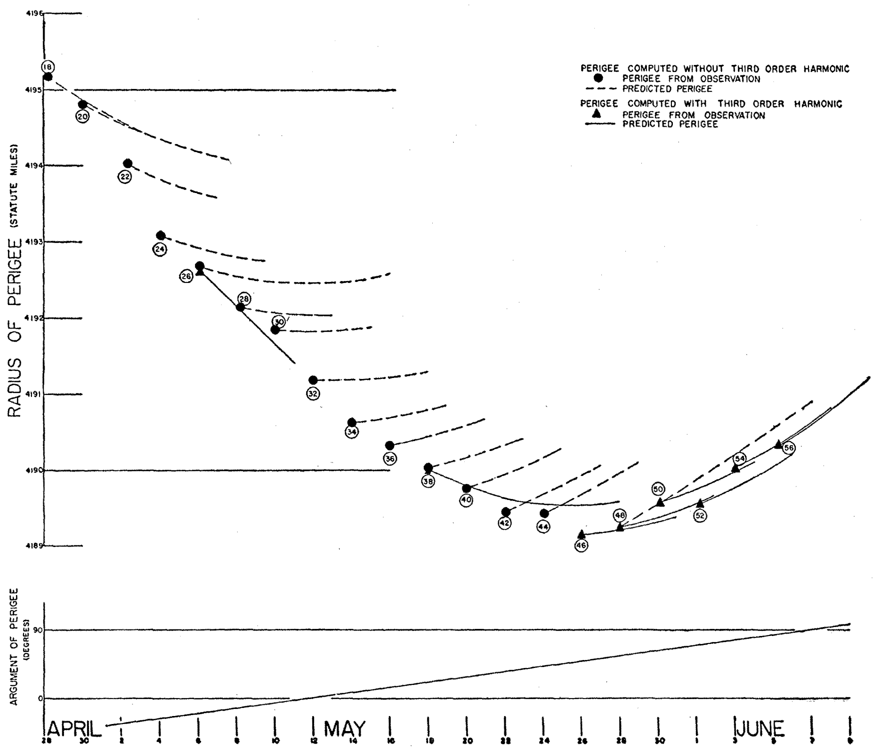

Fig. 1. Perigee observation and prediction for Transit 1B.

and of 1960γ. The Doppler observations of 1960γ at five of the six tracking stations were on the 324-to-54 Mcy/sec coherent frequencies radiated by the satellite. The received frequencies were combined in the data processing to eliminate the first-order effects of ionospheric refractions. One of the stations observed on the 216-to-162 Mcy/sec coherent frequencies with an analog combination to eliminate the first-order ionospheric refraction effects. The numerical integration for the Transit orbit takes account of various gravitational harmonics and of atmospheric drag, the air density being taken as a function of height only.

The story of the confirmation of the third-order harmonic is much like that of the original discovery. Without the third-order harmonic, the predicted

Table 1. Data on 1958β and 1960γ earth satellites.

Feature	1958β	1960γ
Perigee height	410 mi	230 mi
Apogee height	2450 mi	470 mi
Inclination	34°	51°
Tracking system	IGY Minitrack system	Doppler data from six Northern-Hemisphere stations
Orbit computation	General oblateness perturbation	Numerical integration

perigee distance was found to deviate systematically from the distance deduced from subsequent observations. However, with a third-order harmonic of 0.24 $Mm^6/ksec^2$, as an average of O'Keefe's 0.25 and Kozai's (*2*) 0.228, the bias between the predicted and subsequently determined perigee distances is essentially removed.

This is shown in Fig. 1. The encircled numbers are the day numbers. The solid circles represent the perigee distances every 2 days as determined from the various Doppler measurements obtained during one day. The measurements were used to estimate first the orbital position and velocity vectors at an epoch shortly before the first observation of the day. The perigee distance given is the perigee distance computed from this position and velocity for the osculating Keplerian orbit at the first ascending equator-crossing after epoch. (It is not the osculating value at epoch, nor a mean osculating value over a revolution, as was used in the preliminary Vanguard analysis.) The dashed curves forward of the circles are the loci of the predicted perigee distances at subsequent ascending equator-crossings. Both the circles and the dashed curves are based on orbits estimated without a third-order gravitational harmonic. It is apparent that the predictions deviate systematically from those found through subsequent observation.

In Fig. 1 the triangles represent perigee distances determined when the third-order harmonic is used in the computations, and the solid lines represent the corresponding predictions. It is seen that the errors of prediction are now close to the noise level. A measure of the accuracy of the third-order harmonic based on our data is therefore the ratio of the uncertainty in the slope of the curve through the observed values to the difference in slope between the dashed and solid curves. This is roughly 5 percent. The lower plot shows the argument of perigee corresponding to the perigee distances.

Variations in the observed eccentricity of the Transit orbit are also accounted for, just as dramatically, by the same third-order harmonic.

The results presented here are based on limited operational computations. By special analyses over longer periods of time there is promise of much greater refinement in the determination of gravitational and geodetic parameters from the Transit system.

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13 June 1960

Temperate Pollen Genera in the Eocene (Claiborne) Flora, Alabama

Abstract. Pollen, spores, hystrichospherids, dinoflagellates, and the fresh-water alga *Pediastrum* occur in marine clays at the classic Claiborne Bluffs locality, Alabama. The presence of *Ephedra* pollen provides the first documented Tertiary record of this genus from the southeastern states. The occurrence of several characteristically temperate genera lends support to the idea that a deciduous hardwood forest was present in the Appalachian uplands during the Eocene.

Thanks to the prodigious work of E. W. Berry, the fossil floras of the Coastal Plain and Mississippi Embayment, largely preserved in near-shore marine sediments, provide a unique record of successive change through time of strand and lowland vegetation. Among the most prolific, with remains throughout many of the South Atlantic and Gulf states, is the triad of well-known Eocene floras: Wilcox (Lower), Claiborne (Middle), and Jackson (Upper). From these Berry described about 200 genera of plants (many common to the three floras) and hundreds of species. By comparison with living species, he interpreted the fossils as lowland, chiefly coastal-strand, lagoon, and estuarine types with affinities largely with the near-shore vegetation of subtropical and tropical Mexico and Central and South America. He considered none of the Eocene floras, however, to be "strictly tropical" (*1*, p. 1).

Among numerous genera now largely confined to the equatorial lowlands, Berry identified a few with temperate implications, in what he called warm-temperate (Wilcox) and subtropical-tropical (Claiborne, Jackson) floras. Using Berry's floral lists, Cain (*2*) demonstrated high correspondence at the *generic* level between the Eocene floras and the vegetation of the temperate southern Appalachians. Sharp (*3*) showed a similar correspondence between the Wilcox and the vegetation of the eastern Mexican escarpment region, with its mixture of temperate and tropical climates (*3, 4*). Brown (*5, 6, 7*) added to the Wilcox five other temperate genera represented by relatively rare specimens, and predicted that "Examples of other missing temperate genera will doubtless be found as collectors become aware of the possibilities" (*6*, p. 350).

Thanks to the medium of microscopic study, a number of the "missing temperate genera" can now be included in the southeastern Middle Eocene flora. It is suggested that they lived in interior sites and possibly on the upland slopes of the Appalachians, which appear to have been strongly emergent during the early Tertiary. The value of adding plant microfossils to the Eocene floral picture cannot be overestimated. For pollen, widely scattered and unrestricted in its distribution, may be supposed to shed considerable light on the nature of the regional (and upland) forest, although mega-remains from these facets of the flora were less accessible to lowland sites of deposition than structures of coastal plants.

The plant microfossils and other microorganisms have been concentrated from the uppermost formation (Gosport sand) of the Claiborne group at Claiborne Bluffs, southern Alabama. The Gosport is here disconformably overlain by the Ocala limestone (Upper Eocene) and underlain by the Lisbon formation. A coarse, highly glauconitic marine sandstone with abundant invertebrate fossils, the Gosport locally contains thin clay beds from which plant megafossils (*1*), as well as pollen, have been recovered (Table 1, Fig. 1). Berry considered the 13 megafossil genera represented in the Gosport sand to be the commonest Claiborne plants. The vascular plants new to the florule, including essentially all the identified genera characteristic of, or largely restricted to, regions of temperate climate, are new as well to the southeast Middle Eocene flora. Several of these genera have megafossil remains in Cretaceous Coastal Plain sediments (Table 1): *Abies* (*Abietites*) is not otherwise reported as a fossil in the East; tulip-tree is encountered again only in the Pleistocene; pine remains (Eocene, Miocene) are known only from the Middle Atlantic States before the Pleistocene. Fossil elm first appears in the Miocene; alder, *Carpinus* and *Ostrya* are not known from pre-Pleistocene sediments. As otherwise reported (*8, 9*) from the middle-south Atlantic and Gulf states, birch and beech (Pliocene, Pleistocene) occur also in the Wilcox (*6, 7*); linden (Pleistocene) and chestnut (Pliocene) in the Jackson (*1*); sweet-gum (Pleistocene) in the Wilcox and Jackson (*1, 10*). The absence of these genera from the Claiborne may be due to chance or to a change in their distribution. The same is true of oak and holly, whose megafossil histories in the East are essentially complete through the Tertiary into the Cretaceous, although Berry referred oak-like remains in the southeastern Eocene floras to *Dryophyllum*, and reported *Ilex* in this area only from the Wilcox.

The presence of *Ephedra* among the Claiborne assemblage arouses much interest in the first record of this genus in eastern American Tertiary sediments

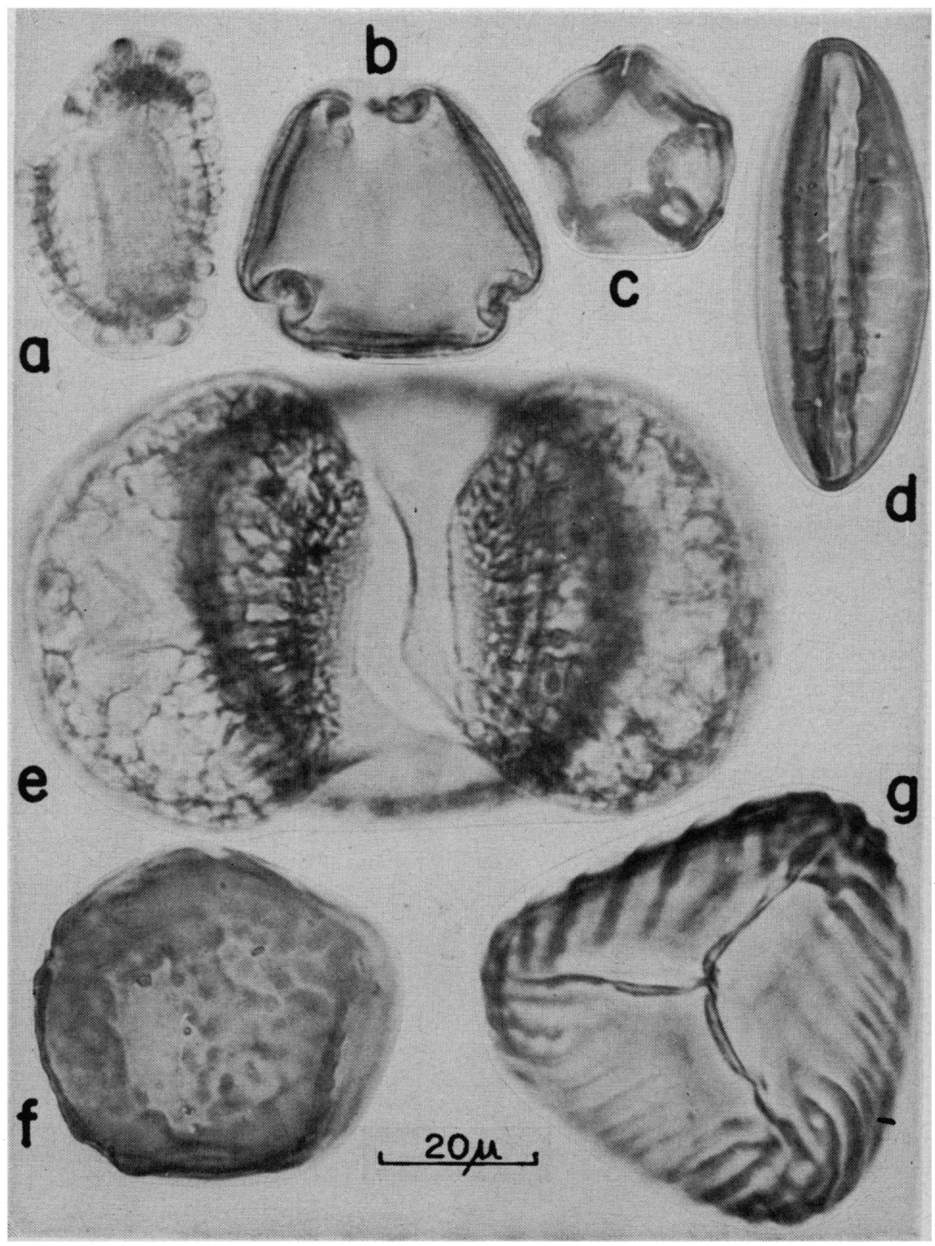

Fig. 1. Photomicrograph of Claiborne (Middle Eocene) plant microfossils. (*a*) *Ilex* (holly); (*b*) *Nyssa* (tupelo); (*c*) *Alnus* (alder); (*d*) *Ephedra* (Mormon tea); (*e*) *Pinus* (pine); (*f*) *Ulmus* (elm); (*g*) *Aneimia* (compare *Mohria*).

(*11*). The North American ephedras now occur widely in and at the margins of the warm-temperate, subtropical deserts: their habitats show wide range in elevation, but are characterized generally by shallow, rapidly drying, highly permeable soil. To account for the presence of the Claiborne ephedras in an environment of high atmospheric humidity (*1*), it is possible to speculate that local conditions of edaphic aridity may have existed in highly insolated sites, on shifting sands, beach dunes, or sand-flats adjacent to the coast, without surmising that this species had environmental requirements entirely different from modern ones. However, it seems as plausible to question the assumption that early Tertiary ephedras were physiologically as fully differentiated as the living species. Thus the tentative suggestion may be put forward that the Claiborne species did not have the limiting adaptive relations of living ephedras, although it may have been confined to drier, better-drained sites where it survived largely because of limited competition with associates.

Bearing in mind the several temperate genera now added to the Middle Eocene flora, it seems possible to postulate (i) a long southeast history for some genera whose remains have been found in this area, heretofore, only in late Tertiary sediments, and (ii) the continued survival, possibly from the Upper Cretaceous, of a temperate assemblage whose members largely lack early Tertiary megafossil records. The fossil records lend support to the thesis advanced by Cain (*2*) which postulates the antiquity of the vegetation of the southern Appalachians, and its essential constancy in the Southeast throughout the Tertiary. That none of the temperate genera were among the more common or widely distributed of the Claiborne plants at low elevations is supported by two facts: (i) essentially all of them have only microfossil records; (ii) the total percentage of their pollen is a small proportion (about 20 percent) of the microflora, although most of these genera are wind-pollinated, or less obligately entemophilous, and their pollen would tend to be more common if the plants had been abundant. Thus the probability of distant transport seems to explain the apparent mixture of deciduous hardwoods and broad-leafed evergreens of now unlike climatic zones, without the necessity of assuming a "greater genetic variability at the generic level" (*3*) or that many of these genera have changed their climatic requirements through time. One or the other of these factors may also have been operative for some genera, for example, *Ephedra*, but I do not feel that they best explain the over-all composition of the Gosport florule.

The temperate genera occurring as pollen, together with some found as megafossils, represent an assemblage which can be compared directly with the existing deciduous hardwood forest of middle latitudes, and the temperate Holarctic Eocene flora, although admittedly some of the more important members of both are still missing. This comparison strongly suggests that the temperate pollen stems from an upland community, quite modern in aspect, which clothed the inland foothills and lower slopes of the Eocene Appalachians, while a subtropical flora thrived at lower elevations and along the strand. A close parallel is found today in the eastern Mexican forest, where communities of the tropical "tierra caliente" merge with those of the temperate "tierra templada" at elevations of about 3300 to 4000 feet at "the dividing line between elements of the great arcto-tertiary and neo-tropical floristic regions of classical phytogeography" (*4*, p. 313; *12*).

Table 1. Identified plant fossils from the Gosport sand, Claiborne group. *C*, genera or families reported from other Claiborne localities.

Group	Micro-fossils	Mega-fossils (*1*)
Hystrichospherids	+	
Algae		
Dinoflagellates	+	
Pediastrum spp.	+	
Ferns		
Aneimia (cf. *Mohria*)	+	C
Lygodium		+
Polypodiaceae (cf. *Polypodium* spp.)	+	
Acrostichum		+
Gynmosperms		
*Abies**?	+	
Ephedra (cf. *E. nevadensis*)	+	
*Pinus** (*haploxylon* and *sylvestris* types)	+	
Taxodiaceae-Cupressaceae	+	C
Angiosperms		
Alnus	+	
*Betula**?	+	
Carya	+	C
Castanea	+	
Celtis	+?	C
Citrophyllum		+
Coccoloba		+
Combretaceae	+	
Conocarpus		+
Laguncularia		+
Terminalia		+
cf. *Engelhardtia-Alfaroa*	+	
*Fagus**	+	
Gramineae	+	
Arundo		+
*Ilex**	+	
Juglans	+	C
Liquidambar	+	
*Liriodendron**	+	
Moraceae	+	
Ficus		+
Myrica		+
Myrtaceae	+	C
Nectandra		+
Nyssa	+	C
Ocotea (*Oreodaphne*, *Mespilodaphne*)		+
Onagraceae	+	
Ostrya-Carpinus	+	
Palmae	+	C
*Quercus**	+	
Sapindaceae cf. *Cardiospermum*	+	
Sapindus		+
Sapotaceae	+	C
Tilia	+	
Ulmus (cf. *Zelkova*)	+	

* Genera new to the Claiborne with Cretaceous fossil records in the middle-south Atlantic and Gulf regions (*8, 9*).

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11. The abundant, well-preserved grains do not suggest transport from distant inland regions of more continental climate.
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27 May 1960

Isotopic and Zoogeographic Paleotemperatures of Californian Pleistocene Mollusca

Abstract. Pleistocene paleotemperatures inferred from zoogeographic evidence are based on temperatures at species' range limits at present. Paleotemperatures inferred from isotopic evidence are based on average former shell-growth temperatures which commonly, but not exclusively, lie between present range-limiting temperatures. With allowance for these differences, the two lines of evidence suggest similar thermal patterns.

Average temperatures of shell deposition of 43 specimens representing 22 molluscan species from 13 Californian Pleistocene fossil assemblages were estimated by the O^{16}/O^{18} method (*1*). For these specimens, Table 1 lists (i) isotopic paleotemperatures (based on average Recent sea water, with instrumental error $\pm$ 1°C), (ii) present approximate range-limiting temperatures (average February temperatures at northern and average August temperatures at southern range end-points, corrected for depth), and (iii) the most probable depth at which each specimen lived [based on the present ecology of the species and supported by paleoecologic analyses of the 13 fossil assemblages (*2*)].

A few forms yielded isotopic paleo-