our results and those of Platford is not due to the presence of calcium carbonate in our experiments. We also observed precipitation at pH values between 9.8 and 9.9 upon addition of base. Calcium carbonate, though supersaturated, does not appear to precipitate because the formation of nuclei is slow (*11*). The absence of coprecipitation of calcium with magnesium has been known for some time and is used for the separation of these ions in the analytical scheme of Pate and Robinson (*12*). Perhaps addition of a base causes initial supersaturation. In any event, our values for the activity coefficient of magnesium ions and those determined by Platford are lower than those determined by Garrels and Thompson.

Activities of single ions have thermodynamic significance, but they cannot be measured rigorously. The effect of the difference between our assumptions and those made by Garrels and Thompson cannot be evaluated at present.

Specific and nonspecific interactions probably differ only in a matter of degree. Also, these two types of interactions are not strictly separable because they are not independent of one another. Each ion added to seawater will affect the structure of the water and the environment and activity of the other ions present. Thus the interpretation of activities in terms of specific and nonspecific interactions is an idealization that provides only a preliminary insight into the structure of seawater.

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Recent Emerged Beach in Eastern Mexico

Abstract. *A bluff on the eastern coast of Mexico reveals a cross section through an ancient beach deposit now lying 4 meters above sea level. Radiocarbon dates on the shells within the deposit reveal an age of 1940 years. The deposit appears to be valid evidence for submergence greater than that of the present, but whether that submergence was due to a higher eustatic stand of the sea or whether there has been an uplift of the land since that time cannot yet be determined.*

The position of absolute sea level during the last 5000 years has recently been studied and debated by several workers (*1, 2, 3*). Although many of these workers have discredited the hypothesized absolute stands higher than the present one because of lack of evidence in areas they have studied, evidence from other areas (*4*) prevents me from disregarding the possibility entirely without further testing. I report here a previously undescribed beach deposit in eastern Mexico that contains shells whose C^{14} ages fall within the period in question and that now stands up to 4 m above sea level.

The deposit is located at longitude 97°46–47′W, latitude 24°29′30″N, on the south end of a southward projecting peninsula between Bahia Salada (also referred to as Bahia de los Algodores) and Laguna Madre in the state of Tamaulipas, Mexico (Fig. 1). It is exposed in an east-west trending bluff about 2 km south of the fishing village of La Carvajal. The south-facing bluff is a wave-cut cliff, the waves being generated by predominating southeasterly trade winds.

Figure 2 is a diagrammatic representation of exposure in the bluff. It trends perpendicular to the present coastline and is a cross section through deposits which strike parallel to the coast. The bluff contains three distinctive units.

The lowermost unit is a yellow-orange, clayey sand (24 to 30 percent clay, 56 to 68 percent sand) and continuously underlies all other units to an unknown depth. It is devoid of macrofossils but contains a few foraminifers and abundant calcium carbonate in the form of caliche. It is rather friable but distinctly more compact than the overlying units. The upper surface of this sand has two depressions, lower portions of which are 0.5 to 1.3 m above sea level (*5*), and these depressions are reflected in the present topography. The highest elevation of this surface is about 3.6 m; the unit is massive and shows no bedding whatsoever. Within this unit are two outcrops of beach rock, specimens of which have given C^{14} ages of 25,000 and 35,000 years. However, both specimens were highly recrystallized and contained shell material converted from aragonite to calcite, secondary sparry calcite cement, and grain-growth calcite. Thus, although it is improbable that the C^{14}-

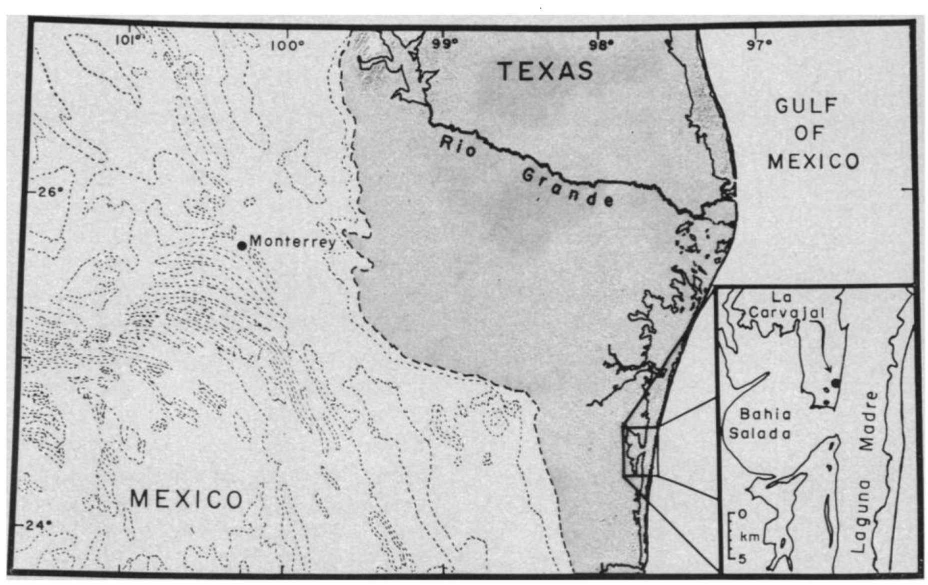

Fig. 1. Index map. Landward limits of Gulf Coast geosyncline indicated by extent of Eocene and younger sediments (shaded area). Structural trends indicated by strikes of contacts of Cretaceous formations (dashed lines).

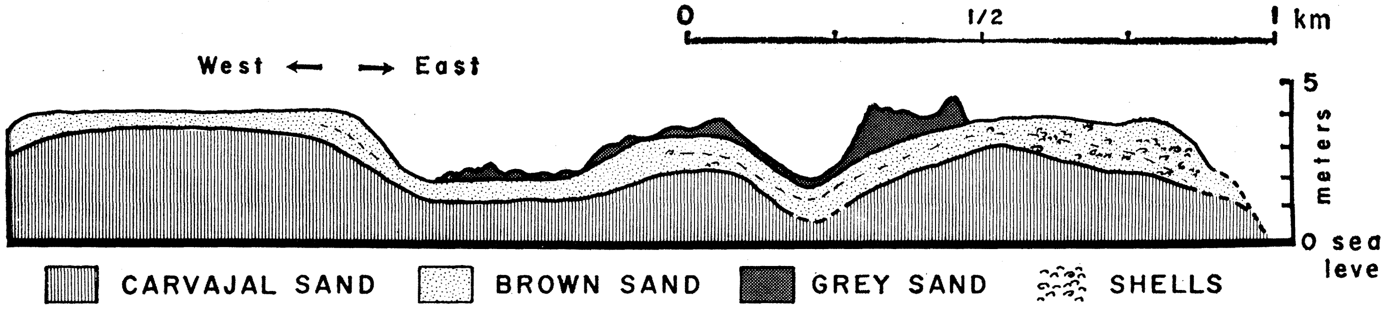

Fig. 2. Cross section exposed in bluff at south end of peninsula separating northern half of Bahia Salada and Laguna Madre.

derived ages are accurate, the unit is Pleistocene and is referred to here as the Carvajal sand. It probably correlates with the Ingleside barrier deposits of Texas (*6*).

Above the Carvajal sand is a variable, loose, brown, fine to very fine sand. Curves of the distribution of grains, by size, for much of this material are finely skewed and show moderate sorting. However, curves for sediment from near the base of the unit are commonly bimodal with a secondary clay peak like the curves for underlying Carvajal sand. Similarly, size-distribution curves for samples in depressions, which often form temporary ponds in other parts of the peninsula, are usually very strongly fine-skewed. The unit varies in thickness from 0.5 to 2.0 m and contains from one to three beds. Macrofossils are very abundant in the easternmost (seaward) 0.4 to 0.5 km and are very rare in the remaining 1.6 km (Fig. 2). The most common mollusks are pelecypods (*Macrocallista nimbosa, Dinocardium robustum, Aequipecten irradians, Codakia orbicularis,* and *Chione cancellata*) and gastropods (*Busycon* cf. *contrarium, Fasciolaria* sp., *Polinices duplicatus, Murex pomum, Fusinus* sp., and *Pleuroploca gigantea*). Shells are unaltered aragonite and commonly retain their original color markings.

Three samples, consisting of mixtures of shells from five or six of these genera, were dated by the radiocarbon method (*7*) and revealed ages of 2340 $\pm$ 100, 1930 $\pm$ 80, and 1940 $\pm$ 60 years. Alteration was tested for by evolving carbon dioxide from the last sample in three steps corresponding roughly to the outer, middle, and inner thirds of the shells. The respective δC^{14} values were -212 ± 9, -221 ± 8, and -208 ± 9 per mille. Thus no alteration was evident, and the age is an average for the sample. Whether the greater age of the first sample represents sample variation or statistical variation in age determination is unknown.

Above the brown sand unit is a very loose, discontinuous, grey sand. It extends from about 0.5 to 1.4 km from the seaward limit of the deposit (Fig. 2) and occurs as irregular hummocks on the surface of the bluff. The sediment is 50 to 80 percent fine to very fine sand, and grain-size distribution is very strongly fine-skewed. Macroscopic shell material is common but occurs almost exclusively as fine fragmental detritus.

The cross section shown in Fig. 2 is basically that of the present barrier islands of the Texas and Mexican coasts. From the sea landward the sequence is shelly beach, dunes, and a barrier flat. Furthermore, the shell assemblage in brown sand is typical of the inner shelf assemblage found on the back-shore of the present barrier island beaches. The position of shells almost exclusively seaward of dunes is also the same as their distribution on the present barrier islands.

On the basis of these similarities it is concluded that brown and grey sand units are barrier island-like deposits formed on a Gulf of Mexico beach during a time of greater submergence. The brown sand unit has an elevation seaward of the first grey dune of 4 m; the present barrier back-shore, an elevation of about 1 m. Therefore, relative sea level at the time of deposition must have been about 3 m above its present position.

No data are available to determine whether the present submergence represented by these deposits is due to eustatic lowering of sea level or whether there has been a local uplift of the land. Good correlation exists with some data from other regions. For example, van Andel and Laborel (*4*) dated a sample of biogenous limestone (A-21) 2.2 m above sea level on a granitic coast, which forms part of the eastern margin of the Brazilian Shield, at 1750 $\pm$ 170 years. Fairbridge (*2*, pp. 168–169) reports observation of "molluscan shell flats . . . on low sandy coasts of warm latitudes" formed during a 1.5- to 2-m high stand from about 2600 to 2100 years ago (Abrolhos Terrace time). However, more numerous are other studies on the east and Gulf coasts of the United States and in the Netherlands (*3*) which find no evidence of Recent submergence greater than that of the present. Although many of these coasts are described as stable they are characterized by both immediate (tide-gage data) and long-term (geosynclinal) subsidence. The Carvajal area is also within the Gulf Coast geosyncline, but it is south of a major reduction in width of this trough (Fig. 1). It is thereby more likely to have been affected by tectonic uplift than other parts of the geosyncline. On the other hand, it is less likely to have evidence of former absolute, high, sea-level stands masked by subsequent subsidence. Thus, until more evidence on Recent history of the area is obtained the significance of the Mexican emerged beach remains ambiguous.

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8. I thank Dr. W. Armstrong Price for reading and criticizing this manuscript.

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