MICROPALEOBOTANICAL RESEARCH ON THE LATE TERTIARY SEDIMENTS OF ARIZONA

By

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In view of the abundance of fossil leaves and fruits in late Tertiary sediments of southern California, Nevada, and other parts of the Great Basin, the near absence of plant remains in sediments of the same age in Arizona is conspicuous and difficult to understand. Scraps of wood and leaf fragments, generally of undeterminable affinities, are fairly widely distributed. Identifiable remains have been found at only two localities in Pliocene sediments [Axelrod, 1950, p. 246; R. W. Brown identified a few leaves from the Bidahochi formation (J. F. Lance, personal communication)].

It is known, however, that pollen is often preserved where other remains of former plant life are no longer found. Moreover, a precedent was set for expecting microfossil recovery from Arizona Tertiary deposits by the abundant, often well-preserved pollen yielded by post-glacial and glacial sediments. Thus, it was hoped to obtain through the medium of pollen the missing Tertiary vegetational record and to determine the climatic and general environmental conditions under which that vegetation lived. It was hoped that sufficient information would be available from examination of sedimentary units whose relative ages are known to establish a pollen chronology for Late Tertiary sediments in this area. With the possibilities in mind for using fossil pollen as an environmental index, and eventually as a means of "dating" and correlating Tertiary sediments in Arizona, several hundred rock samples from all parts of the State have been examined during the past year and a half. Small amounts of poorly preserved pollen from several localities, and one rather diversified and well-preserved microflora, culminate an otherwise nearly fruitless search for plant microfossils.

At present there is no satisfactory explanation for the failure to find pollen. More than likely, however, a combination of factors related to the depositional and/or postdepositional environments of the microfossils make the recovery of material difficult. Pollen obtained from sediments of this area is commonly corroded. Even the more resistent conifer grains are generally poorly preserved. This suggests that the plant microfossils have been oxidized, although it is difficult to say now whether this happened long after deposition as a result of weathering of the sediments, or whether it occurred at the time of deposition because of the absence of conditions suitable for trapping and preserving pollen. Most of the sediments examined for pollen are from surface out-crops, but the zone of weathering and leaching in many of these does not appear to be more than a few inches deep. However, the late Tertiary section of Arizona apparently contains few lake beds ideal for pollen preservation, but consists predominantly of flood-plain and fluviatile deposits laid down by through-flowing streams. If pronounced annual dry seasons were prevalent and streams were largely ephemeral with newly deposited sediments being continually and thoroughly oxidized, the circumstances would have been unfavorable for pollen preservation. Experience has shown that plant microfossils are seldom extensively preserved where conditions are prevailingly aerobic. Oxidation often eliminates the least resistant grains thus over-representing some types of pollen and at the same time reducing the total pollen content of the sediment to the point where it is difficult to recover many microfossils. Moreover, it is obvious that pollen counts from oxidized sediment would have little meaning for the interpretation of the vegetation.

Another explanation, possibly independent of the above suggestion, may relate to the pH at sites of deposition. Faegri and Iversen (1950, p. 29) observed that pollen preservation seems to be perfect only in "acid sediments". Dimbleby (1957) demonstrated the "close correlation between pollen breakdown and base status (sic)..." by showing that "soils whose pH is above 6 are virtually useless

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for pollen analysis..." Apparently, it is for this reason that limestones and other highly calcareous sediments seldom contain large quantities of pollen. Possibly high pH conditions in the environment at the time of deposition are responsible for the absence of pollen in many of the rock deposits.

Micropaleobotanical research in this area is limited not only by the poor preservation of material but by the small amounts of pollen recoverable. The stratigraphic and paleofloristic usefulness of plant microfossils depends on 1) the wide and uniform dispersal of large quantities of pollen, and 2) the possibility of obtaining at a later date a reliable sample of the universe of grains disseminated from the vegetation previously growing in the area. Paleobotanical data indicates that the pronounced floristic changes which occurred during the Tertiary are related primarily to migrational rather than evolutionary phenomenon. The causes of migration are in turn largely related to regional climatic changes. Over long periods of time the vegetational shifts are expressed in major alterations in composition of the vegetational cover. Through short time spans these shifts are reflected in variation in dominance of some of the plants of a flora. In the pollen diagram (a composite of counts from single horizons in a vertical sequence of sediments), variation in relative abundance of plants (determined in terms of the total pollen population represented) reflect the changing vegetational cover. The modifications in the association of plants (the floral succession) are important in the environmental analysis and in establishing regional correlations. Thus the methods of pollen analysis are fundamentally statistical, and therefore, subject to errors in sampling when only small amounts of pollen are available.

It is too early to maintain with any confidence that the Arizona sediments provide no opportunities for the Tertiary micropaleobotanist. An extended program of pollen research is not encouraged by the amount of time spent attempting to extract pollen from a wide variety of sedimentary rock types, since it now appears that the recovery of many good Tertiary microfloras will be due large to chance finds. On the other hand, we have yet to learn all the possible environments favoring pollen deposition and preservation in this region, and we have not tapped the pollen potential of subsurface sediments. The recovery of some plant microfossils hints that continued search in Arizona may still bring to light other microfloras.

The work done to date centers primarily in the southern half of the State. Samples from various facies of the Bidahochi formation in northeastern Arizona were processed without recovering microfossils other than the algae Pediastrum. Sediments from which pollen has been recovered come from the Safford, Tonto, and Verde Basins; from the vicinity of Prescott; and from several miscellaneous sites south of the Plateau area. The location, composition and preliminary interpretation of the more specific of these pollen floras will be discussed briefly in the following section.

SAFFORD VALLEY - No pollen has been recovered from rock samples from the northern end of the valley or from the 111 Ranch area being studied respectively by J. Marlowe and P. Seff, geology graduate students at the University of Arizona. A small, very poorly preserved microflora has been found, however, from lake clays to the east of the town of Safford, in the area being mapped by J. Harbour. Harbour considers these sediments to be of early Pleistocene or possibly late Pliocene age.

SAFFORD MICROFLORA

Arborescent Pollen (AP)	No. of grains	%	Nonarborescent Pollen (NAP)	No. of grains.	%
Pinus (pine)	370	83.3	Compositae (sunflower family)	10	2.3
Celtis (hackberry)	7	1.6	Gramineae (grass family)	1	.2
Abies (fir)	5	1.1	Typha (cat tail)?	1	.2

Artemesia (sagebrush)	4	.9	Chenopodiaceae-Amaranthaceae (goosefoot and amaranth families)	1	.2
Quercus (oak)?	3	.7			
Alnus (alder)	1	.2			
Picea (spruce)	1	.2			
Total AP:	391	88.	Total NAP:	13	2.9

Unknowns: 40 grains
Total Pollen: 444 grains

The microflora suggests the tentative interpretation that during the early Pleistocene a pine forest with occasional fir, and possibly spruce (both at somewhat higher elevations), was growing in an area whose vegetation now is typical of the lower Sonoran Life Zone. It is to be stressed that the climatic alteration necessary for such a vegetational change would be momentous, implying not only somewhat lower temperatures, but far more mesic conditions than exist in the valley of Safford today. More and better preserved pollen must be obtained from this area before detailed interpretations can be made of the microflora. Three other samples taken immediately adjacent to this one in the section contained essentially no microfossils.

Of 24 other samples from 13 cores from the vicinity of the town of Safford, some had "shows" of pollen. These core samples came from borings along the axis of the site of a dam proposed for the area by the Soil Conservation Service. The sediments are also regarded as being lake clays; in the samples examined depths below the surface ranged from 11.5 to 49 feet. Counts exceeding 20 grains were obtained from only 5 of the core residues following concentration. Four of these, however, contained less than 50 grains. The count from station 30 + 00, Boring 4-3, of the S.C.S. dam site, at 16 feet, contains almost enough pollen to regard as significant the results of the count treated statistically.

STATION 30 + 00, BORING 4-3, 16 FEET, S.C.S. DAM SITE, SAFFORD

Arborescent Pollen (AP)	No. of grains	%	Nonarborescent Pollen (NAP)	No. of grains	%
Pinus	32	21.9	Compositae	71	48.6
Quercus	7	4.8	Chenopodiaceae-Amaranthaceae	16	10.9
Ephedra (Mormon tea)	1	.7	Malvaceae cf. Sphaeralcea (Globe-mallow)	3	2.1
			Gramineae	2	1.4
Total AP:	40	27.4	Total NAP:	92	63.0

Unknowns: 14 grains
Total Pollen: 146 grains

The vegetation suggested by this pollen spectrum shows some resemblance to that presently growing in the Safford area, but does not compare to the vegetation implied by the Safford microflora (p. 5). The two microfloras are, in fact, remarkably different. The relative abundance of pine (and oak) in this spectrum is perhaps greater than we might expect to find in the modern pollen rain over the area today.suggesting that both these genera may have been more abundant at lower elevations than they are now. But the flora is definitely less mesic than the other as related to the high NAP, and the presence of Ephedra.

TONTO BASIN - Poorly preserved pollen has been recovered from one site near Pumpkin Center, about 13 miles north of Roosevelt Lake. The sample comes from within about 6 inches of a tooth of Pliohippus (J. F. Lance, personal communication.

PUMPKIN CENTER MICROFLORA

Arborescent Pollen (AP)	No. of grains	%	Nonarborescent Pollen (NAP)	No. of grains	%
Pinus	140	40	Chenopodiaceae-Amaranthaceae	118	33.7
Juniperus (juniper)	7	2	Compositae	50	14.3
Quercus	2	.6	Gramineae	7	2.
Ephedra	1	.3	Fern spores	4	1.1
Total AP:	150	42.9	Total NAP:	179	51.1

Unknown: 21 grains
Total pollen and spores: 350 grains

The site is at the northern limits of the Snoran Desert. The nearest pines are about 10-15 miles distant; the other plants (except ferns?) now grow in the vicinity. The NAP is high, but the abundance of chenopod-amaranth pollen may be largely related to local conditions of soil alkalinity. If so, it would appear that the Pliocene vegetation of this area, now desert, was a woodland-savanna community, dominated by pine.

PRESCOTT - The Prescott microflora is the best preserved and most diversified known from Arizona to date. A manuscript is now being completed with details of its occurrence and composition. The pollen-bearing sediment is a rhyolitic tuff, exposed in two small prospect pits about 4 miles northeast of Prescott, at an elevation of about 5600 feet. All the microfossils come from a single horizon from which pollen was recovered on two extractions, but not at the third attempt. These sediments are tentatively considered to be equivalent to the Hickey formation (of Anderson and Creasey, 1958) and a lower Pliocene age is suggested for them by associated, poorly preserved camel toe bones similar to some in the Walnut Grove fauna to the south (J. F. Lance, personal communication).

PRESCOTT MICROFLORA

Arborescent Pollen (AP)	No. of grains	%	Nonarborescent Pollen (NAP)	No. of grains	%
Quercus	114	23.8	Gramineae	54	10.8
Pinus	82	16.4	Compositae	40	8.
Juniperus-Cupressus (juniper-cedar)	79	15.8	Chenopodiaceae-Amaranthaceae	26	5.2
Artemesia	4	.8	Malvaceae cf. Sphaeralcea	+	
Juglans (walnut)	3	.6	Fern spore (trilete)	+	
Fraxinus (ash)	2	.4			
Celtis	1	.2			
Rhamnus (Ceanothus?) (buck-thorn)	+				
Ulmus (elm)	+				
Alnus	+				
Betula (birch)	+				
Ephedra	+				
Total AP:	285	58.0	Total NAP:	125	25.0

+ SEEN ON PRELIMINARY SCANS

Unknowns: 89 grains
Total Pollen: 499 grains

Except for Ulmus, all these genera still grow at Prescott, or within comparatively short distances; elm are cultivated in the town. All of them but alder occur in approximately the same relative abundance in the modern pollen rain of the Prescott area, as was determined from sediments now being deposited within a radius of 15 miles of the fossil site. A comparison between the relative abundance of the genera represented in the microflora and that of the same genera as represented in the modern pollen rains at approximately the same elevation as the fossil site, suggests several differences between the Pliocene and living vegetation of the Prescott area.

1. The fossil flora contains considerably less pine than do sediments at the same elevation near Prescott today. Moreover, size frequency studies of the fossil pine pollen, in comparison with the pollen of modern yellow pine, and that of the three species of pinyon pines, indicate that the fossil pollen population is closest in size to that of the small pinyon pine pollen. On this basis, it is suggested that one of the pinyon species, or a closely related form, was more common in the vicinity of Prescott during the late Tertiary than was yellow pine. The reverse is true today.

2. The relative abundance of oak and juniper pollen is correspondingly greater in the fossil material than in modern samples at the same elevation. These genera appear to have been more abundant than pine near the site of deposition. The relative abundance of Juniper pollen is never more than about 5% from samples at the same elevation in present-day sediments.

3. The NAP runs somewhat higher in the fossil material than in modern samples from sites at the same elevation, now woodland.

4. Ephedra pollen was not encountered in any of the modern pollen rains, except in those at elevations close to the altitudinal limits of the genus in southern Yavapai County, i.e., at about 5000 feet.

It is tentatively proposed that the climate may have been somewhat drier in the area, and/or that the basin of deposition may have been at a lower elevation than that at which these sediments are now found. The changes indicated, however, do not appear to have been of any great magnitude. The flora and climate for the area of Prescott in the early Pliocene does not appear to have been vastly different from that in the same region at the present time.

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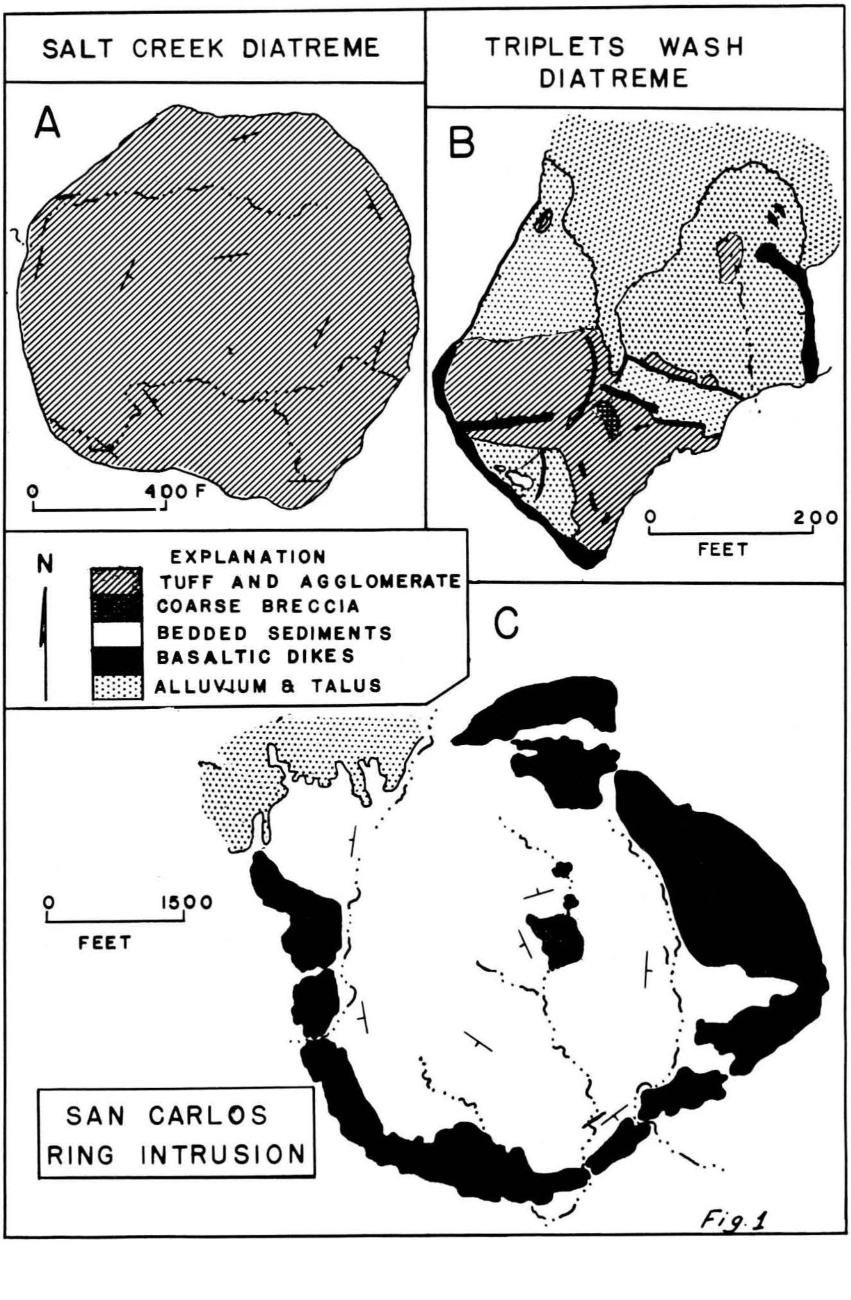
SALT CREEK DIATREME
A
0
400 F
TRIPLETS WASH
DIATREME
B
0
200
FEET
N
EXPLANATION
TUFF AND AGGLOMERATE
COARSE BRECCIA
BEDDED SEDIMENTS
BASALTIC DIKES
ALLUVIUM & TALUS
C
0
1500
FEET
SAN CARLOS
RING INTRUSION

Fig. 1