of the lagoons and playas. The influence of fluviatile processes over marginal marine was more pronounced eastward toward the interior of Baja California where a region of higher relief persisted.

Prior to the discovery of the hadrosaurian *Hypacrosaurus* in Baja California, the genus was known only from the Edmonton Formation of central Alberta, Canada, and one possible specimen from the Two Medicine Formation of Montana. Fossils of *Hypacrosaurus*, usually consisting of disarticulated limb bones or portions of the vertebral column, are common in Alberta and Baja California. The problem of the dispersal route of the genus *Hypacrosaurus* and the question of the temporal equivalence of the two widely separated beds containing dinosaur bones are only partially solved by information from the formations in Baja California.

The Edmonton Formation is generally considered to be stratigraphically younger than the underlying marine Bearpaw Formation although the two apparently interfinger; the Edmonton Formation represents a marginal marine and nonmarine deposit formed during the retreat of the Bearpaw Sea. The Bearpaw Formation, in turn, overlies a second nonmarine unit, the Oldman Formation (*7*). The typical hadrosaurian of the Oldman Formation is the crested form *Corythosaurus*. *Hypacrosaurus* has only been found in the Edmonton Formation.

Potassium-argon (K-Ar) dating has been used to set the time of the retreat of the Bearpaw Sea at 66 to 68 million years ago (*8*). The advance of the Bearpaw Sea, as indicated by K-Ar dates, occurred between 72 and 73 million years ago. The former group of dates gives a maximum age for the Edmonton Formation, while the latter gives a minimum age for the Oldman Formation. Invertebrate faunas from the Bearpaw Formation are indicative of latest Campanian age. With this as a basis, the Edmonton Formation is considered to be Maastrictian, and the Oldman Formation is thought to be Campanian. The K-Ar dates also suggest this chronological sequence (Fig. 1).

The age for the El Gallo Formation (late Campanian) is temporally equivalent to the Oldman or Bearpaw Formation. It has been suggested that *Corythosaurus* is the ancestral form leading to *Hypacrosaurus*, but it may have occurred too late to be the direct ancestor. It is certain that there was some interchange of fauna between Alberta and Baja California during the Cretaceous period. *Hypacrosaurus* from Baja California has been positively identified, and it is a well-established taxon in the Canadian Cretaceous deposits. Possible pathways for distribution of this form were apparently along the tectonic belt (north to south) of the Rocky Mountains. *Hypacrosaurus* has not been found in late Cretaceous deposits along the eastern flank of the Rocky Mountains, although hadrosaurian dinosaurs are common. Hence, *Hypacrosaurus* probably moved into the Baja California area along the Pacific. It is surprising that *Hypacrosaurus* is absent from late Cretaceous beds containing dinosaur bones in northern Mexico and the southern Rocky Mountains. Certainly the presence of this dinosaur in Canada and in Baja California indicates a pandemic population. In spite of this, the mainland faunas seem to have been dominated by various saurolophine hadrosaurs and the genus *Kritosaurus*. The restriction of *Hypacrosaurus* to the Pacific margin of Baja California suggests either a paleoecological or a paleogeographic barrier to the east during late Campanian time.

Ceratopsian dinosaurs have not yet been found in the deposits of Baja California; yet these dinosaurs are very common in late Cretaceous strata along the east flank of the Rockies, and are even present in the deposits of Central America. Absence of this otherwise pandemic form gives further support to the theory of the isolation of the Baja peninsula during the late Cretaceous period. Further paleontologic study of the nonmarine Cretaceous of Baja California will certainly solve some of the problems within this critical area.

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Pleistocene Shoreline Sediments in Coastal Georgia: Deposition and Modification

Abstract. *New evidence invalidates the former concept that Pleistocene shorelines are "terrace" cut and fill structures. Comparison of Pleistocene and Holocene sediments with morphology of the shoreline indicates that Pleistocene deposits accumulated in barrier-island environments and that the "terraces" are former lagoon–salt marshes. Stratigraphic evidence supports six major Pleistocene shorelines below an elevation of 100 feet (30 meters).*

The controversy of a marine versus a fluvial origin for the coastal "terraces" of southeastern Georgia has been summarized by Flint (*1*) and Cooke (*2*). In recent reports, MacNeil (*3*) and Doering (*4*) consider the "terraces" below an elevation of 100 feet (30 m) as marine, but they do not detail the depositional environments; the origin, history, and position of the shorelines is uncertain. This report, based on new sedimentologic and morphologic evidence, outlines briefly the development of the Georgia coastal plain. Similar studies have been completed in southeastern Virginia by Oaks and Coch (*5*); the findings are compared with those we obtained in the study of the Georgia shorelines.

Six major Pleistocene shorelines, at 95 to 100 feet (Wicomico), 70 to 75 feet (Penholoway), 40 to 45 feet (Talbot), 24 feet (Pamlico), 13 feet (Princess Anne), and 4.5 feet (Silver Bluff), occur in Georgia and extend from the present shoreline to an elevation of 100 feet. Deposits of each of these shorelines constitute formations of the same names. Established nomenclature is retained because it is convenient, is widely recognized, and has a useful history of several decades. A change in concept of origin and history of some units is involved, but these changes do not justify major reclassification. Formations are subdivided into barrier-island facies and lagoonal-marsh facies (Fig. 1). Elevations of the lower three shorelines are known with considerably more precision than those of the upper three because of better control from the fossil burrows of the marine decapod *Callianassa* (*Ophiomorpha nodosa* Lundgren). Studies along the Georgia coast show that the upper limit of these burrows can be an indication of mean sea level (*6*). Eustatic fluctuations in sea level during the Pleistocene were superimposed on a general emergence of the Georgia coast. Major shoreline deposits accumulated during stillstands of the sea at times of submergence.

Origin of the Pleistocene deposits is best understood by comparing them with the Holocene coastal accumulation. Holocene barriers are low segmented islands composed of fine- to medium-grained sand and rarely attain heights exceeding 30 feet. The islands vary in length from 1 to 7 miles (1.6 to 11 km), and segmentation is inherited from adjacent barrier islands of Silver Bluff age. Seaward progradation along the front of the islands results in a relatively thin deposit commonly extending only 20 to 30 feet below sea level. Adjacent to shifting inlets, however, accumulation occurs to a depth of 50 feet and more below sea level (*7*).

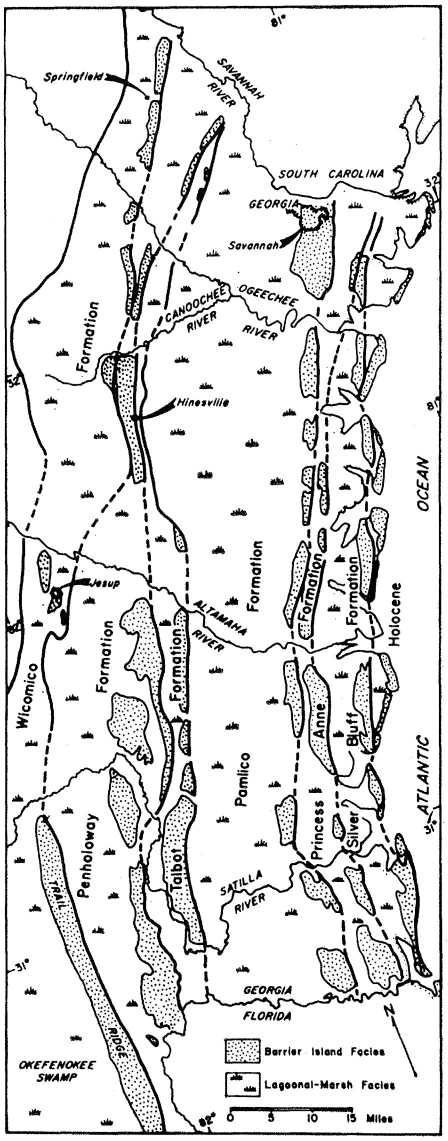

Fig. 1. Geologic map of southeastern Georgia showing distribution of barrier-island and lagoonal-marsh sediments in Pleistocene formations and Holocene sediments.

Sediments landward of the Holocene barriers are deposited in lagoonal–salt marsh environments that are drained by tidal creeks flowing into estuaries; however, there probably were shallow open-water lagoons during the development of some Pleistocene shorelines. Lagoonal–salt marsh sediments are characterized by sands, silts, and clays, whereas the barriers are composed of fine- to medium-grained, well-sorted sands. Coarse sands and gravels are common in the estuaries. Sand bodies are common within the lagoonal–salt marsh environment and have formed in a variety of ways. Some are bar deposits formed in the tidal creeks and estuaries (*8*); others formed as spits during the progradation of the barrier island.

Pleistocene shoreline deposits are also associated with barrier-island environments. The broad, approximately horizontal surfaces, designated "terraces" by early investigators, are abandoned salt marshes, lagoons, and filled estuaries. These are bordered on their seaward margin by barrier islands, many of which are preserved along segments of the former shoreline.

Modification of Pleistocene barriers is best understood by comparing modern examples with the Pleistocene features. In several areas along the shoreline, protecting barriers have been removed and salt-marsh sediments are eroding along the beach. In these areas the barrier remnant is a thin veneer of sand, 3 to 5 feet thick and several yards wide, on the upper foreshore and backshore overlying marsh sediment. Commonly, erosion, during a late stage of a stillstand (or after a stillstand), removes a part or all of the barrier and, in some instances, large parts of the salt-marsh sediment as well. In some areas the Pleistocene barriers are pushed back over the lagoon–salt marsh as washovers and blowovers, forming a veneer of barrier sediment several feet thick over the marsh sediment.

The Wicomico, oldest and highest of the studied shorelines, is poorly defined and difficult to trace in the central and northern part of the area. In the south, Trail Ridge, a well-developed barrier with dunes more than 70 feet high, marks the Wicomico shoreline. Lagoonal sediments landward of this barrier indicate that the shoreline was approximately 100 feet above the present sea level. Trail Ridge increases in height southward in Florida because of the uplift along the flank of the Ocala arch. Remnants of the segmented Wicomico barriers are present near Jesup and Springfield. The lagoon varies considerably in width from a maximum of 25 miles west of Trail Ridge (Okefenokee Swamp) to less than 4 miles west of Jesup.

Table 1. Comparison of shoreline elevations in southeastern Virginia (*5*) and coastal Georgia.

Virginia		Georgia	
Shoreline	Elevation (ft)	Shoreline	Elevation (ft)
Late Sandbridge	0–5	Silver Bluff	4.5
Sandbridge	10–15	Princess Anne	13
Londonbridge	25	Pamlico	24
Norfolk	43	Talbot	40–45

The Penholoway shoreline is clearly defined in several areas at approximately 70 to 75 feet above present sea level. In addition to the height of lagoonal sediments deposited landward of the barrier islands, *Callianassa* burrows have been found at two locations at elevations of 68 and 65 feet, which confirms a sea level to at least 70 feet. The seaward barrier chain is preserved from Canoochee River to south of Hinesville and from the Altamaha to the Satilla rivers. Maximum width of the Penholoway lagoon is approximately 8 miles near Penholoway Creek southeast of Jesup; however, near Hinesville the former lagoon is very narrow or completely removed and the Penholoway barrier is adjacent to the older Wicomico shoreline.

The Talbot shoreline was formed when sea level was approximately 40 to 45 feet higher than the present level. Fossil *Callianassa* burrows were found at two localities, which indicates that sea level exceeded 35 feet. The upper limit of Talbot lagoonal–salt marsh sediments is approximately 45 feet. The best preserved Talbot barrier extends from the Altamaha to the Satilla River. Eolian deposits along the crest of the barrier reach an elevation of 73 feet, approximately 30 feet above Talbot sea level. North of the Altamaha River a small portion of the barrier is preserved, but farther north, east of Hinesville, the barrier has been removed and only a narrow band, ½ to 1 mile wide, of

Talbot lagoon is preserved. North of the Ogeechee River there are small remnants of Talbot barrier which generally overlie lagoonal sediments. Throughout coastal Georgia, the Talbot lagoon is seldom more than 2 miles wide.

The Pamlico barrier system is well preserved. Fossil *Callianassa* burrows at several locations indicate that sea level was approximately 24 feet higher than it is today. The highest and best preserved barriers are near Savannah and to the north of the Altamaha River, where they reach elevations as high as 47 feet above sea level, almost 25 feet above the Pamlico sea. The Pamlico lagoon–salt marsh is a broad distinctive feature, ranging from 10 to a maximum of 20 miles in width, east of Hinesville.

Barriers along the Princess Anne shoreline developed only a short distance seaward of Pamlico barriers in the central portion of the coast, but the lagoon–salt marsh widens to both north and south. Sea level was about 13 feet above the present level, as indicated by *Callianassa* burrows at several locations. The barriers have a maximum elevation of 30 feet above present sea level, or 17 feet above Princess Anne sea level, and are fairly continuous except in the area of the Ogeechee River where erosion and dissection have left only small remnants.

The Georgia sea islands are late Pleistocene and Holocene in age. The Silver Bluff (late Pleistocene) parts of the islands were formed when sea level was about 4.5 feet above the present level. The lagoonal salt marsh landward of the Silver Bluff barriers has been reoccupied by Holocene marsh. Along the front of most Silver Bluff islands the Holocene salt marsh is narrow or missing, so the Holocene beach is adjacent to the Silver Bluff barrier. South of the Savannah River, however, the Holocene salt marsh is as much as 6 miles wide.

In southeastern Virginia, Oaks and Coch (*5*) have described shoreline features consisting of barrier islands and associated environments. The elevations of the lower four shorelines that they studied correspond very closely with those reported here, which suggests direct correlation (Table 1). Possible minor warping makes correlation of the upper shorelines more speculative (*9*).

Comparison of modern and Pleistocene shoreline features provides a means of understanding the deposition and modification of the coastal plain sediments. Within the area of this study, the shorelines are approximately horizontal. Morphologic and sedimentologic variation within the preserved segments of the Pleistocene shorelines indicate that detailed study of small areas should be undertaken after thorough regional mapping has located the general position of the shorelines applicable to the local area. Detailed mapping and stratigraphic studies of small areas will give a greater precision for establishing histories of shoreline elevations and deposition.

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Virus-Like Particles in Established Murine Cell Lines: Electron-Microscopic Observations

Abstract. *Virus-like particles identical in morphology to the RNA tumor viruses have been observed by electron microscopy in six lines of murine L cells and one line of murine liver cells. Control cultures of embryonic mouse cells and 3T3 cells do not contain the particles, and no biologic activity has as yet been associated with them.*

The L-cell line of malignant fibroblasts has been widely used for tissue culture studies since it was established from connective tissue of a C_3H mouse (*1*). In the course of studies on the replication of a murine leukemia virus (Gross) in vitro, virus-like particles were noted in control cultures of L cells. A single similar observation has previously been reported (*2*). We have extended these observations to various lines of L cells and other cultures derived from mouse cells.

We handled cell cultures from various sources (*3*) by a standard procedure to exclude the possibility of introducing contaminating viruses. Upon receipt, the bottle was opened under strict aseptic conditions. The cells were removed from the glass surface with sterile glass beads. One-half of the cells were centrifuged at low speed for 10 minutes to form a pellet for electron-microscopic examination (*4*). Additional samples were taken for electron microscopy from serial subculture in our laboratory. Cells received from the American Type Culture Collection in a frozen ampule were thawed and transferred to prescription bottles in a separate laboratory that was not used for culture of stable murine lines or for virus studies; they were prepared for electron microscopy as soon as a complete monolayer had formed. Mycoplasma was not found in cells or supernatants cultured for its detection (*5*), nor was it indicated by autoradiography with tritiated thymidine (*6*).

Abundant structures resembling RNA tumor viruses (*7, 8*) were seen in six lines of L cells and in one line of NCTC-1469 liver cells (Table 1). Both type-C and type-A particles were present. The type-C particles had an outer membrane and an electron-opaque nucleoid; the total diameter varied from 90 to 115 $m\mu$ (Figs. 1 and 3). The nucleoid had a diameter of approximately 65 $m\mu$. The type-A particles were of the same size, lacked a dense nucleoid, and contained an inner, hollow sphere 65 $m\mu$ wide. An intermediate dense band between the outer membrane and the inner sphere was often observed (Fig. 2); this intermediate band was not observed in type-C structures. The particles were formed by the typical process of budding from the cell membrane into the extracellular space or into vesicles formed by the endoplasmic reticulum (*8*).

The cell lines differed with respect to the amount, location, and morphological type of virus-like particles present. In L-cell clones of L-929 and in the NCTC-1469 liver cells, large numbers of type-C particles were localized in the extracellular space, although budding forms and free type-A particles were occasionally seen both extracellularly and within cytoplasmic vesicles of the endoplasmic reticulum. Abundant particles were