

Origin, Characteristics, and Provenance of Plant Macrodetritus in a Holocene Crevasse Splay, Mobile Delta, Alabama

ROBERT A. GASTALDO, DONALD P. DOUGLASS,¹ and STEVEN M. MCCARROLL²

Department of Geology, Auburn University, Auburn, AL 36849-3501

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Lower delta plains are primary sites for the deposition, accumulation, and preservation of macrodetrital plant parts. Chacaloochee Bay, an interdistributary estuary in the Mobile Delta, Alabama, is being infilled actively by crevasse-splay sedimentation. Within this system are a variety of sites in which plant macrodetritus has accumulated and has the potential of being preserved. Aerial plant parts constitute laminar leaf-litter beds within various sediments, in addition to extensive accumulations of relatively pure organics (peats).

The leaf-litter beds in the crevasse-channel distributary mouth bar and a detrital peat shoal have been examined with respect to the distribution of accumulated plant parts and their size fractionation. Whole leaves recovered from the sediment-water interface of the crevasse channel provide an insight as to the provenance of the accumulated plant litter. The vast majority of leaves being incorporated into the interdistributary bay sediments have not originated from the surrounding vegetational communities. Rather, most recovered leaves originated from communities existing at least 13 km north of the depositional site. The taphonomic processes responsible for the transport, deposition, and alteration of the accumulated macrodetritus include heterochronous leaf fall, fluctuations in bedload and suspension-load transport, rates of periodic flooding, redistribution by tidal and wind-generated surface currents, biodegradation, and bioturbation.

INTRODUCTION

An understanding of the processes responsible for the development of plant-bearing strata can provide substantial insight into various depositional environments of terrestrial sedimentary systems. However, due to a general lack of

knowledge with respect to the taphonomy of plant-bearing regimes, interpretations of depositional environment based, in part, on recoverable megafloreal assemblages have been minimally adopted (Wing, 1984; Gastaldo, 1986a). Although deltas are one of the most commonly encountered terrestrial systems in the stratigraphic record and are sinks for both organic and inorganic detritus, they have been studied primarily from a sedimentological perspective. Although plant macrodetritus acts similarly to other sedimentary particles, the relationships between accumulations of plant parts and the clastic sediments within which they are preserved have been virtually ignored. Where plant detritus has been reported during sedimentological studies of deltaic regimes, the characterizations of these accumulations are superficial (Gastaldo, 1986b). Only recently have studies been initiated concerning how plant-bearing sediments form and what the megafloreal assemblages actually represent in these coastal sites (Scheiing and Pfefferkorn, 1984; Gastaldo, 1985, 1986b; Raymond, 1986).

The Mobile Delta, Alabama, provides an excellent study area for assessing plant accumulating sites in clastic sedimentary environments as Holocene analogs for Neogene coastal sediments (Frils and Pederson, 1986). The delta is of recent origin, with deltaic deposition beginning about 9500 years before present (BP) and prograding through a drowned Pleistocene river valley (May, 1972). Unlike the Mississippi Delta, this bayhead delta is a closed system in which lobe switching does not occur. Presently there is no evidence of sediment reworking by marine processes and the intervention by man is localized. These conditions provide for a relatively complete sediment record from which plant taphonomic processes can be ascertained. Additionally, the recognition of these processes and resultant beds can be used as extrapolative models towards understanding deltaic coastlines of other temperate to subtropical climatic regimes in the stratigraphic record.

The present study focuses on the origin, characteristics, and vegetational provenance of macrodetrital accumulations (those plant parts identifiable in hand sample) in an interdistributary bay being actively infilled by crevasse-splay sedimentation. Approximately 25 years ago during a record flood event, the east levee of the Tensaw distributary channel adjacent to Chacaloo-

¹Present address: Department of Geology, Southern Illinois University, Carbondale.

²Present address: Department of Geological Sciences, University of Illinois, Chicago.

chee Bay was breached. Since then, a subaerial/subaqueous crevasse shield has developed, occupying approximately 0.58 km² (0.28 mi²). Within this relatively short period of time, accumulations of high-organic muds and peats, and bedded leaf litter horizons have been deposited and preserved. The characteristics of these deposits in relation to sediments of passively infilled interdistributary bays and other deltaic deposits may aid in delimiting these systems in the rock record. Also, the recognition of the contributing plant communities, either of local origin or upper-delta-plain origin, provides an understanding as to the usefulness of interdistributary-bay deposits as bases for reconstructing ancient vegetational communities in temperate coastal lowlands.

PHYSIOGRAPHIC SETTING AND VEGETATION

The Mobile Delta lies in the Coastal Lowlands of the East Gulf Coastal Plain province and is the result of the confluence of the Alabama and Tombigbee rivers (Fig. 1). These alluvial and terrace deposits are of Pleistocene and Holocene age, and comprise approximately 115,103 acres of wetland habitats (Copeland, 1982). The delta discharges the third largest volume of water in the conterminous United States (Simons et al., 1982), debouching into Mobile Bay, which is a mixed estuary, and is protected at its southernmost end by barrier islands and spits. Water velocities are low (maximum mean velocity in 1980–1981, 1.33 m/sec; Simons et al., 1982), sediment discharge is moderate (378,179,000 short tons each year; Curtis et al., 1984—data period 1952–1969; Ryan and Goodall, 1972), a microtidal influence prevails (0.46 m displacement), and the climate is predominantly subtropical, with a high average rainfall (66 inches/year; Riccio et al., 1973).

The upper delta plain is characterized by well-developed levee-bound alluvial swamps located between distributary channels, whereas transitional delta swamps are bounded by poorly developed levees. Delta vegetation belongs to the *Quercus falcata*—*Quercus laurifolia* province (Daubenmire, 1978), and the forested wetland-swamp ecological patterns are dependent on the frequency, depth, and duration of flooding, as well as interactions between soil characteristics and water level. Based on dominant canopy and understory plants, density of forestation, and flooding patterns, six swamp types have been delimited (Stout and Lelong, 1981; Stout et al., 1982).

The lower delta plain is characterized by open-water interdistributary bays, four major distributary channels (the Mobile, Tensaw, Apalachee, and Blakely rivers), and semi-emergent (may be exposed or near water interface during low water) and emergent levees. Estuarine interdistributary bays occupy a surface area of approximately 20,323 acres (Chermock, 1978) encircled by marshes and submerged grass beds. Low-marsh herbaceous vegetation (sedges and grasses) occurs in shallow flats within open and restricted bays, and is frequently covered with water either by seasonal flooding or daily tidal action. Scattered shrubs and individual trees of limited diversity, and high-marsh communities dominated by sedges and grasses, may be found in slightly higher topographies (less than 1 m relief) developed in response to better drainage of overbank deposits. These plants may occur as isolated patches within low marshes, as a continuous zone between low marshes and forested wetlands, or on steeper, stable shorelines.

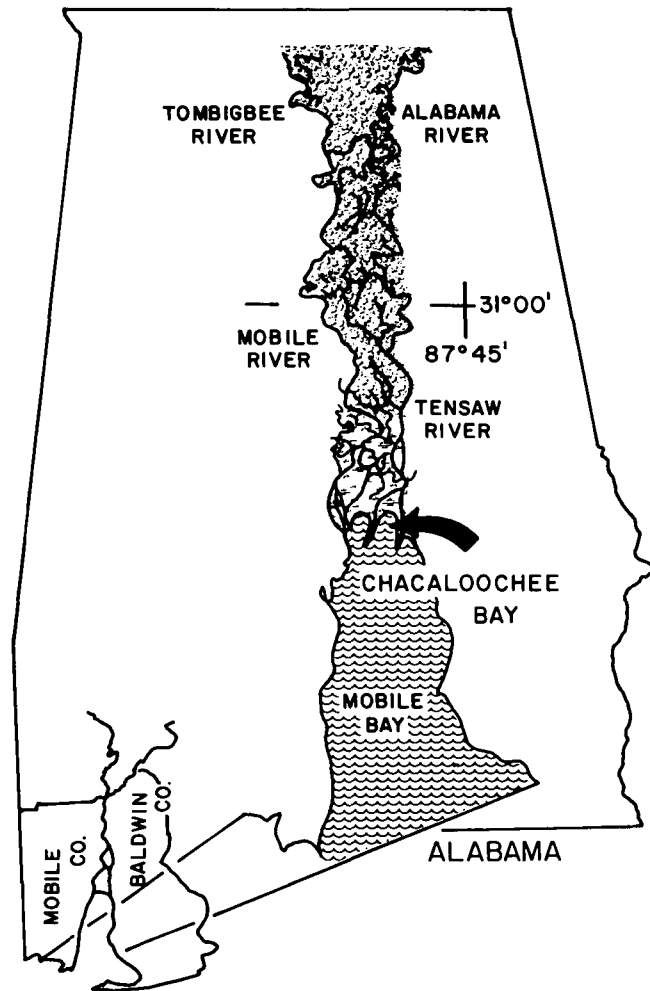


FIGURE 1—Location of Mobile Delta in Mobile and Baldwin counties, Gulf Coastal Plain of Alabama. The position of Chacaloochee Bay is shown in the lower delta plain.

STUDY AREA AND METHODOLOGY

The Tensaw river is flanked by two interdistributary bays: to the east is Chacaloochee Bay and to the west is Delvan Bay. Chacaloochee Bay is the second largest bay in the Mobile-Tensaw delta, consisting of 1919 acres of open water (Dark and Hinkle, 1982). In April, 1961, the maximum recorded flood peaked 22 feet above mean river level and it is believed that this event was the cause of the levee breach in northwestern Chacaloochee Bay. Aerial photographs available from the U.S. Army Corp of Engineers, Mobile, bracket this interval. Aerial photographs taken in 1962 show the breach; photographs in the mid-1940s show an unbreached levee.

The resultant crevasse splay is composed of a subaqueous portion that covers 0.54 km² (0.21 mi²), parts of which are vegetated during the spring and summer by submerged grasslands (Fig. 2). The subaerial portion, covering 0.17 km² (0.07 mi²) and having a relief of less than 0.5 m, is vegetated

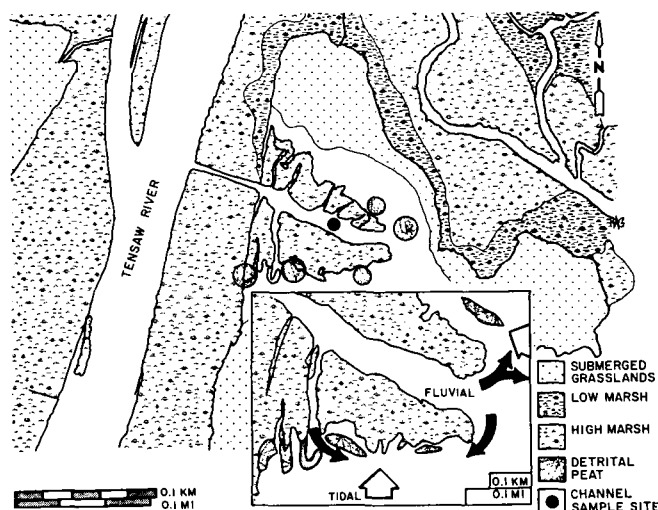


FIGURE 2—Site of the crevasse splay in the northwest corner of Chacaloochee Bay with respect to local vegetation communities of submerged grasslands and low and high marshes. The inset diagram illustrates the differences between water currents generated by fluvial and tidal activity. Surficial water currents generated by winds may move the macrodetritus in any direction depending on the prevailing wind direction. The drawing depicts the configuration of the crevasse splay in 1980 as taken from a high-altitude infrared photograph.

by the high-marsh community. Episodic deposition of organic and inorganic sediments is continuing primarily within the subaqueous crevasse splay. The principal active distributary channel and its associated distributary mouth bar (DMB), located 1 km (0.6 mi) from the levee, contain various plant-litter horizons interspersed with fine-grained muddy sands (Fig. 3). A smaller, active lateral channel extends southward toward the open bay. Extensive organic-rich muds and detrital peat deposits have developed adjacent to this channel in the form of shoals or bars, attaining a maximum thickness of approximately 2 m (Fig. 2).

METHODS

During a reconnaissance survey of the crevasse splay, plant-bearing horizons and anomalous peats were encountered in parts of the splay. To discern the overall taphonomic conditions responsible for these accumulations, samples were collected using various methods in specific sites due to differences in the sediment and the nature of the plant accumulations. Leaf samples were recovered from the channel's sediment-water interface within a medial (Fig. 2) part of the splay channel. In addition, DMB sands of the main splay channel (Fig. 3) as well as shoaled peat located on the bay-ward side of the splay were sampled (Figs. 4, 5).

Leaf samples from the channel's sediment-water interface were collected by hand because of the relatively fragile nature of the water-logged detritus. Within the DMB sands, samples were recovered with hand-pushed PVC cores (30 cm length, 7.5 cm diameter). After maximum penetration into the silty sands, the core barrels were filled with water, stoppered, and



FIGURE 3—Oblique aerial photograph of distributary mouth bar (DMB) of main crevasse channel (March, 1985). Sample was cored from approximate crest of DMB. Arrow to the right of the DMB designates the site of accumulation of macrodetritus; arrow in the upper left designates the site of the peat shoal. Sites of macrodetrital accumulations can be identified by the black tones highlighted in the shallow-water areas adjacent to the subaerial crevasse shield. Due to a change in water movement affecting the DMB of the lateral channel, the peat shoal has been covered by silty muds and slightly reworked by tidal and surficial currents.

pulled up. Thick peats were sampled using post-hole diggers. PVC coring was attempted but recovery of samples was not successful due to high fluid content and often impenetrable subjacent sediments. Samples were taken from distal and proximal portions of the elongate peat shoal (Fig. 5). Recovered litter was water-logged and fragile. This being the case, a certain amount of post-collection breakage was unavoidable, especially after the litter was dried. Standard sedimentologic analyses were conducted at Auburn University and the University of South Alabama.



FIGURE 4—Aerial photograph of lateral channel and peat sites (March, 1985). Note that water currents are no longer being directed eastward resulting in the deposition of organics in the peat shoal, and that wave crests are directed northwestward (adjacent to arrow). Arrow points to position of covered peat shoal. Note the dark lines of redistributed organics onto the subaerial crevasse. Black areas high-light sites of subaqueous organic accumulations.



FIGURE 5—Photograph of the peat shoal as found in April, 1983. Note the elongate character of the shoal and the development of a crest. Distal and proximal sample sites are shown.

Bulk samples of peat that were approximately equal in size and cores were disaggregated and set in large metal pans filled with a solution of Calgon and distilled water. Flotation dispersed the detritus evenly, after which the water was decanted, the macrodetritus left to dry, and subsequently component- (organ) and size-sorted. The litter was sorted into the following organ categories: leaf fragments (angiospermous and gymnospermous), branch fragments, rounded and unrounded wood fragments, bark fragments, blades of grasses, root fragments, tendrils, seeds and other reproductive structures, animal fragments, and miscellaneous. Most components were then sorted by size (incremented by 0.5 cm) to find frequency distributions.

Channel-bottom litter was identified to species where possible ($n = 443$; 281 identifiable). Systematic identifications were made using the Auburn University herbarium collections, and preliminary seed identifications were provided by Dr. John Freeman (Department of Botany, Auburn University). Because of the whole-leaf nature of this recovered litter, a list of deposited taxa more complete than that for the peat accumulations can be made. Since the crevasse channel is the main source for transport to the plant-accumulating areas, it can be inferred that this list may also be used to represent the more fragmentary plant litter composing the peat accumulations.

RESULTS

Distributary Mouth Bar Sands

Macrodetritus recognized in the cores from the muddy, fine-grained sands occurred in two distinctive modes of the DMB. First, bedded detritus at depths to 18 cm was identifiable only as organic-rich horizons having undergone decay either through chemical alteration by fluctuating water levels or biochemical alteration by bioturbation as a result of polychaete activity and fungal biodegradation. Second, a preserved leaf-

litter bed approximately 3 mm thick was recovered at a depth of 20 cm. The sample ($N = 409$) is comprised of coniferous leaves, entire deciduous angiospermous leaves (most of which underwent fragmentation during disaggregation), blades of grasses, bark fragments, tendrils, rooting structures, seeds, and invertebrate body parts (Fig. 6). Leaves of deciduous angiosperms (entire and fragmented), along with grasses and leaves, fascicles, and leafy branches of conifers (*Taxodium* and *Pinus*), dominate the sample. Other recovered categories of plant macrodetritus comprise a very small percentage of the assemblage. Size distribution of recovered plant parts is concentrated below the category less than or equal to 2.0 cm, although entire parts were recovered from the bed. It must be noted that since the plant detritus was recovered from a 7.5-cm diameter core, the core diameter is the limiting factor to identifying entire parts larger than this dimension.

Additional plant litter is accumulating in the quiet-water areas just distal and lateral to the crest of the DMB (Fig. 3). These peaty areas are restricted to the less-active channel diverted north of the DMB and have been observed in thicknesses of up to 30 cm. These accumulations are similar to detrital peats accumulating at the mouth of the Mississippi delta (P. Lowry and E. Kusters, pers. comm.). Although no analyses with respect to plant-organ composition or size distribution per organ category have been conducted on these deposits, preliminary observations suggest that their compositions are similar to those of the DMB litter bed and the peat shoal.

Peat Shoal

Macrodetritus recovered from the surface of the proximal portion of the shoal consisted of plant parts similar to those recovered from the leaf-litter bed of the DMB, but also included were branches and unrounded and rounded wood fragments including wood cobbles (Gastaldo et al., 1985). Surface collections from the distal part of the shoal consisted of highly fragmented detritus. Subsurface samples from both sites were

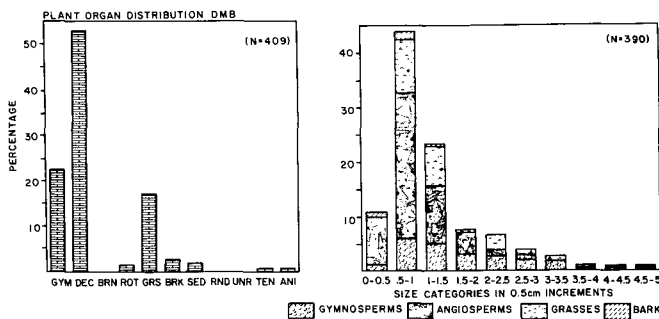


FIGURE 6—Histograms of recovered plant organ distribution and macrodetrital fragment size of selected organ categories from the subsurface leaf-litter bed of the distributary mouth bar. GYM—Gymnosperm leaves, fascicles or leafy branches; DEC—Deciduous angiosperm leaves; BRN—Branch and twig detritus (undifferentiated); ROT—Roots; GRS—Blades of grasses or sedges; BRK—Bark; SED—Seeds; RND—Rounded wood fragments; UNR—Unrounded wood fragments; TEN—Tendrils; ANI—Animal parts (principally arthropod carapaces).

analyzed with regard to organ composition (proximal shoal sample N = 9125; distal shoal sample N = 12,923; Fig. 7) and size distribution of selected organ categories (Figs. 8, 9).

Overall macrodetritus composition is similar to that of the DMB. However, the distribution of plant parts within the proximal and distal shoals is slightly different. In the proximal peat shoal, the macrodetritus is principally that of leaf fragments (deciduous angiosperm and conifer) and/or branches with attached leaves (i.e., *Taxodium* deciduous branch system; Table 1; Fig. 7). Other photosynthetic organs include blades of grasses (probably *Spartina* and *Rhynchospora*) and blades of sedges. Fragments of branches, usually with attached bark, are more commonly encountered than isolated bark, or rounded and unrounded wood. Seeds (Table 1), tendrils (modified leaves found on vines aiding in attachment), and invertebrates (parts of insect carapaces) constitute but a small part of the sample. Size distribution of fragments in each assessed organ category are concentrated below the 1.0–1.5 cm size fraction with a mode in all cases in the 0.5–1.0 cm size fraction (Fig. 8).

Within the distal peat-shoal sample, fragmented angiospermous leaves and entire coniferous leaves do not dominate the recovered parts; rather, woody and periderm detritus are most commonly encountered (Fig. 7). Unrounded wood fragments followed by bark, branch, and rounded wood fragments account for nearly 70 percent of the sample. The percentage of conifer remains is not statistically different (based on 95% confidence limits of sample population) between this sample and the proximal peat sample, but the quantitative share of recovered angiospermous leaf remains in the two samples is different.

Accessory macrodetritus includes blades of grasses, roots from hydrophytic *Myriophyllum*, tendrils, seeds, and a small number of invertebrate remains. Similar to the proximal sample, the size distribution of fragments is concentrated below the 1.5-cm fraction (Fig. 9). In the cases for conifer leaves and branch, grass, and bark detritus, the mode is within the

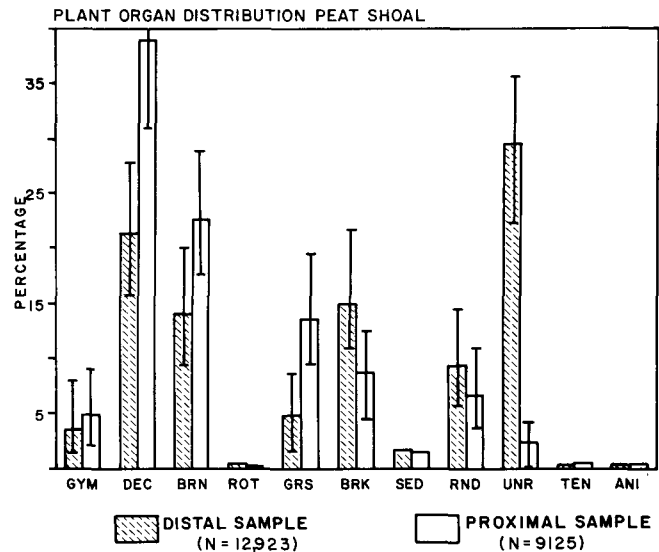


FIGURE 7—Histogram of recovered plant organ distribution from the distal and proximal samples of the peat shoal with 95% confidence intervals. Abbreviations same as in Figure 6.

0.5–1.0 cm category; angiospermous leaves, seeds, and rounded and unrounded wood detritus display a mode within the 0–0.5 cm range.

Sediment-Water Interface

Since the angiospermous leaves recovered from the subsurface peat were almost all highly fragmented and unidentifiable as to taxonomic status, an analysis was done of the whole-leaf litter at the sediment-water interface within the main crevasse-splay channel (Fig. 10; Table 2). Channel sediments are moderately sorted silty sands that are strongly skewed to the fine-grained end. Four hundred forty-three leaves were recovered from the sediment-water interface. All leaves are black and few are “fresh” in appearance, displaying discoloration by loss of chlorophyll and probably also because of fungal attack. This indicates that leaves have been in the water for some time. Due to either advanced stages of degradation of some leaves at the time of recovery, or fragmentation that occurred during drying and sorting, only 281 leaves were identifiable to species. Of these, deciduous dicotyledonous and angiospermous leaves dominate the sample (N = 263). The remainder of the sample comprises gymnospermous leaves and blades of grasses (Fig. 10).

The identifiable angiospermous leaves are dominated by the genus *Quercus*: Water Oak (*Q. nigra*) is encountered most frequently (Table 2). Other taxa include Willow Oak (*Q. phellos*), Laurel Oak (*Q. laurifolia*), Pin Oak (*Q. palustris*), Southern Red Oak (*Q. falcata*), Overcup Oak (*Q. lyrata*), Post Oak (*Q. stellata*), and Swamp Chestnut Oak (*Q. prinus*). Sycamore (*Platanus*) leaves of various dimensions and Willow (*Salix*) are common, in addition to twenty-four other identifiable genera. Most of these additional genera are represented by less than five leaves in the sampled population.

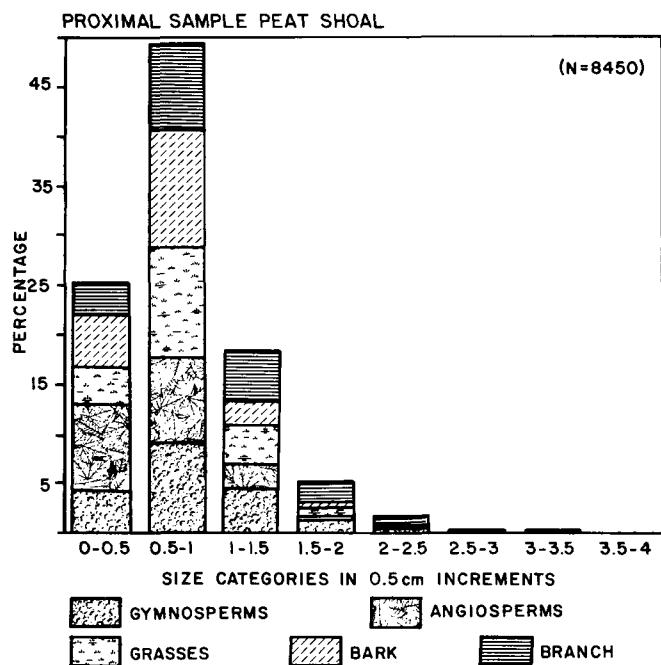


FIGURE 8—Histogram of macrodetrital fragment-size distribution of selected organ categories from the proximal peat-shoal sample. GYMNOSPERMS—Leaves, fascicles, and leafy branches; ANGIOSPERMS—Deciduous angiosperm leaves; GRASSES—Leaves of grasses and sedges; BRANCH—Branch and twig detritus (undifferentiated).

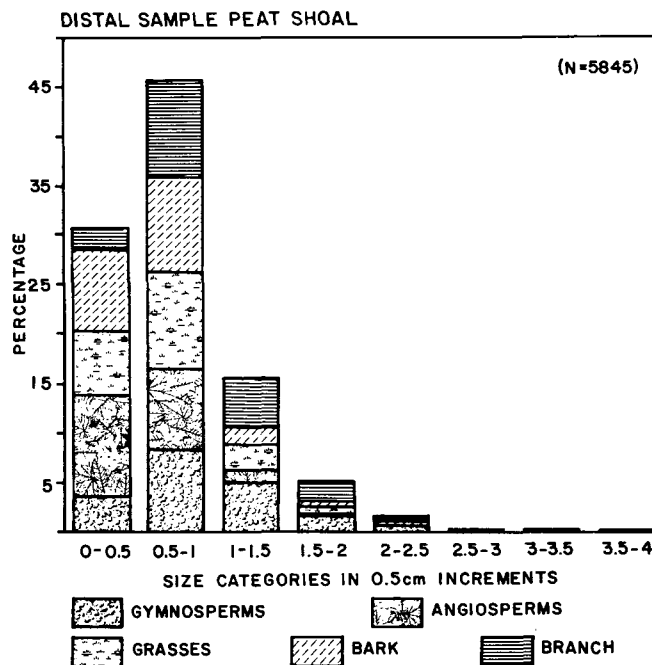


FIGURE 9—Histogram of macrodetrital fragment-size distribution of selected organ categories from the distal peat-shoal sample. Abbreviations same as in Figure 8.

In order to discern the plant communities from which leaves were derived, the original ecological community within the delta of each identified taxon was assessed using the plant demographics of Stout et al. (1982) (Table 2). Surprisingly few plants that live in either the low marsh or high marsh were represented in macrodetritus recovered from the crevasse channel bottom. Although Bald Cypress (*Taxodium*), Tupelo Gum (*Nyssa*), Ash (*Fraxinus*), Willow, and *Baccharis* ($N=1$) are reported to live in these marsh communities; only Willow, *Baccharis*, and the grasses inhabit the subaerial part of the crevasse or are in close proximity to the sample sites. All other genera recovered are not indigenous to the lower-delta-plain marsh communities; rather, these parts originated from natural-levee and/or swamp communities. A stand of Water Oak (*Q. nigra*) has been found in the high marsh adjacent to the breach site of the main crevasse channel, which may account for some or most of the *Q. nigra* detritus.

DISCUSSION

Among other plant-accumulating sites within the lower delta plain (Gastaldo, 1985, in prep.), the crevasse-splay system appears to be the site most suitable to the accumulation of plant-bearing sediments that would result in preserved, identifiable macrofloral assemblages. Flood-event pulses of large quantities of sediment laden with plant macrodetritus are

brought into the bay through the splay. Macrodetrital accumulations occur in the shallows of the principal channel DMBs and the crevasse shield and, during low velocity periods, along channel bottoms. This detritus is a mixture of autochthonous (in the site of growth), hypoautochthonous (transported a minimal distance from original community), and allochthonous (transported a distance greater than 0.5 to 1.0 km) elements. Transported plant parts arrive in various states that are reflective of deterioration stage when introduced into the water column, or alteration by redeposition; and may be subsequently altered by biological, mechanical, or chemical mechanisms. These taphonomic processes ultimately provide unique floral-assemblage characters.

Plant-Part Transport and Sorting

Bedded leaf-litter horizons in the DMB sands of active crevasse channels are the result of event sedimentation. The recovered litter bed was probably buried when sufficient quantities of flood-generated silty sands were deposited over this channel-bottom accumulation. Sediment velocities were apparently not high enough to scour the channel bottom, which would have dislodged the plant materials. Spring flooding of lowlands is a gradual process that is not characterized by a standing wave of energy as one would envision in a short-term flood event, such as with dam failure. Rather, water velocities may increase gradually as the flood crest approaches. Before maximum velocity occurs, bed-load sands have been transported and deposited over the litter bed. Because of its water-logged

TABLE 1—Identifiable plant organs recovered from peat-shoal samples.

	LOW MARSH	HIGH MARSH	LEVEE	ALLUVIAL SWAMP	DEEP ALLUVIAL SWAMP	PINE SAVANNAH	BAY FOREST	UPLAND
SEEDS								
<i>Rhynchospora</i> sp.	X			X		X	X	X
<i>Hypericum</i> sp.			X	X	X	X	X	
<i>Polygonum</i> sp.	X		X	X			X	
<i>Cephalanthus</i> sp.	X		X	X	X			
<i>Carex</i> sp.	X	X	X	X	X		X	
<i>Taxodium disticum</i>	X		X	X	X	X	X	
<i>Pinus</i> sp.						X	X	X
<i>Xanthium</i> sp.								
? <i>Cyrilla</i> sp.						X	X	
? <i>Nyssa</i> sp.	X		X	X	X	X	X	
? <i>Panicum</i> sp.	X	X	X	X	X	X		X
? <i>Carya</i> sp.			X	X	X			X
LEAVES								
<i>Taxodium disticum</i>	X		X	X	X	X	X	
<i>Juniperus virginiana</i>								
<i>Chamaecyperis thyooides</i>							X	
<i>Myrica cerifera</i>		X		X		X	X	

Leaves and seeds identifiable to taxon recovered from distal and proximal peat-shoal samples in relation to their possible original communities. Community correlations from Stout et al. (1982).

condition, the litter horizon may be a deterrent to, or a baffle against, continued transport of the sand. The flaccid nature of the litter provides resistance to sand-grain movement and may ultimately be the mechanism by which these litter beds are incorporated into the sediment package. Experimental investigations simulating these conditions in flumes would assist in substantiation of this hypothesis. The litter-bed depth in the water column was not altered appreciably by silty-sand compaction. This burial depth was sufficient to generate anoxic conditions under which the detritus could be preserved. As bay fill continued and DMB sands thickened, suprajacent litter beds ultimately were not preserved due to fluctuating oxygen levels, which were correlated with fluctuating water levels (flood vs. dry seasons and accompanying tides) and biodegradation by polychaete worms and microbiota. These litter horizons are composed of entire leaves and fragmentary plant parts introduced by a variety of mechanisms (see below).

Peaty accumulations adjacent to the active crevasse channels are caused by water-velocity reduction in shallow areas (less than 30 cm of water). Only a small fraction of water-logged suspension-load plant detritus (i.e., entire leaves) accumulates in these sites. Most is transported into Chacaloochee Bay and becomes incorporated into the muddy silts. Litter horizons can be identified in cores recovered from the open waters of

Chacaloochee Bay (Gastaldo, 1985). Fluvial, tidal, and wind-generated currents account not only for the redistribution of the plant materials into shoals and bars, but also for the mechanical fragmentation of leafy material. The surface of the detrital peats are covered by entire leaves, whereas samples recovered at depth are comprised of fragmentary parts. The fragmentary nature of subsurface peats is a function of reworking possibly in combination with biodegradation. The extent of biological degradation and its influence on laminar fracture has not been assessed in this system to date. Spicer (1981) and Ferguson (1985) provide data on decay rates of leaves in limnic systems, but tidal influence in these environments of deposition is not a contributing factor. Plant organs partially degraded by fungal or microbial activity might be more prone to mechanical breakup when subjected to daily agitation. Tides and storms move macrodetritus, as evidenced by peaty drapes at the sediment-water interface of the subaerially exposed crevasse shield (Fig. 4). The force of some of these events must be significant because dislodged, living *Rangia* have been found at times in the very shallowest of waters intermixed with the plant detritus. Although daily tidal activity may not be the single cause for mechanical fragmentation, in combination with high winds accompanying severe storms, it is probably the primary mechanism responsible for laminar breakage.

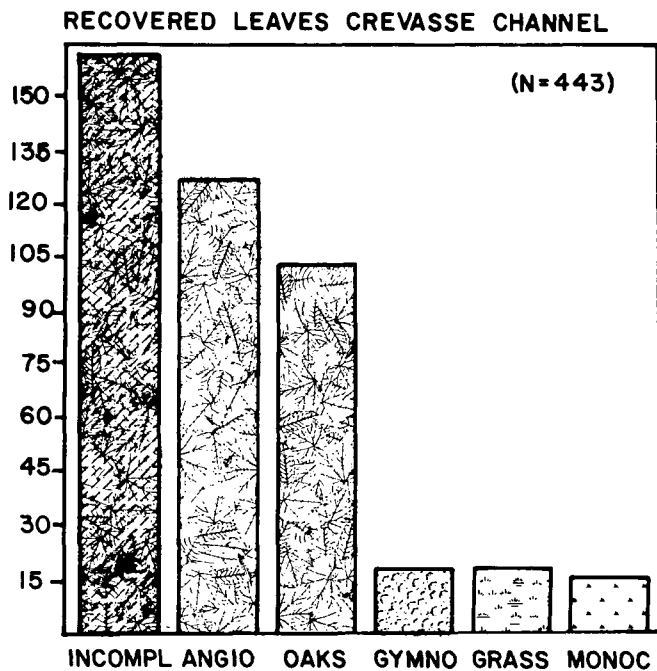


FIGURE 10—Histogram of quantitative share of major groups of leaves recovered from the sediment-water interface in the main crevasse-splay channel (see Figure 2 for location). INCOMPL—Incomplete or degraded leaves unable to be identified to taxon at this time (all following categories include entire leaves); ANGIO—Deciduous dicotyledonous angiosperm leaves other than oak; GYMNO—Gymnosperm leaves, fascicles, and leafy twigs; GRASS—Blades of grasses and sedges; MONOC—Leaves of monocotyledonous angiosperms.

Macrodetrital fragmentation and sorting by currents are exemplified by the size and organ distribution in the peat shoal. The distal shoal adjacent to the open bay waters is composed principally of woody fragments, including bark, as compared to the quantitative share of leaf fragments in the proximal shoal (Fig. 7). Wood and periderm are heavier than leaves of the same size class due to their inherently greater densities and, in the case of woody fragments, the water-logging of the xylem tissues. Wood-fragment size mode in the distal shoal is one category smaller than that found in the proximal shoal. This suggests that during tidal activity smaller wood fragments are concentrated in the distal shoal and that some of the leaf fragments are culled from the system. The source of the wood fragments is probably from within the shoal deposit. The depletion of woody fragments from the proximal part of the shoal supports this mechanism. Leaf remains culled from the distal shoal may be deposited in the proximal shoal, accounting for some of the leaf enrichment, or transported bayward. The smallest size fractions of the proximal-shoal leaf litter do not differ significantly in their frequency of occurrence. In all other macrodetrital organ categories, the size distribution in the distal and proximal portions of the shoal do not differ.

It is noteworthy that the fragmented woods may be either

rounded or unrounded. This differentiation suggests that wood fragments, once they are introduced into the channels, may be subjected to a variety of transport processes. It is common to find woody debris along the channel forebank oriented parallel to flow direction. This wood may be refloated and redeposited several times as a result of periodic flooding. Similar conditions no doubt exist along the distributary channel bottom. This bed-load wood component would also be subjected to refloating and redeposition, probably by means of saltation (for the smaller fragments) in addition to suspension-load transport. Abrasion of water-logged bed-load wood would result in the rounding of the smaller fragments. Hence, the rounded woods represent detritus introduced into the distributary channel system, deposited as bed load, and subsequently moved as either bed load and/or suspension load to the crevasse site. The unrounded wood fraction, on the other hand, would suggest principally suspension-load transport. No data are presently available to suggest whether or not rounding of wood is taxon specific. Although unrounded woods may have been resident on the channel bottom, they were not significantly rounded probably due to their short duration as bed load. Wood transport, then, may be facilitated by either suspension-load and/or bed-load processes.

Taphonomic Controls on Plant Parts and Species Representation

The most significant aspect of the recovered megafloreal assemblage is its provenance. One would expect that the local vegetation should contribute a significant proportion of identifiable detritus to the sediments accumulating in close proximity to their habitats. This is not the case in the present study. An analysis of the recovered leaves from the channel-bottom sediment-water interface demonstrates that macrodetritus supplied to the DMBs, peaty accumulations, and the open-bay waters are principally allochthonous, originating from distant communities.

Incorporation into subaqueous sedimentary environments must be accomplished through the movement of the various plant parts from aerially exposed sites. Organ disarticulation may be facilitated by wind (usually accompanied by severe storms), seasonal responses (such as leaf fall), or reproductive propagule dispersal. Wind and/or water provide the impetus for abiotic movement of the local vegetation into a depositional site. The low representation of marsh-community components in the assemblages is probably due to a combination of effects. Marsh topographic gradients are low and vegetation density is high. Meteoric waters, for the most part, percolate into the soils, providing little runoff. The movement of macrodetritus lying on the marsh surface would under normal circumstances be inhibited by adjacent standing vegetation. Vegetation density also prohibits large quantities of aerial parts from lateral transportation by wind. For example, the shrub *Baccharis* inhabits slightly higher microtopographies away from channels. It is not surprising that few leaves of this deciduous shrub occur in the recovered flora. Those plants living adjacent to, or in, waterways are best represented in the recovered suite (*Salix*, blades of grasses, and seeds of grasses and sedges), yet the numbers of individuals are quite low in most instances. This

TABLE 2—Identifiable plant leaves recovered from crevasse-splay channel bottom

	#	LOW MARSH	HIGH MARSH	LEEVE	ALLUVIAL SWAMP	DEEP ALLUVIAL SWAMP	PINE SAVANNAH	BAY FOREST	UPLAND
<i>Pinus palustris</i>	3						X		X
<i>Pinus elliottii</i>	3						X	X	X
<i>Taxodium distichum</i>	12	X		X	X	X	X	X	
Grasses	18	X	X	X	X		X	X	X
<i>Platanus occidentalis</i>	28			X	X				
<i>Smilax bona-nox</i>	1			X					
<i>Smilax</i> sp.	14			X	X		X		X
<i>Carya</i> sp.	3			X	X	X			X
<i>Carya aquatica</i>	5			X	X	X			
<i>Carya</i> cf. <i>laciniosa</i>	4			X					
<i>Salix nigra</i>	27		X	X	X	X		X	
<i>Carpinus caroliniana</i>	5			X					
<i>Betula nigra</i>	7			X					
<i>Fagus grandifolia</i>	7								
<i>Quercus nigra</i>	44			X				X	
<i>Quercus laurifolia</i>	20			X	X	X		X	
<i>Quercus phellos</i>	17			X					
<i>Quercus palustris</i>	8								
<i>Quercus falcata</i>	7								X
<i>Quercus lyrata</i>	4			X					
<i>Quercus stellata</i>	2								
<i>Quercus prinus</i>	1								
<i>Ulmus americana</i>	12			X	X				
<i>Planera aquatica</i>	1			X		X			
<i>Celtis laevigata</i>	1			X					
<i>Persea palustris</i>	1				X		X	X	
<i>Fraxinus caroliniana</i>	4	X		X	X	X			
<i>Crataegus viridis</i>	1			X					
? <i>Gleditsia aquatica</i>	2			X					
<i>Osmanthus americana</i>	3							X	
<i>Acer rubrum</i>	1			X	X	X		X	
<i>Nyssa sylvatica</i>	1	X		X	X	X	X	X	
<i>Nyssa aquatica</i>	4			X	X	X			
<i>Lyonia lucida</i>	1						X	X	
? <i>Halesia carolina</i>	3			X					
<i>Trachelospermum difforme</i>	3			X					
<i>Baccharis halimifolia</i>	1		X						

Identifiable entire leaves recovered from the sediment-water interface at the channel bottom of the crevasse splay (see Fig. 2 for location). Plants are correlated to possible communities from which the detritus could have originated (after Stout et al., 1982).

NOTE: Total number of leaves (N=443) recovered from the channel bottom were not all identifiable primarily due to degradation. Fragmental leaves are represented by 162 specimens and are not included in the table.

may be explained for the grasses by their life habit where leaves are not deciduous and are used by invertebrates and vertebrates as food. *Salix* leaves and seeds, on the other hand, may be transported into the open bay before sinking to the sediment-water interface.

Flooding occurs during the spring before the marsh vegetation rejuvenates. Prostrate grass stalks and leaves on the marsh surface are decayed to a large extent. Interactions of fungi, bacteria, and invertebrate phytophages with the dead vegetation reduce the quantity of transportable litter. When

flooding occurs, what remains is often floated and flushed during the cresting phase. Once flood waters subside, litter characteristic of transitional-upper delta and alluvial flood plains may be deposited. Therefore, flooding inhibits the chance that marsh detritus will become incorporated into distributary bay sediments.

The majority of recovered leaves originated in communities defined as alluvial swamps, deep alluvial swamps, or natural levees. In many cases, the macrodetritus could have only originated from the natural-levee association. This is not surprising due to the close community proximity to the distributaries and the taphonomic factors that may affect channel-margin vegetation (Scheihing, 1980). Alluvial swamps occur to the north within an approximate 1.8-km radius of the splay channel, and litter could have originated from at least this close to the study site. Since these interior lowlands are bounded by low- and high-marsh communities, detritus originating from these swamps must have traveled via a series of slow moving bayous into the Tensaw distributary channel before being diverted into the splay. The probability is low that a high proportion of allochthonous detritus found in the splay originated from these particular swamps.

Most likely, this plant litter originated from levee communities beginning some 13 km north, or from extra-basinal communities (*sensu* Pfefferkorn, 1980). This first supposition is based on the high proportion of plants representative of the levee vegetation. It must be noted that most of the taxa adapted to alluvial swamp conditions are also inhabitants of levees (i.e., *Taxodium*, *Platanus*, *Carya*, etc.), but specific taxa such as the lianas (*Smilax* and *Trachelospermum*), some of the oaks (*Q. nigra* and *Q. phellos*), and other canopy trees (*Crataegus*, *Betula*, *Celtis*, etc.) are restricted to levee communities (Table 2; Stout et al. 1982). This would suggest that the elements characteristic of the delta wetlands probably originated from near-channel sites. The timing of leaf drop may play an important role in the ultimate composition of the assemblage. Oaks retain their leaves for a longer period of time than most other deciduous angiosperms in the lowlands. These leaves may dehisce throughout the winter and early spring before new leaves develop from bud. This tendency to shed leaves during spring-flood times may provide a biased sampling that ultimately is reflected in the recovered macroflora. Additionally, oak leaves are coriaceous and more resistant to decay than other taxa (Spicer, 1981).

On the other hand, a small percentage of recovered elements are not inhabitants of the deltaic wetlands. These parts include fascicles of Pine (*Pinus palustris* and *P. elliottii*) and leaves of Pin Oak (*Q. palustris*). The fascicles may have been transported into the splay by a number of mechanisms. Pines dominate the upland vegetation, inhabiting cliffs and higher elevations adjacent to the delta. Fascicles may have been transported by winds into the bay and redistributed to the splay by either tidal or surficial currents generated by northwardly blowing winds. It is not uncommon to find leaves of *Platanus* in the embayment north of the splay that were moved to this site by either of these processes. Another possibility is the loss of fascicles from bay forest communities via transport down tributaries and creeks emptying into the Tensaw River. These fascicles are ultimately diverted into the splay. Since *Q. palustris* is only

recorded from upland communities, wind is the most likely mechanism by which these parts were initially transported.

Leaf-litter movement is principally by suspension-load transport as suggested by the non-abrasion of leaves recovered from the channel bottom. Their black coloration is due to biodegradation and long term residence in the water. Since the leaves become water-logged after being introduced into the channel and consequently become heavier, they apparently are transported beneath the air-water interface until reduction in water velocity causes them to settle out of the water column. This hypothesis will be tested during the next major flood cycle.

Implications for Paleovegetational Reconstructions

The ramifications of the correlation between the recovered macrofloral assemblages and their original plant communities are numerous. Plant-bearing sediments, other than some autochthonous rooting horizons in lower delta plains of temperate climatic regimes, generally do not provide an accurate picture of the local vegetation. Hypoautochthonous local elements are underrepresented in macrofloral remains, although there is probably a better chance of recovering both vegetative and reproductive structures of these plants. Plant parts of those plants living adjacent to or within the waterways have a higher probability of becoming incorporated into the sediments than do plants inhabiting sites more distant from the channel margin. This is also true of the allochthonous elements even though they are overwhelmingly represented in the deposit. Those plants living closest to distributary channels have the higher probability of being sampled and transported downstream some distance (km's), to be incorporated eventually in splay sediments. These plants are represented principally by vegetative parts, although reproductive structures are occasionally recovered (i.e., *Taxodium* and ?*Nyssa*; Table 2). Even extrabasinal elements may be present (*Pinus*), represented by both vegetative and reproductive parts.

In Neogene temperate-subtropical deltas of the northern hemisphere, macrofloral assemblages recovered from interpreted interdistributary bay sediments probably are not valid sample suites to use in the paleoecological reconstructions of deltaic lowlands due to the conditions outlined above. These deposits, though, would provide data on those plants inhabiting near-channel sites. In addition, the possibility exists that, by comparison with time- and/or laterally equivalent upper-delta-plain autochthonous or hypoautochthonous plant-bearing deposits, allochthonous species in lower-delta-plain deposits may be recognized. Their recognition may provide a means for developing a more accurate assessment of lower-delta-plain vegetation. Successful vegetational reconstructions depend upon the understanding of the depositional environment and the specific taphonomic processes operating in that environment (i.e., Gastaldo, 1987).

Extrapolation back in geologic history with regard to other temperate deltaic regimes may be difficult due to the absence of herbaceous grasslands prior to the Oligocene. Incorporation of plant macrodetritus in crevasse splays in deltas of tropical climates may follow a similar pattern to that documented for the Mobile Delta, but since taphonomic characterization of tropical, clastic-accumulating deltas has only begun, this hypothesis has yet to be tested.

CONCLUSIONS

- 1) Crevasse splays appear to be the sites most suitable for the accumulation of plant-bearing sediments that would result in identifiable macrofloral assemblages in lower-delta-plain sequences of temperate/subtropical deltas.
- 2) The accumulations are a mixture of autochthonous rooted sediments and/or poorly developed soils, underrepresented hypoautochthonous lower-delta-plain plants, and overrepresented allochthonous elements originating from the distant upper-delta-plain and extrabasinal communities.
- 3) Litter beds are interpreted to represent channel-bottom accumulations buried during initial phases of flooding, accounting for their preservation.
- 4) Detrital peats accumulate as a result of water-velocity reduction in shallow areas. Fluvial, tidal, and wind-generated currents affect the redistribution of these plant parts as well as providing the mechanical impetus for fragmentation of leaves. Biodegradation of leaves may facilitate or enhance mechanical fragmentation.
- 5) Plant parts may be differentially sorted depending on their size fraction and inherent density differences. Woody and leafy fragments of the same size may either be concentrated or culled from detrital peat accumulations by currents.
- 6) Rounded and unrounded fragments support a variety of transport processes for wood. Rounded wood represents detritus transported mostly as a bed-load component, whereas unrounded wood suggests transport principally as suspension load.
- 7) Plant parts of vegetation living adjacent to or within waterways have a higher probability of incorporation into sediments than do plants inhabiting sites more distant from the channel margins.
- 8) Plant-bearing sediments other than some autochthonous rooting horizons in lower delta plains of temperate/subtropical climatic regimes generally do not provide an accurate representation of the local vegetation. Successful vegetational reconstructions depend upon the understanding of the depositional environment and the specific taphonomic processes operating in that environment.

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Because of the utter impersonality of scientific creative knowledge, we have the paradox that Robert Merton has pointed out: one can only secure this private intellectual property of discovery and creativity by open publication. The more open the publication, the more secure the private property. It is for this reason, I think, that there has come about a certain international constancy in what constitutes a publishable and good scientific paper in a good journal in any particular field.

—Derek de Solta Price