Fossil Maize from Panama

Abstract. *Wild maize, agricultural maize, and associated* Manihot *fossil pollen indicative of early agriculture after about 7300 years ago have been discovered in the Gatun basin, Panama. The course of rising sea level in the Canal Zone during the past 11,300 years is calculated.*

Two basic questions regarding the nature and origin of corn *Zea mays* had remained unanswered, despite exhaustive research and much speculation. First, the nature of the original wild corn, which no longer exists today, was unknown. Second, the place of its origin, a subject of extended controversy, was also unknown.

Answers to both of these questions were gradually resolved with the discovery of fossil maize at various sites in Mexico and New Mexico. A review of these findings has been presented (*1*). An important initial discovery was that of cobs and fragments in Bat Cave, New Mexico, in 1948 and 1950. The oldest of these were associated with charcoal radiocarbon dated as 5600 years ago. Subsequent discoveries in the Valley of Tehuacan, Mexico, yielded wild maize in cave deposits dated as 7200 years ago. These discoveries provided clues about the nature of early corn and its morphology and enabled Mangelsdorf to undertake genetic studies in efforts to reconstruct experimentally the ancestral form of maize.

The question of the geographic origin of maize was answered, according to Mangelsdorf *et al.* (*1*), by the discovery (*2*) of pollen identified as that of maize in deep cores from Mexico City. This maize pollen, found at a depth of 60 to 70 m is considered to antedate man's arrival in the New World. In this study, size and axis-pore ratio were used to differentiate the presumed maize pollen from that of wild grasses and the two closest relatives of maize, *Tripsacum* and teosinte. The use of an axis-pore ratio to distinguish maize pollen was questioned (*3*). The earlier identification of the Mexico City maize was confirmed (*4*) as part of an extended investigation of the pollen exine of maize, *Tripsacum*, and teosinte. This study demonstrated that maize can be distinguished from the other two grasses on the basis of spinule pattern and the presence or absence of an incised reticulum in the pollen exine.

Fossil maize has also recently been discovered (*4–6*) in two cores from Lake Petenxil, Guatemala. Tsukada (*6*) found maize pollen and evidence of agricultural activity throughout both cores from the oldest level to the youngest (from about 3990 to 600 years old).

We now report the discovery of fossil pollen, from both wild and cultivated maize, in core sediments from the Gatun basin in Panama. A palynological investigation of sediment samples from nine deep cores representing a period of deposition of over 11,300 years showed maize pollen present in nine samples from four cores from an area about 5.6 by 2.5 km (*7*).

In Panama during the low sea-level phase of the last major cycle of sea-level fluctuation associated with the Wisconsin stage of the Pleistocene, the major streams of the Gatun basin became entrenched by as much as 300 feet (91 m) below present sea level. Later, the rising sea level, accompanying late-glacial and postglacial climatic amelioration, controlled deposition of a complex sequence of estuarine and nonmarine intercalated sediments on this deeply dissected topography. The core samples on which this study was based range in age from about 11,300 to 1275 years (samples UCLA-183–185; 1019–1025; 1335, 1353–54) (*8*), and in depth from 162 feet (49.37 m) below present mean sea level to 10 feet (3.04 m) above. This sediment was deposited at or very close to sea level, much of it in mangrove swamps, as shown by the very high content of *Rhizophora* (red mangrove) pollen. Radiocarbon dates from the period 7300 to 4800 years ago show that the rate of rising postglacial sea level slowed and freshwater peats were deposited over the mangrove swamp sediments.

A palynological study and ^{14}C dates obtained from selected samples from the entire length of four cores and portions of several additional cores showed good stratigraphic correlation between the cores. The sequence of vegetational change as represented in the cores is consistent throughout the basin.

A number of radiocarbon dates obtained from five cores were used to construct a chronology of rising postglacial sea level. When these dates are plotted the resulting curve is similar to that presented by Shepard (*9*) in showing worldwide (eustatic) sea-level change from the late glacial to the present (Fig. 1) (*10*).

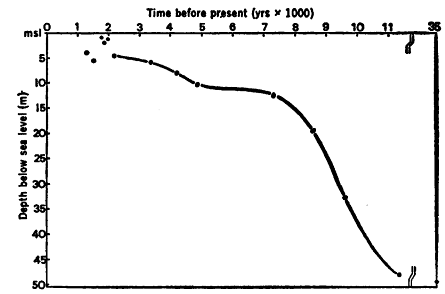

Fig. 1. Chronology of rising postglacial sea level at the Gatun basin, Panama Canal Zone.

The pollen of maize is present in the freshwater sediments and peats deposited after 7000 years ago. The maize pollen, identified by previously established criteria (*4*), occurs 43 feet (13.1 m) below sea level and in the sedimentary interval between 26 feet (7.92 m) and 3 feet (0.91 m) below sea level.

The 22 grains of maize pollen other than those at the −43-foot level are indicative of agriculture. There is a striking abundance (up to 52 percent of the 200 grains counted in each sample) of Gramineae and Compositae (*Ambrosia*-type) pollen in the maize-bearing units of the cores from 26 to 3 feet below sea level. The presence of high percentages of these pollen types, together with pollen of other herbaceous weeds such as *Borreria* and a scarcity of tree pollen suggest that agricultural activity took place nearby. Additional evidence of agriculture during this period, from about 3100 to 1800 years ago, is the presence of finely divided charcoal in four of the maize-bearing sediment samples. The fact that the charcoal is present solely in the maize-bearing samples further supports this conclusion.

The maize pollen from the lowest stratum occurring at −43 feet, is not associated with any of the above-mentioned palynological evidence of agriculture. This maize pollen possesses an exine with a very regular spinule pattern, with no trace of the spinule

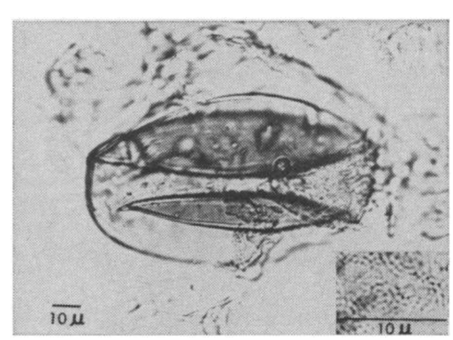

Fig. 2. Fossil *Zea mays* pollen from the −43-foot level. Inset shows distribution of exine spinules.

clumping or incised reticulum characteristic of *Tripsacum* and with no trace of the irregular spinule arrangement and thinner, more easily deformed exine of teosinte (Fig. 2). This maize pollen differs from that at the higher levels in having a slightly heavier, much less easily deformed exine. The number of spinules per unit area and per grain is also higher than that of the younger maize grains in the sediments above. The significance of this is not clear. Tsukada and Rowley (*5*) have indicated that spinule density may vary greatly depending upon the source, viability, preservation, and treatment of the pollen. The size of the four maize pollen grains found among the more than 12,000 grains examined at this level (*7*) varied from 100 to 110 μ which is much larger than *Tripsacum* pollen. The average size of teosinte pollen (*2*) varies between 79.3 and 86.4 μ, with an upper extreme of 102.0 μ; Tsukada (*11*) reports no grains of teosinte pollen larger than 85 μ. Maize pollen, however, is generally from about 85 to 120 μ in size, and some grains may be about 140 μ. The four grains found at the −43-foot level, therefore, are those of wild maize.

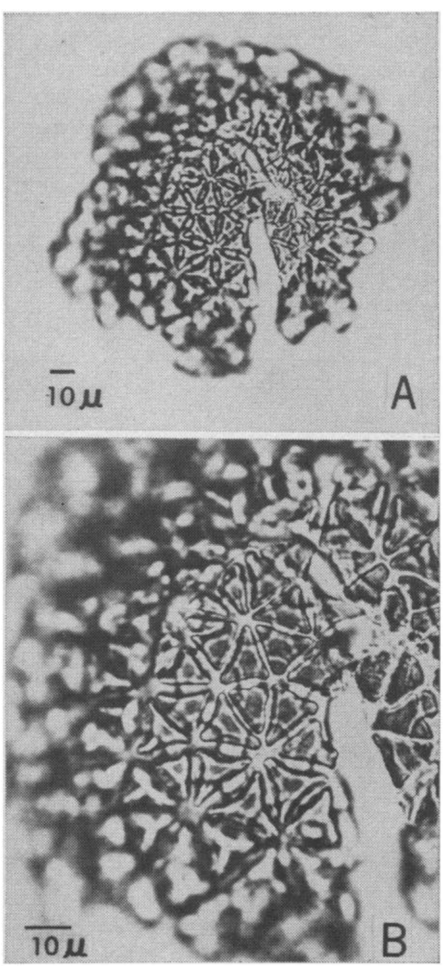

Fig. 3. (A) Fossil *Manihot esculenta* pollen. (B) Detail of *Manihot* pollen showing croton pattern.

We attempted to measure directly the radiocarbon age of this maize-bearing sample by assaying associated organic matter, and we obtained the numerical value of 3170 ± 60 years (UCLA-1335). Clearly this determination is suspect when compared with two other radiocarbon dates based on wood fragments from two other nearby cores at the −43-foot level which are 6230 ± 80 and 7300 ± 130 years (UCLA-1353 and UCLA-183, respectively). The anomalous value is also incompatible with the distribution of all other dated samples along the sea-level curve (Fig. 1). Indeed, an age of 3170 years would correlate with the −20-foot (6.09-m) level and not with that 23 feet lower. In addition, if the relation 3170 years ago at −43 feet were correct, a sedimentation rate of 1 foot (0.3048 m) per 11.5 years would be required for the interval between −26 and −43 feet. This is entirely inconsistent with the sea-level curve which indicates an average sedimentation rate of 1 foot per 150 years. Consequently, it is probable that the spurious date must have resulted from contamination of the sample with recent carbon perhaps in the form of substances containing bomb-produced radiocarbon during drilling operations or after storage in core boxes. No evidence of contamination by nonindigenous pollen is present. In the absence of recent tectonic movements altering the stratigraphy and in consideration of all the geological and vegetational evidence, the maize-bearing sample at −43 feet must be between 6230 and 7300 years old.

Discovery of this wild maize pollen supports the hypothesis that maize is of American origin, and also Mangelsdorf's hypothesis that the ancestor of corn is maize (*Zea*) and not *Tripsacum* or teosinte. The discovery of this pollen also extends the known range of uncultivated wild maize, which has heretofore been found only as far south as Mexico. The probable age of our fossil maize is comparable to that of megafossil remains from the Valley of Tehuacan, Mexico—considered (*1*) to be those of wild maize. The latter have radiocarbon ages of 5400 to 7200 years.

Other pollen of interest found in association with cultivated maize pollen in the Gatun basin sediments dated at 1800 years is that of *Manihot esculenta* Crantz (cassava or juca), one of the most important Central American root crops. Pollen of *Manihot esculenta* can be distinguished from that of the other Central American species of *Manihot* on the basis of exine characteristics. The exine, which possesses the croton pattern characteristic of many members of the Euphorbiaceae, has large peglike excrescences which are triangular in surface view (Fig. 3). The ratio of the height of these triangles to the diameter of the pollen is invariably greater in the cultivated species of *Manihot* than in the others. Also found in this sample and in another maize-bearing sample is pollen of *Ipomoea*. This pollen is possibly that of a cultivated *Ipomoea*; however, as there are many Central American species with pollen which is not highly distinctive, specific determination cannot be made. The Gatun basin sediments thus span a period from preagricultural to agricultural time and demonstrate the capacity of such sediments to provide evidence of the beginnings of agriculture in Middle America.

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