When samples were melted in a transparent container, an insoluble crystalline residue, which appeared to be XeF_4, was always found. Because of the immiscibility of XeF_6 and XeF_4, fractional vaporization and condensation effect only limited purification.

We have found XeF_6 and NaF form an addition compound of sufficient stability to be useful for purification and separation of XeF_6 from XeF_4, XeF_2, and $XeOF_4$.

Ten grams of sodium fluoride in a nickel container were fluorinated with a mixture of xenon fluorides, and all volatile material was removed at 500°C. About 10 grams of XeF_6 containing XeF_4, XeF_2, and $XeOF_4$ was condensed onto the NaF, and the mixture was warmed at 50°C for 2 hours and allowed to remain at room temperature overnight. Fractions volatile at room temperature, at 50° to 55°C, and at 125°C were collected and identified by means of their infrared spectrum (*5*). The fraction volatile at room temperature was almost exclusively $XeOF_4$, indicating essentially no binding of $XeOF_4$ to NaF. At 50°C the volatile material was mainly XeF_2 and XeF_4 with small amounts of $XeOF_4$. Whether the higher temperature for XeF_2 and XeF_4 collection is required to dissociate weakly bound addition compounds of these materials with NaF or merely to increase the vapor pressure to facilitate collection is not yet established. The infrared spectrum of the fraction collected at 125°C, which contained approximately 8 grams of XeF_6, showed no absorption bands associated with $XeOF_4$, XeF_4, XeF_2, and HF. Only absorption bands due to XeF_6 were present. While the strong XeF_6 absorption in the region of XeF_4 and XeF_2 absorption bands limits the determination of XeF_4 and XeF_2, the absence of an insoluble residue in the liquid XeF_6 and the low solubility of XeF_4 and XeF_2 in XeF_6 would set an upper limit on the amount of XeF_4 or XeF_2 which could be present.

The melting point of the purified XeF_6 was determined in a sapphire tube attached to a small Hoke valve. The melting point, determined several times on two separate samples, was 47.7° ± 0.2°C, about 1.5°C higher than previously reported (*3*). The solid XeF_6 turned yellow at 43° to 43.5°C, melted to a yellow liquid with no insoluble residue, and became colorless on solidification and cooling.

The XeF_6-NaF adduct was also prepared in a sapphire tube by adding excess XeF_6 to NaF. The NaF dissolved in the XeF_6 to give a yellow solution. On removing the excess XeF_6 under vacuum at 50°C, a pale yellow addition compound resulted.

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Planktonic Foraminifera from the American Oligocene

Abstract. *Planktonic foraminiferal assemblages from the Vicksburg group of the Gulf Coast region comprise species comparable with those found in the Oligocene of Tanganyika and northern Europe. The fauna is transitional between typical Upper Eocene and Miocene; its intermediate position is indicative of an Oligocene age.*

During the more than 60 years since Maury (*1*) made her fundamental study of the Oligocene in the southeastern United States and Caribbean region, geologists have recognized the Vicksburg group as typical of the American Oligocene (*2*). Eames *et al.* (*3*), by considering that the Vicksburg group is Miocene in age, have suggested that the whole Oligocene is missing in the well-known marine sediments of the Gulf Coast and Caribbean regions. They made an extensive study of benthonic and planktonic Foraminifera as well as

Table 1. Abundance and species composition of planktonic Foraminifera of the Oligocene Vicksburg group and an Upper Eocene deep-sea core. Figures given are the number of specimens per gram of dried sediment. Only pertinent species are listed in the Eocene core.

Species	Marianna formation			Byram	A 167-21 ||	
	A*	B†	C‡	§	365 cm	150 cm
Globigerina ampliapertura Bolli	4.0	12.7	23.3	2.9		
G. angustiumbilicata Bolli	37.5	401.2		2.4		
G. ciperoensis Bolli	14.2	31.6		11.2		
G. gortanii (Borsetti)		0.6				
G. ouachitaensis Howe & Wallace	77.6	993.6	60.6	44.9		
G. praebulloides Blow	1.6	44.9		8.0		
G. tripartita Koch	1.6	0.6		0.5		
G. yeguaensis Weinzierl & Applin	4.9	31.0	9.3	7.6		
Globorotalia increbescens Bandy	2.7					
G. opima nana Bolli	4.9	51.3	15.1			
G. cf. *permicra* Blow & Banner	13.8					
G. postcretacea (Myatiluk)	104.0	113.2	11.6			
Pseudohastigerina micra (Cole)	695.2	741.1	186.2		7837.8	2292.5
Globoquadrina conglomerata (Schwager)	1.6	4.4		2.2		
Globigerinita dissimilis (Cushman & Bermudez)		0.6				
Globorotaloides variabilis Bolli	0.8	56.3	2.3			
Cassigerinella chipolensis (Cushman & Ponton)	0.8	5.7	1.2	0.2	1621.6	158.1
Chiloguembelina cubensis (Palmer)	334.9	2234.1	65.3	0.5	378.3	
C. martini (Pijpers)					3459.4	2687.7
Miscellaneous (Juveniles sp. indet.)	536.7	432.4	23.3	15.4		

* Sample A, Marianna limestone in Little Stave Creek, Clark County, Alabama. † Sample B, Marianna limestone, 1.2 m above the top of the Mint Spring marl member in Little Stave Creek. ‡ Sample C, Marianna limestone, 3.0 m above the top of the Mint Spring marl member in Little Stave Creek. § Byram sample, bluff on west bank of Pearl River beneath bridge, at Byram, Hinds County, Mississippi. || A 167-21, 29°49′N, 79°39′W, 1455 m depth; two Eocene samples from 365 cm and 150 cm below top of core.

of mollusks, corals, and echinoids. The planktonic Foraminifera (Globigerinacea) received special emphasis; they considered that benthonic dwellers reflected facies influences and could lead to miscorrelations and that their taxonomy and stratigraphic ranges for this region were not adequately established. Their main argument was that a series of planktonic foraminiferal zones of Upper Eocene and Oligocene is missing from the Gulf Coast and Caribbean regions; their zonation was based on their studies in Tanganyika and other parts of the world.

Several authors (*4*) have questioned the concept of Eames *et al.* concerning "Oligocene" as well as the concept concerning the age and geographic extent of their *Globigerina oligocaenica* (that is, *G. sellii*) zone represented by the Lattorfian and Rupelian stages (Fig. 1).

We have examined planktonic Foraminifera (Table 1) of the Marianna and Byram formations of the Vicksburg group (*5*); these indicate Oligocene age judging from the fauna which is similar to the *Globigerina oligocaenica* zone. The Marianna formation contains species comparable with those of the *G. oligocaenica* zone and the formation is characterized by the concomitant occurrence of *Globorotalia postcretacea, Pseudohastigerina micra, Chiloguembelina cubensis,* and *Cassigerinella chipolensis.* The superjacent Byram fauna differs from the Marianna fauna in lacking *Globorotalia postcretacea* and *Pseudohastigerina micra,* though *Globigerina ampliapertura, G. ouachitaensis, G. yeguaensis* and others occur commonly in both formations.

Blow and Banner (*3*) gave six criteria for discerning the Oligocene *G. oligocaenica* zone from the succeeding *G. ampliapertura* zone which was considered to be the lowest Miocene (Aquitanian) beds. Among them the following three criteria should shed light on the age of the present Vicksburg planktonic Foraminifera. First, the occurrence of *G. yeguaensis yeguaensis* in the Eocene sediments as well as in the Oligocene serves to distinguish it from the overlying Miocene *G. ampliapertura* zone. Typical *G. yeguaensis* occurs commonly throughout all of the Vicksburgian samples studied; hence the Oligocene age of the present assemblages is suggested. Second, the concomitant occurrence of *G. oligocaenica, G. ouachitaensis gnaucki, Globigerina turritilina turritilina* (that is, *Globigerina gortanii*), and *Globigerinita martini scandretti* is restricted only to the *Globigerina oligocaenica* zone but not to the *G. ampliapertura* zone. Only *G. gortanii* is present in the Vicksburg assemblage, thus this criterion is not suitable in the present case. Third, an important criterion is that the overlap in range of *Pseudohastigerina micra,* a common Eocene species, and *Cassigerinella chipolensis,* a common Miocene species (Aquitanian to Burdigalian), occurs only in the *Globigerina oligocaenica* zone. The joint occurrence of these two species is observed in the Marianna formation. The finding of *Pseudohastigerina micra* by Batjes (*6*) in the Septarian clay (middle Oligocene) of Pietzpuhl, northern Germany, is noteworthy since the upper range of this taxon establishes the typical middle Oligocene in Europe. However, *Pseudohastigerina micra* has never

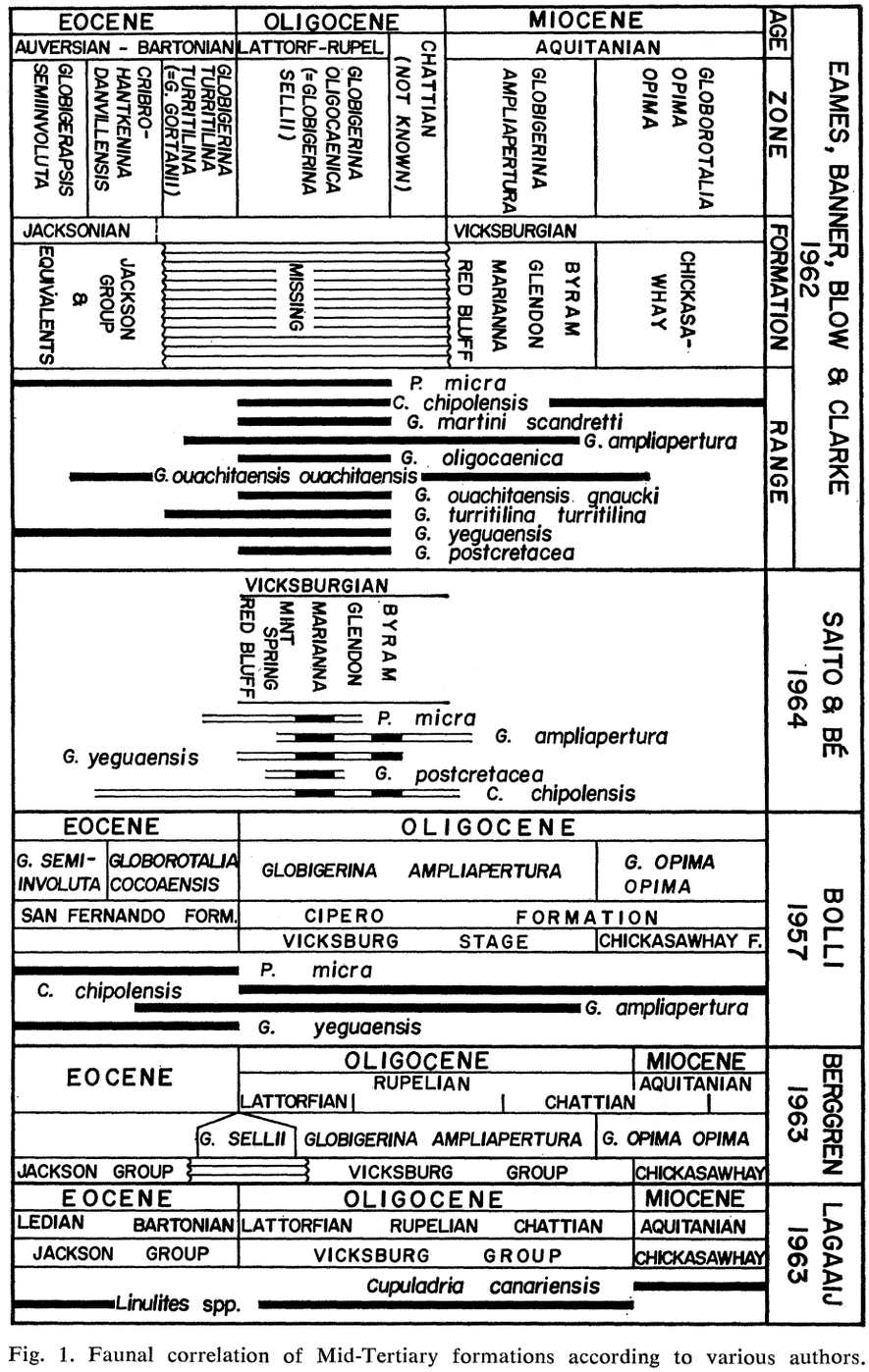

Fig. 1. Faunal correlation of Mid-Tertiary formations according to various authors.

been reported from beds equivalent or younger than the *Globigerina ampliapertura* zone; hence this view upholds the correlation of the Marianna fauna with the *G. oligocaenica* zone, which is older than the *G. ampliapertura* zone. On the other hand, we have observed the overlap in range of *Pseudohastigerina micra* and *Cassigerinella chipolensis* in the Upper Eocene. They occurred together in Lamont core A 167-21—from off the coast of Florida, 29°49′N, 79°39′W (1455 m)—in association with the typical Upper Eocene planktonic Foraminifera *Hantkenina alabamensis, H. primitiva, Globorotalia centralis, G. cerroazulensis,* and so forth.

Berggren (*4*) questioned the third aspect claiming the overlapping of these two species in North Africa as high as 135 feet (about 41 m) above the base of the *Globigerina ampliapertura* zone, which he considered as the Rupelian age of Oligocene and denied the presence of *G. oligocaenica* zone in a time sense. However, this statement does not necessarily contradict the view by Blow and Banner, since *G. ampliapertura* has already been known in the Upper Eocene (*7*).

Micropaleontologists have differed in their "zone" concept (*8*). According to the Code of Stratigraphic Nomenclature (*9*), the unmodified term *zone* may imply three different biostratigraphic categories characterized by a fossil taxon or taxa occurring in any given stratum or body of strata; namely, assemblage zone, range zone (that is, the biozone of some authors) and concurrent-range zone. If the *Globigerina ampliapertura* zone of Berggren represented the "range zone," it covers the total life-span of the species, from the *Globigerina ampliapertura* zone to the Upper Eocene. Therefore, the overlap of *Pseudohastigerina micra* and *Cassigerinella chipolensis* as high as 41 m above the base of the *Globigerina ampliapertura* range zone is quite natural. Blow and Banner define their zones as the biozone (range zone); but their "biozone" of *Globigerina turritilina turritilina* represents only the earlier part, not the total range of the species. This usage is inconsistent.

The occurrence of *Globigerina postcretacea* in the Marianna formation is significant. Myatiluk originally described this species from beds possibly of Oligocene age in Ukraine. Later Subbotina (*10*) described and illustrated it in detail from the lower part of the Oligocene of Caucasus. Blow and Banner observed this species only in the *Globigerina oligocaenica* zone in Tanganyika and also in the Rupelian of Elmsheim, Germany.

Mornhinveg (*11*) already noticed the occurrence of *Pseudohastigerina micra* in the type Vicksburg and in the lower half of the Red Bluff clay, a subjacent formation of the Vicksburg group. This species was attributed by Eames *et al.* to reworking from the underlying Jackson group (Upper Eocene) from where typical Eocene genus *Hantkenina* was also considered to have been redeposited into the Red Bluff clay. To disprove that older Jackson fauna was reworked into the younger Vicksburg fauna, the following arguments are presented.

First, the consistent occurrence throughout the samples and the great abundance of *Pseudohastigerina micra* (more than 50 percent of the total identifiable planktonic Foraminifera in the two samples) makes it unlikely that it has been reworked. Second, the absence of the common Eocene species *Chiloguembelina martini* (*12*, Table 1) in the Marianna formation is evidence that older material was not mixed. Ac-

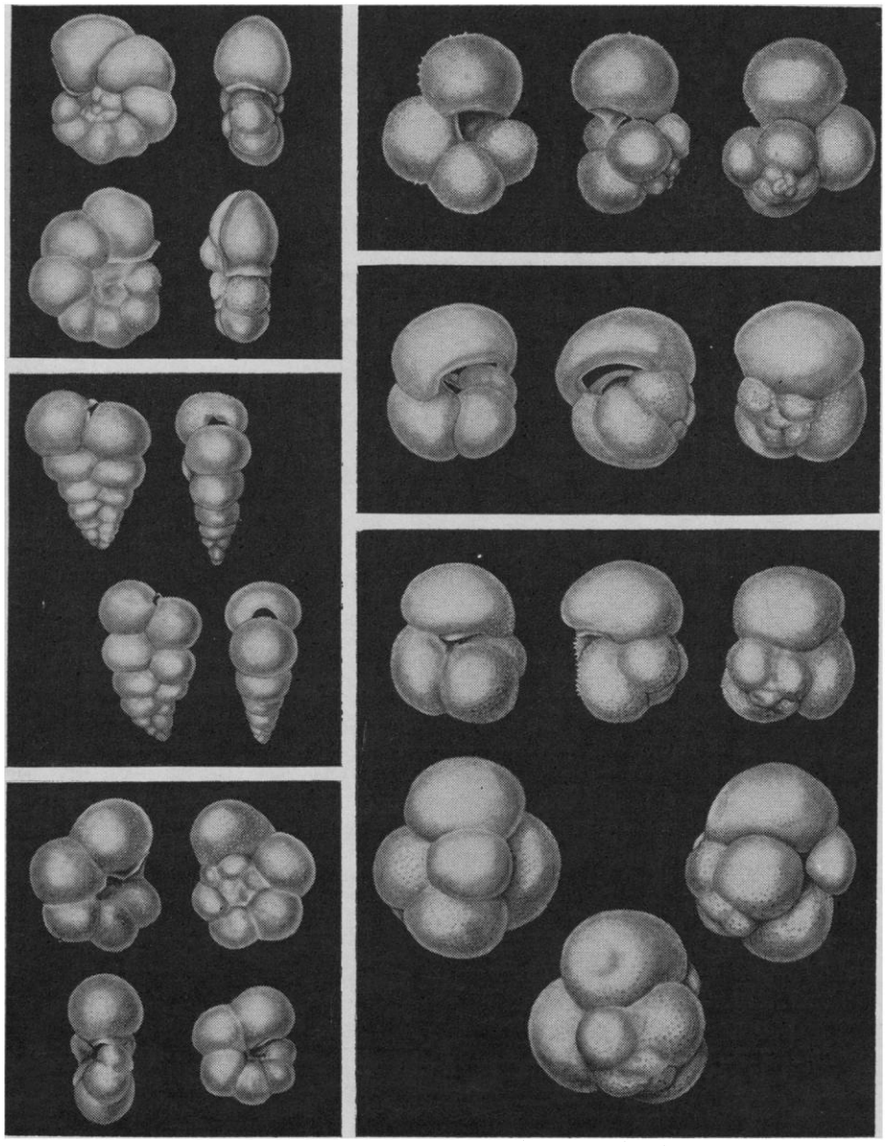

Fig. 2. Six species of planktonic Foraminifera of the Vicksburg group that indicate the existence of Oligocene in the Gulf Coast region. *Pseudohastigerina micra* (top left; ×117), *Globigerina ouachitaensis* (top right; ×76), *Chiloguembelina cubensis* (middle left; ×117), *Globigerina ampliapertura* (middle right; ×50), *Globorotalia postcretacea* (bottom left; × 117), and *Globigerina yeguaensis* (bottom right; × 50).

cording to Lagaaij (*13*), Oligocene age for the Vicksburg group is also indicated by the first appearance of the bryozoan *Cupuladria canariensis* in the Chickasawhay formation which directly overlies the Vicksburg group. The first appearance of this species, which marks the Oligo-Miocene boundary in Europe as well as in the Gulf Coast and Caribbean regions, is placed somewhere between the top of the *Globigerina ampliapertura* zone and the lower one-third of the *Globorotalia opima opima* zone.

The evidence from the planktonic Foraminifera strongly suggests that the Vicksburg assemblages are closely comparable with the fauna of the *Globigerina oligocaenica* zone of Tanganyika and some Oligocene faunas from northern Europe. The present planktonic Foraminifera are transitional in character between the typical Upper Eocene below and the *G. ampliapertura* zone above and, therefore, indicate their intermediate age, that is, Oligocene. In conclusion, this interpretation reaffirms the existence of the Oligocene in the Gulf Coast region.

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Potassium-Argon and Lead-Alpha Ages of Plutonic Rocks, Bokan Mountain Area, Alaska

Abstract. *Most of the granitic rocks in the Bokan Mountain area, southeastern Alaska, are early Paleozoic (probably Ordovician) judged by potassium-argon and lead-alpha age measurements. The Bokan Mountain Granite, the youngest intrusive unit in the area, belongs to a Mesozoic plutonic episode. These age measurements are the first direct evidence for the emplacement of early Paleozoic granitic intrusive rocks close to the Pacific margin of North America.*

Potassium-argon and lead-alpha age measurements indicate that most of the granitic rocks in the Bokan Mountain area are Paleozoic in age, thus providing the first documentation of Paleozoic intrusive rocks in western North America contiguous to the Pacific Ocean. The results also indicate a possible source for granitic clasts in the middle Paleozoic conglomerates that occur elsewhere in southeastern Alaska.

The Bokan Mountain area, about 189 km² of the southern part of Prince of Wales Island (Fig. 1), is underlain largely by a complex assemblage of granitic rocks ranging from pyroxenite to syenite and peralkaline granite (*1*). Quartz diorite, diorite, granodiorite, and quartz monzonite are the dominant rock types. The granitic rocks intrude metasedimentary and metavolcanic rocks in the northern part of the area; metamorphic rocks also occur as small screens or pendants. Intrusive relationships among the granitic rocks indicate that the more mafic rocks were emplaced earlier than the felsic types. The Bokan Mountain Granite is the youngest intrusive unit in the area. It is a peralkaline granite which forms a boss approximately 8 km² in area that is surrounded by a roughly concentric alteration aureole approximately 3 km wide. Alteration of the quartz monzonite and granodiorite in the aureole is characterized by albitization of plagioclase, chloritization of biotite, and local silicification.

Table 1. Potassium-argon age for plutonic rocks, Bokan Mountain area, Alaska (*10*). The numbers in parentheses indicate the number on Fig. 1.

K_2O (%)	Ar^{40}_{rad} (10^{-10} mole/g)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Age (10^6 yr)
	Riebeckite (1)		
1.72	4.819	0.83	181 ± 8
	Riebeckite (4)		
1.46	4.215	0.82	186 ± 8*
	Hornblende (5)		
0.392	2.792	0.43	431 ± 21
	Biotite (6)		
4.06	24.75	0.96	372 ± 18
	Hornblende (7)		
0.628	4.691	0.57	446 ± 22

Decay constants for K^{40}:
$\lambda_\epsilon = 0.585 \times 10^{-10}$ year^{-1}
$\lambda_\beta = 4.72 \times 10^{-10}$ year^{-1}
Atomic abundance of
$K^{40} = 1.19 \times 10^{-4}$

* Age reported previously by Wasserburg and others (*8*).

According to Buddington and Chapin (*2*) the prebatholithic rocks of southern Prince of Wales Island are Devonian in age. No fossils have been found in the Bokan Mountain metamorphic rocks, and their possible Devonian age is based on correlation with fossiliferous rocks in other parts of Prince of Wales Island.

Criteria for dating (in the field) the granitic rocks in the Bokan Mountain area are meager, but like the other granitic rocks of southeastern Alaska, they were previously assigned a Mesozoic age (*2*, *3*). The granitic rocks here intrude metamorphic rocks of possible Devonian age and are cut by dikes of possible Tertiary age (*1*). The Coast Range batholith on the mainland intrudes rocks as young as Middle and Late Jurassic and Early Cretaceous and has been considered to be Late Jurassic to Early Cretaceous in age (*2*). The plutons in the islands west of the Coast Range generally have been considered to be satellitic to the batholith and, by inference, of the same age. Measurement of the lead-alpha ages of zircon suggests a Mesozoic age for granitic rocks in two southeastern Alaska localities (*4*)—near Taku Inlet south of Juneau and near Tolstoi Point in the central part of Prince of Wales Island. Potassium-argon ages of 163 and 186