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QUATERNARY MARINE TERRACES IN SOUTHWESTERN VIZCAINO PENINSULA, BAJA CALIFORNIA, MEXICO

by

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INTRODUCTION

The Peninsula de Vizcaino is, of all the coastal regions of Baja California, one of the richest in Quaternary marine remnants. The first mention of late Cenozoic uplift of the area, deduced from the occurrence of high Quaternary terraces, was made nearly a century ago by Lindgren (1889). A few early studies dealt with the paleontology of the Pleistocene marine deposits (Jordan & Hertlein, 1926; Hertlein, 1931; Chace, 1956). The marine terraces of the Vizcaino Peninsula were mentioned in various reconnaissance geologic maps (Mina, 1956, 1957; Troughton, 1974; Robinson, 1975; Rangin, 1978). Quaternary tectonic activity has been recently reported in the neighboring offshore areas (Normark, 1974, 1977; Minch, et al., 1976; Blake et al., 1978).

Preliminary results of the on-going studies of the Quaternary marine terraces, in relation to the neotectonic behavior of this part of Baja California, have just been published (Ortlieb, 1979a, 1979b).

THE SANGAMON TERRACE

Around several rocky headlands of the southwestern Vizcaino Peninsula is found a low wave-cut terrace. Its elevation is about 5 m above present mean sea level (MSL). Generally, this abrasion platform supports a few decimeters of fossiliferous gravel which is itself covered by a sheet of colluvium or deflated sands. The main occurrence of this terrace are indicated in Figure 1.

The paleo-sea level corresponding to the maximum of this transgression, in each outcrop, has been determined to be presently registered at 5 to 7 m above present MSL. As this terrace is the lowest one in the region, and as it presents the best preserved fossil fauna, it is considered to be Sangamonian (last interglacial, between 120,000 and 80,000 y B.P.). From correlative studies along the coasts of Baja California and Sonora (Malpica et al., 1978; Ortlieb and Malpica, 1978; Ortlieb, 1978), it can be inferred that the maximum Sangamon sea level has been, in the whole region, at 5 m above the present MSL datum.

THE "TIVELA STULTORUM COQUINA" AND ITS LATERAL EQUIVALENTS

The second lowest conspicuous marine terrace of the region is informally named "Tivela stultorum coquina" (Ortlieb, 1979a, 1979b) in reference to the particular abundance of fossil shells of this species in the extensive paleo-littoral deposits cropping out in Bahía de San Hipolito and Bahía de Asuncion. The sediments of the "coquina" are generally sandy, poorly consolidated, and a few meters thick; they accumulated in wave-built terraces presently at maximum elevations of 15 to 20 m. Along the coast, northwest from Bahía de Asuncion, several remnants of littoral deposits showing comparable weathering, elevation and thickness, are interpreted to be lateral equivalents of the "coquina" (Figure 1). Distinct fossil assemblages and sedimentologic characteristics of the deposits are representative of different paleo-environments such as high-energy open beaches, protected embayments and rocky shores.



The transgression corresponding to these deposits is clearly anterior to the Sangamonian terrace but, according to the good preservation of the fossils and the weak cementation of the sediment, it must not be much older. Age determinations by both U-series and amino-acids methods on Tivela stultorum shells from this and other Pleistocene marine deposits of the area are presently underway. For now, a late Middle Pleistocene age (200,000 ? y B.P.), possibly corresponding to the stage 7 of the deep ocean isotopic curve of Shackleton and Opdyke (1973), is assigned to this transgression.

The paleo-sea level, at the maximum of this transgression, is registered at about + 15 m above present MSL. On a regional scale, it is most probable that this paleo-shoreline had been uplifted (by a few meters), and mainly before the Sangamon.

OLDER PLEISTOCENE TERRACES

Remnants of various Pleistocene transgressions prior to the "Tivela stultorum coquina" are relatively numerous along the coast of the Vizcaino Peninsula. Tectonic deformations, as well as intense weathering and erosion, seriously complicate their correlation. Old Pleistocene marine deposits have been surveyed up to 130 m elevation, but Robinson (1975) and Rangin (personal communication) mention higher terraces up to 250 m above MSL. The lithologies of the terrace material include bioclastic calcirudites and calcarenites, conglomerates and sandstones. The fossils are most commonly leached or recrystallized. From all the old terraces observed in the region, only the most meaningful will be mentioned here.

Along Bahia de Asuncion and Bahia de San Hipolito, inland from the remnants of the "Tivela stultorum coquina", appear several ridge-like terraces with increasing elevations up to + 50 m (Figure 1). In Bahia de Asuncion, natural cross-sections reveal distinct marine layers which were also deposited prior to the "coquina". All these paleo-littoral remnants are probably related to the Middle Pleistocene high stands of sea level.

In the area of Bahia de San Roque, several calichified deposits of a 30-meter terrace may be observed. Farther inland, higher Pleistocene terraces crop out between 45 and 130 m above MSL. In the bay, south of Cabo Tortolo, five Pleistocene discontinuous terraces have been numbered, at +55 m, + 20 m, + 12 m, + 5 m, and at MSL. North of Bahia Tortugas, and at Punta Eugenia, various mesas are capped by relatively thick terrace deposits (+80 to +130 m).

Warping and tilting of some of the oldest terraces are evident, particularly in Bahia de San Cristobal and north Bahia Tortugas. These deformations seemed to be controlled essentially by local readjustments, and probably also by some regional NW-SE main structures (Robinson, 1975; Minch et al., 1976; Normark, 1977; Blake et al., 1978).

If the two sets of terraces, in staircase disposition to the southwest of Cabo Tortolo and in Bahia de Asuncion, correspond to Middle Pleistocene (700,000 to 120,000 y B.P.) transgressions, a roughly estimated regional uplift rate of $70 \text{ mm}/10^5 \text{ year}$ could be calculated. Extrapolating this uplift rate, the Early Pleistocene (1,800,000 ? to 700,000 y B.P.) terraces would be at elevations between +50 and +130 m. This entirely hypothetical age estimation, primarily based on the assumption of a continuous vertical motion of the whole area, is not in disagreement with the field data, and is thus proposed until a more precise chronostratigraphy is established.

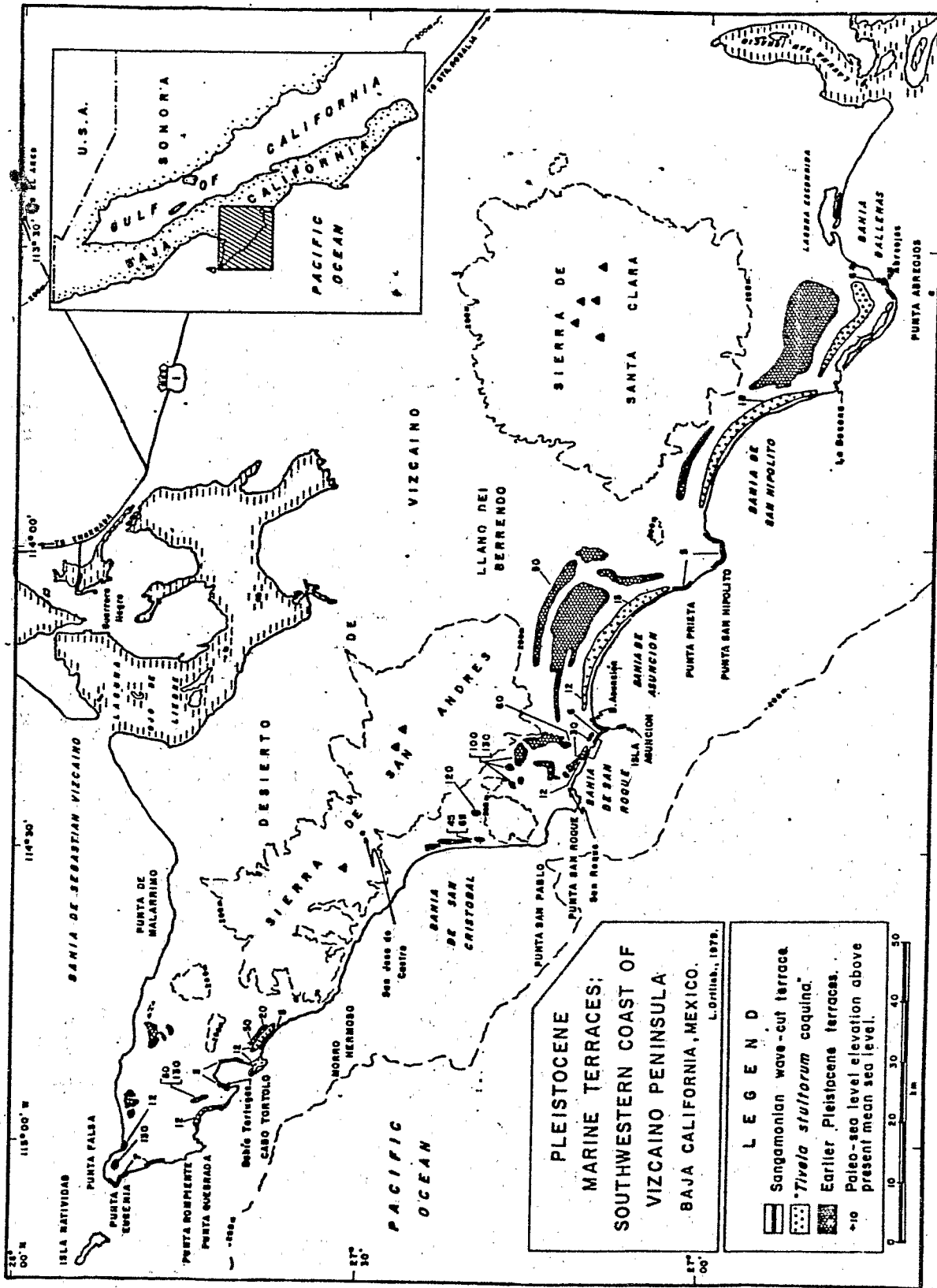


Figure 1. Localization and elevations of Quaternary marine terraces in southwestern Vizcaino Peninsula.

CRUSTAL DEFORMATIONS INFERRED FROM THE QUATERNARY SHORELINES

The Quaternary marine terraces provide probably the best indicators of vertical deformations of the coastal region. Two of the main problems to be solved are: 1) determination of the contemporaneity of isolated remnants of the same transgression and, 2) determination of the age of the terraces. In the Vizcaino Peninsula, these conditions are only partially fulfilled by the remnants of the two lowest terraces.

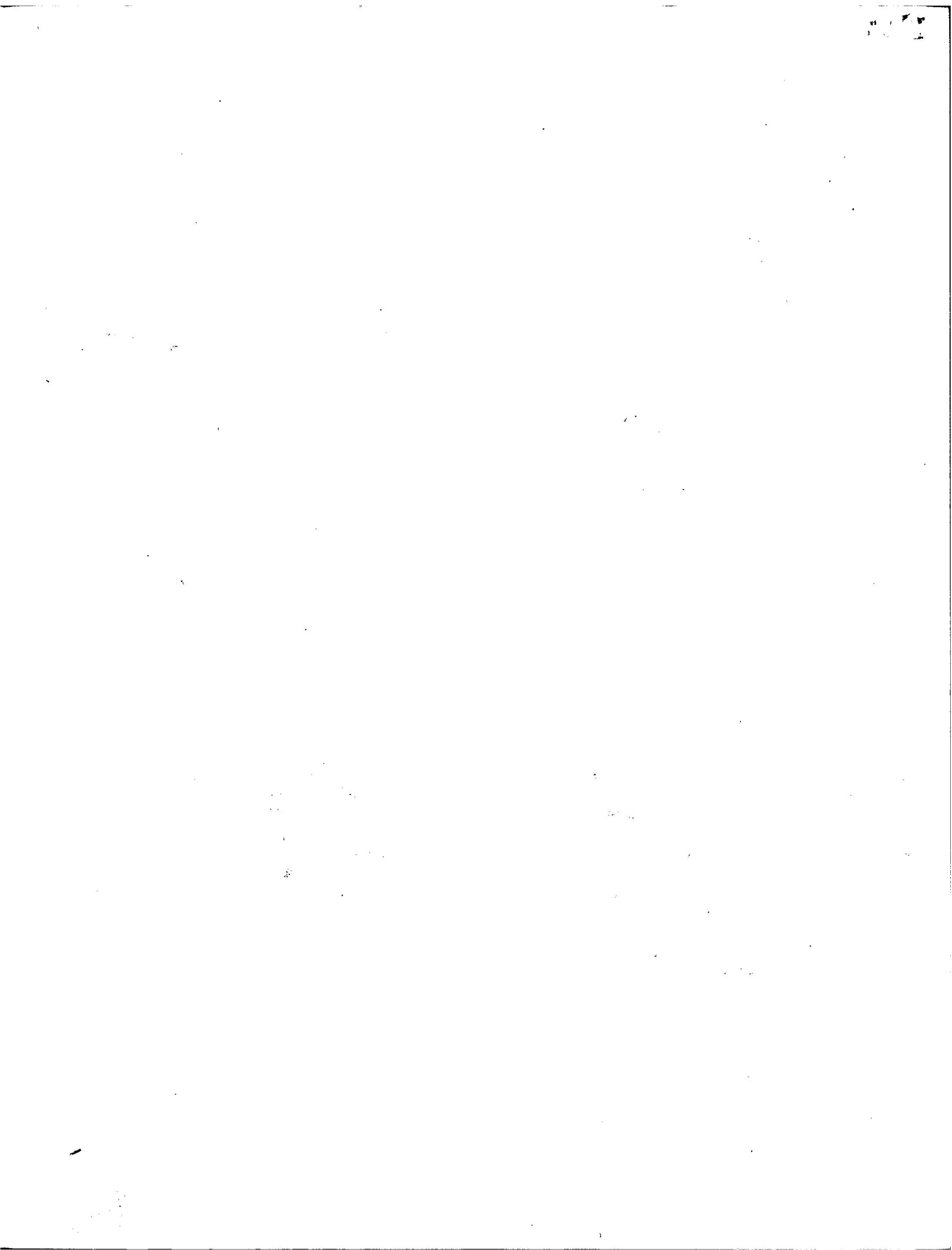
The Sangamon shoreline proved to be almost horizontal along the Peninsula at an elevation close to what its original altitude probably was; the data indicates that little, if any, regional or differential vertical motions did occur during the Late Quaternary between Punta Eugenia and Laguna San Ignacio. The shoreline contemporaneous to the deposit of the "Tivela stultorum coquina" is somewhat more deformed along the whole coastal region, and at such an elevation (+ 15m) that a general uplift of the area be inferred.

For the period between the end of the Pliocene and the late Middle Pleistocene, a possibly continuous vertical motion affected the area (rate of the order of $70 \text{ mm}/10^3 \text{ y}$). It must be added that important uplifts, of the order of one kilometer since the end of the Pliocene, have been reported by Normark (1974, 1977) in the central and western parts of Bahia de Vizcaino. Onshore, along the southwestern Vizcaino Peninsula, evidence of such neotectonic motions have not been found; these uplifts are more probably related to the nearby southern Continental Borderland province.

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