN-PERCENTAGE DIAGRAM

The major components of the pollen-percentage diagram (fig. 2) are *Picea* (spruce, 4–22 percent), *Pinus* (pine, 27–65 percent), *Artemisia* (8–25 percent), Chenopod (goosefoot family, 3–14 percent), Gramineae (2–37 percent), and Cyperaceae (4–143 percent). Arboreal pollen values range from 33 to 80 percent and are more abundant in the lower half of the profile ("tree" curve on summary diagram, fig. 2). The diagram can be subdivided into three zones, based primarily on the relative abundance of *Picea*, *Pinus*, Gramineae, and Cyperaceae pollen.

Zone 1 (65–92.5 cm; ca. 4,600 to 6,500 B.P.) is characterized by moderate percentages of *Pinus* (33–41), low percentages of Cyperaceae (6–14), and minor amounts (less than 5 percent) of *Nuphar* (pond lily). *Artemisia* and Chenopod are slightly more abundant in this zone than in the other zones. Gramineae is present in slightly higher percentages than in the overlying subzone 2a. *Picea* percentages (7–13) are moderate in this zone. *Betula* (birch) occurs in small amounts (about 1 percent) in all but the upper sample of zone 1, and *Juniperus* (juniper) percentages, although small (less than 3), reach maximum values in this zone.

Zone 2 (10–65 cm; ca. 600 to 4,600 B.P.) is defined by maximum *Pinus* (38–65 percent), Cyperaceae (4–143 percent), and arboreal pollen values. Subzones 2a (30–65 cm;

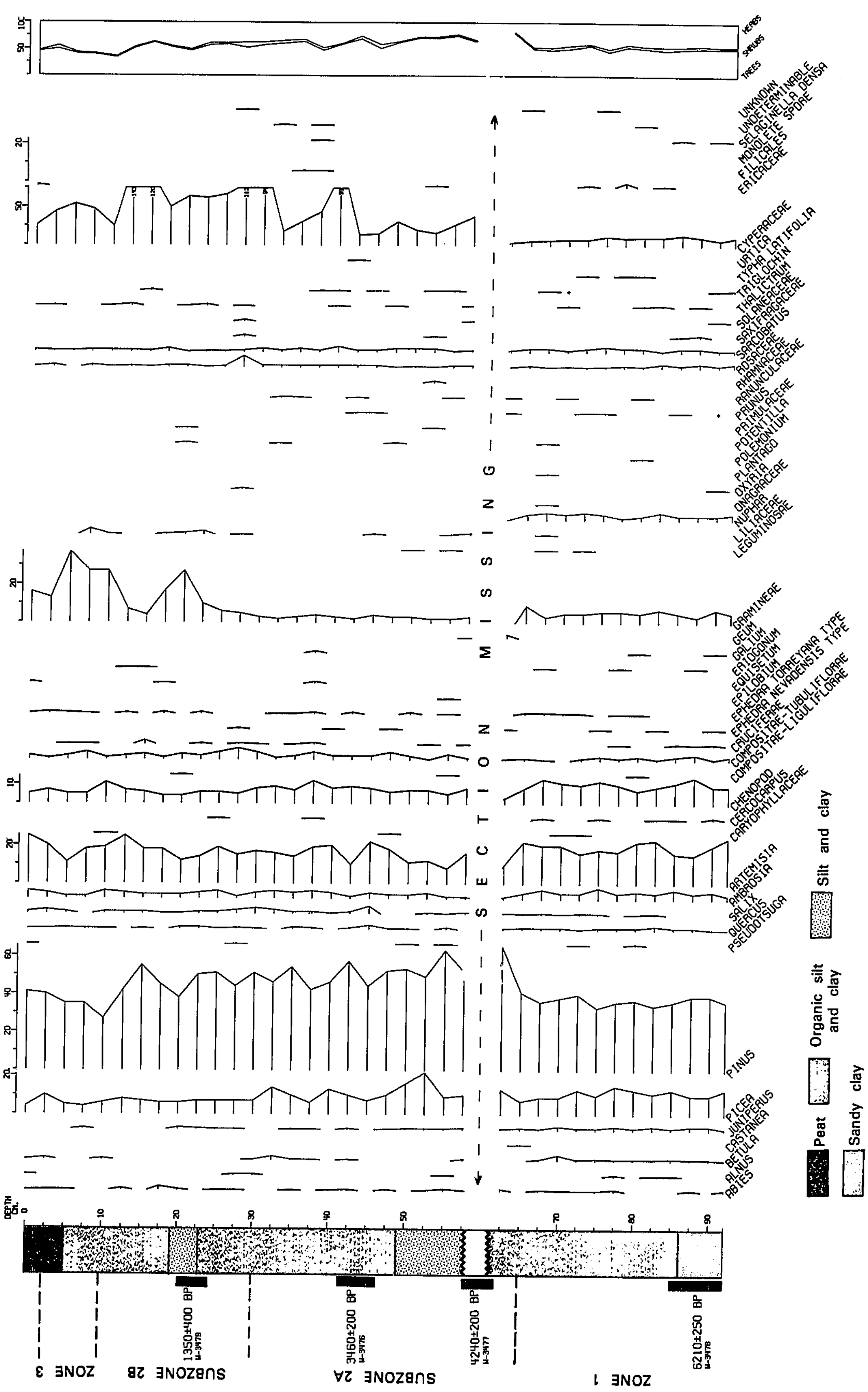

FIGURE 2.—*Pollen-percentage diagram, Leidy Peak area, Uinta Mountains, Utah. Percentages are based on a count of 300 grains, excluding Cyperaceae, Ericaceae, and undeterminable pollen. Percentages for these pollen types are reported as percentages of non-Cyperaceae, non-Ericaceae and nondeterminable pollen.*

ca. 2,100 to 4,600 B.P.) and 2b (10–30 cm; ca. 600 to 2,100 B.P.) are distinguished from each other by the relative abundances of *Picea,* Gramineae, and Cyperaceae. Subzone 2a is characterized by peak *Picea* (22 percent at 52.5 cm) and *Pinus* percentages (65 percent at 62.5 cm), minimum Gramineae values (less than 5 percent) and moderate Cyperaceae percentages (generally less than 50). In subzone 2b *Picea* values decline to generally less than 10 percent, but Gramineae and Cyperaceae are more abundant, a maximum of 143 percent at 12.5 cm is recorded for the latter. Large percentages of *Artemisia* are also registered in subzone 2b with a maximum of 25 percent at 12.5 cm.

Zone 3 (2.5–10 cm; ca. 100 to 600 B.P.) is distinguished by higher percentages of Gramineae (13–37) and lower percentages of *Pinus* (27–40) and Cyperaceae (25–54). The summary curve indicates a noticeable decrease in arboreal pollen.

POLLEN-CONCENTRATION DIAGRAM

The same zones are also shown on the pollen-concentration diagram (fig. 3). The curves of the various pollens on this diagram are similar in shape to those on the pollen-percentage diagram (fig. 2). Total pollen concentration varies from about 123,000 grains gdw^{-1} at 10 cm to as much as 1,090,000 grains gdw^{-1} at 25 cm.

In zone 1, *Artemisia*, Chenopod, and *Nuphar* are more abundant than in the other zones and have values that are in excess of 70,000, 39,000, and 9,000 grains gdw^{-1}, respectively. These pollen types reach maximum concentrations near the top of the zone at 67.5 cm. *Pinus* and Cyperaceae are present in lower concentrations (generally less than 250,000 and 60,000 gdw^{-1}, respectively) than in the overlying subzone 2a. The concentration of Gramineae (generally greater than 20,000 grains gdw^{-1}) is about twice that in subzone 2a.

In zone 2, *Pinus* and Cyperaceae are more abundant than in either zone 1 or 3. Values for both pollen types range between 55,000 and about 540,000 grains gdw^{-1}. Maximum concentrations of *Pinus* and *Picea* occur in the lower part of subzone 2a, at 62.5 cm (542,000 grains gdw^{-1}) and 52.5 cm (170,000 grains gdw^{-1}), respectively, and both types decline upcore. *Picea* concentrations drop off rapidly by the middle of subzone 2a (generally less than 50,000 gdw^{-1}). *Pinus* values decline to moderate levels in the upper part of subzone 2a and subzone 2b. Cyperaceae concentrations rise in subzone 2a and the base of subzone 2b represents the appearance of very large values for this group (greater than 500,000 grains gdw^{-1} at 27.5 and 15 cm). Gramineae concentrations are low in subzone 2a (less than 20,000 grains gdw^{-1}) but rise to moderate levels in subzone 2b (20,000 to 100,000 grains gdw^{-1}).

In zone 3, most pollen types record decreased concentrations. *Pinus* and Cyperaceae are much less abundant, and *Picea* and Chenopods tend to be slightly less abundant than in subzone 2b. However, the Gramineae curve shows a substantial increase in this zone and has a maximum value of 120,000 grains gdw^{-1} at 5 cm.

RELATIVE ABUNDANCE OF CHARCOAL

To determine if changes in pollen assemblages were related to forest fires, the core and pollen samples were examined for detrital charcoal fragments. Numerous fragments were observed at 50–55 cm in the core. Subsequent microscopic examination of the pollen slides revealed that charcoal fragments were present throughout the entire core (table 1). Although quantitative data were not recorded, most pollen samples were found to contain a few charcoal fragments. These fragments are very sparse in the upper 5 cm and at 57.5–62.5 cm, and most abundant at 87.5 cm. They indicate that fires commonly occurred in the forest surrounding the study site during the past 6,500 years. However, these fires never appear to have had a major role in regional vegetation changes because, in the sediment core, variations in pollen percentage and concentrations appear to be unrelated to the abundance or absence of charcoal fragments. In addition, no sharp increase in the pollen of fire-indicator species is noted on either of the pollen diagrams.

DISCUSSION

Climatological interpretations based on the pollen data are somewhat difficult because the minor changes in the pollen diagrams (figs. 2 and 3) reflect, in part, the transition of the study site from a shallow pond to a bog. Despite these limitations, some inferences can be made regarding past changes in climate and the relative position of timberline over the past 6,500 years.

Zone 1 (ca. 4,600 to 6,500 B.P.), has small but maximum values of *Juniperus* and *Betula* and large values of *Artemisia* and Chenopod. Arboreal pollen percentages are lower in this zone than in zone 2. This pollen spectrum suggests more open and possibly cooler climatic conditions. Maximum values of *Nuphar* and diatom data (J. P. Bradbury written communication 1976) indicate open water, suggesting that the study site was occupied by a shallow pond during this period.

Subzone 2a (ca. 2,100 to 4,600 B.P.), has maximum values of *Pinus* and *Picea* pollen. In addition, Cyperaceae pollen shows a significant increase during this period. The abundance of *Pinus* and *Picea* pollen suggests a closed forest, possibly in response to climatic conditions warmer than present. The increase in Cyperaceae pollen, the diatom data (J. P. Bradbury written communication 1976), and lack of *Nuphar* pollen indicate a reduction of

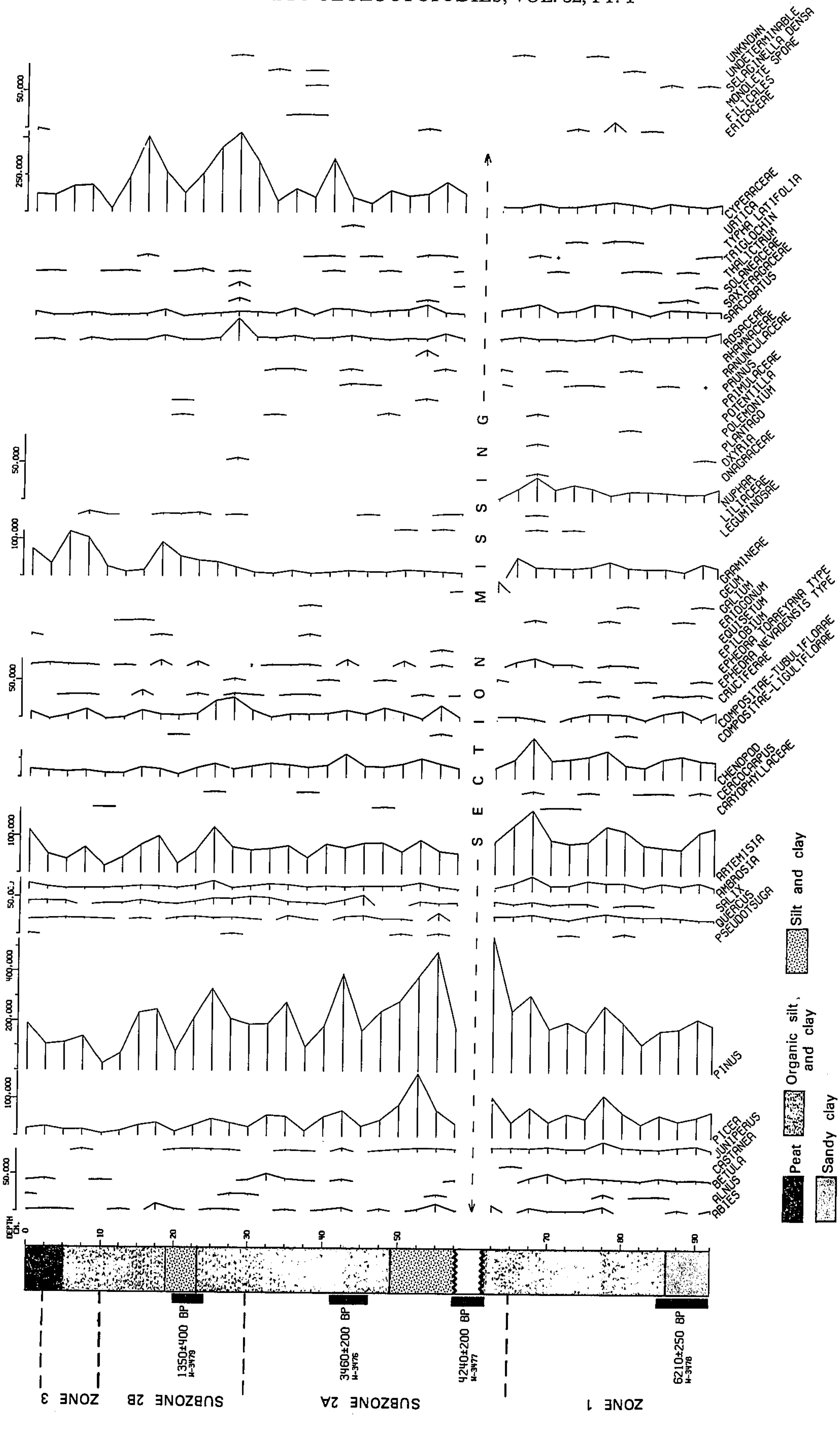

FIGURE 3.—*Pollen-concentration diagram, Leidy Peak area, Uinta Mountains, Utah. Values represent the number of pollen grains per gram dry weight* (gdw^{-1}) *of sample.*

open water, possibly due to drier climatic conditions or to the progressive encroachment of bog vegetation onto the study site.

In subzone 2b (ca. 600 to 2,100 B.P.), *Pinus* percentages decrease slightly from those recorded in subzone 2a but are still higher than those of zone 3 and the surface sample. *Picea* percentages decrease to values similar to that of the surface sample. *Pinus* and *Picea* concentrations also decrease from those in subzone 2a. This suggests a reduction of conifer pollen into the site and a probable thinning of the spruce-fir subalpine forest. Maximum values of Cyperaceae and a sharp increase in Gramineae may indicate the progressive encroachment of bog vegetation onto the site, and hence the climatic significance of this zone is difficult to interpret. However, we suggest this period may have been somewhat cooler than that of subzone 2a, although warmer than present.

Table 1. Relative Abundance of Charcoal Fragments in the Sediment Core, Leidy Peak Area, Uinta Mountains, Utah

(Relative abundance of charcoal fragments is based on microscopic examination of pollen samples: x, very few; xx, few; xxx, some; xxxx, many; —, no data)

Depth (cm)	Pollen zone	Relative abundance of charcoal fragments
0		x
2.5		x
5	3	x
7.5		xx
10		xxx
12.5		xxx
15		xx
17.5		xx
20	2b	xx
22.5		xx
25		x
27.5		xxx
30		xx
32.5		xx
35		xx
37.5		x
40		xx
42.5		xx
45		x
47.5	2a	x
50		xx
52.5		xxx
55		xx
57.5		x
60		—
62.5		x
65		xx
67.5		x
70		xx
72.5		xx
75		xx
77.5		xx
80	1	xx
82.5		xx
85		xx
87.5		xxxx
90		xxx
92.5		xx

Zone 3 (ca. 100 to 600 B.P.) records minimum amounts of *Pinus* and *Picea* pollen, indicating a further thinning of the forest and continuation of the cooling trend observed in subzone 2b. Maximum amounts of Gramineae and other nonarboreal pollen types indicate that the transition of the study site from a shallow pond to a bog had been completed.

On the basis of the pollen data and the basal coniferous wood fragments in the sediment core, the study site appears to have been below timberline for the past 6,500 years. During this period, timberline was probably highest in subzone 2a, ca. 2,100 to 4,600 B.P., and lowest in zone 3, ca. 100 to 600 B.P. It should be stressed that because of the relatively minor vegetational changes indicated by the pollen data, inferred climatic changes discussed in this paper were of a minor nature. Additional studies in the Uinta Mountains are needed to provide a more firmly based paleoecological history of this region in order to allow comparisons with other locations in the western United States.

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