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HOLOCENE VEGETATION AND CLIMATE OF BAJA CALIFORNIA SUR, MEXICO

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ABSTRACT

Research has emphasized pollen and radiocarbon analyses of core samples from coastal mangroves and lagoons and two upland wetlands and dating of raised marine terraces. Mangroves north of La Paz are underlain by up to 4.25 m of peat and lagoonal sediments, deposited over a mid-Wisconsinan coral platform (ca. 25,000 yr BP). Pollen spectra show red mangrove and NAP dominance and suggest relative sea-level rise 9,000 years ago. Significant increases in thorn forest, red and white mangrove, grass and cheno-ams take place after 8,000 yr BP. A progradational event around 4,000 yr BP may be the result of crustal uplift. Subsequently, increases in white and black mangroves and NAP, and decreases in red mangrove suggest development of paludal conditions. By contrast, mangrove deposits in the Bahía Magdalena region average only 1.0 m thick and are dominated by red mangrove. In the Sierra de la Victoria of the Cape region, south of La Paz, the pine-oak woodland antedates 9,000 yr BP with minor fluctuations in pine, oak, and NAP, which are mainly grass, reed, and composites, as well as an early peak of *Acacia*. Raised marine terraces, while devoid of pollen, provide chronologic evidence of several episodes of crustal uplift between 5,100 and 400 years ago.

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Key words: Palynology, Paleoclimate, Holocene, Baja California Sur, Mexico.

RESUMEN

Esta investigación se enfocó hacia los análisis de polen y radiocarbono, en muestras de núcleo, de manglares y lagunas costeros, así como de dos áreas de tierras altas y húmedas; además, se efectuó la datación de terrazas marinas levantadas. Los manglares al norte de La Paz están cubiertos por hasta 4.25 m de turba y sedimentos de laguna, depositados sobre una plataforma de coral del Wisconsiniano medio (hace ca. 25,000 años). Los espectros del polen muestran un predominio de mangle rojo y NAP y sugieren un levantamiento relativo del nivel del mar hace 9,000 años. A partir de 8,000 años antes del presente, tuvieron lugar incrementos importantes en el bosque de espinas, los mangles rojo y blanco, las gramíneas y los cheno-ams. Un evento de progradación, ocurrido hace alrededor de 4,000 años, pudo ser resultado de un levantamiento de la corteza. Subsecuentemente, un incremento en los mangles blanco y negro y en el NAP y un decremento en el mangle rojo sugieren el desarrollo de condiciones paludales. En contraste, los depósitos de manglar en la región de Bahía Magdalena promedian sólo 1.0 m de espesor y están dominados por el mangle rojo. En la sierra de La Victoria, de la región de Los Cabos, al sur de La Paz, los bosques de pino y encino son anteriores a 9,000 años antes del presente, habiendo existido fluctuaciones menores en pino, encino y NAP, las cuales fueron principalmente de gramíneas, tules y compuestas, teniéndose un pico temprano de *Acacia*. Las terrazas marinas levantadas, a pesar de no contener polen, proveen evidencia cronológica de varios episodios de levantamiento de la corteza acaecidos entre 5,100 y 400 años antes del presente.

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Palabras clave: Palinología, paleoclima, Holoceno, Baja California Sur, México.

INTRODUCTION

The vegetational history of Baja California Sur, as interpreted in this paper, is based on field studies of fresh water and coastal wetlands, and pollen stratigraphy of core samples from three sites in the peninsula. A number of coastal wetland sites was investigated and cored or probed with the majority of these sites representing mangroves and salt marshes, with little accumulated organic sediment and limited pollen stratigraphy. These areas of sediment deposition and plant colonization are maintained by rainfall and tidal action and are relatively young wetlands. The organic-rich sediment is usually less than 0.5 m thick and has pollen spectra dominated by *Rhizophora* (red mangrove), indicating latest Holocene colonization. Sites of this type were sampled mainly on the Gulf of California coast at Bahía Concepción, in embayments on the west side of Isla Espíritu Santo and around Bahía de La Paz and the Mogote, a barrier bar that divides La Paz bay. On the Pacific Ocean side of the peninsula, mangroves were sampled around Bahía Magdalena and at a number of sites along the west coast of Baja California, as far north as Estero El Cordón, with essentially the same results (Figures 1 and 2).

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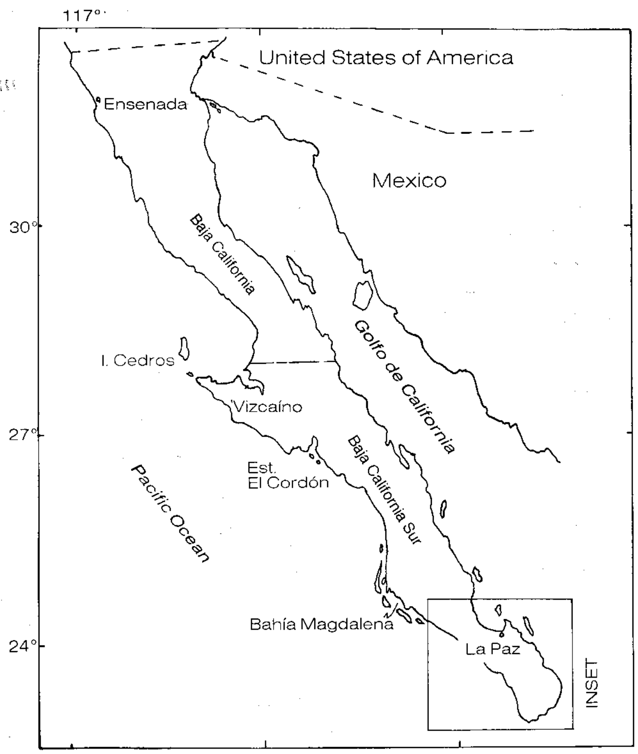

Figure 1.- Map of Baja California Sur with location of the study area.

It is possible that episodic uplift of the coastline has limited the accumulation and preservation of organic sediments in the short-lived coastal wetlands as potential depositional basins drained and sediments oxidized. Under these conditions, organic-rich sediment would accrete and be preserved only in deeper embayments, rather than in shallow wetlands close to sea level. It is significant that no organic-rich

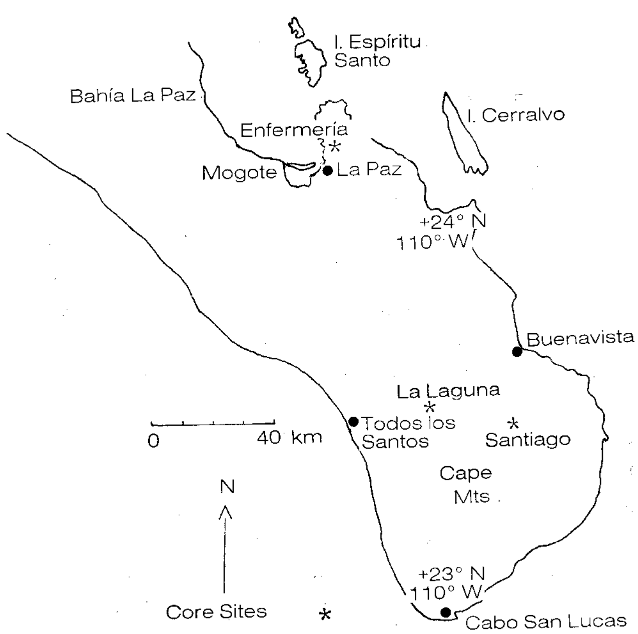

Figure 2.- Map of the study area with location of coring sites.

layers were mapped in the stratigraphically-complex, raised marine terraces that border Baja California Sur (Sirkin *et al.*, 1984). However, at least one mangrove on La Paz bay contains a significant depositional record with more than 4 m of lagoonal sediment capped by mangrove peat, all of which accumulated over a late Pleistocene coral platform. This site, known as Enfermería, has the longest Holocene pollen record for this region, as observed in this study (Figures 1 and 2).

Wetland sites above sea level are much less common, due to the aridity of the region. Semi-arid and desert conditions prevail, vegetational density is low, and standing bodies of water are uncommon. Only two apparently long-lived and productive upland sites were located and sampled. One of these sites is a fresh-water bog in Santiago, a village in the Tertiary foothills on the east side of the Cape Mountains, about 120 km southeast of La Paz. The second site, named La Laguna for the local mountain range, is a small wetland in the headwaters of east-flowing drainage from the Sierra de la Victoria at an elevation of about 800 m and situated over 100 km south of La Paz.

In this study, the pollen stratigraphy of these three sites—Enfermería, Santiago, and La Laguna—is considered and inferences are made about the vegetation and climate in Baja California Sur during the last 10,000 years. Pollen zones are established on the relative abundance of forest and wetland taxa and compared with modern analogs for determination of prior plant associations. Finally, comparisons are drawn with modern climatic conditions and plant associations and those inferred for the Baja California and western Mexico for the Holocene, in general.

PHYSICAL SETTING

Baja California Sur extends southward from the upper or northern part of the peninsula for about 500 km (Figure 1). The peninsula is bounded by the Gulf of California on the east and the Pacific Ocean on the west. The major physiographic provinces include the Vizcaíno Desert in the northwest, the Llano de Magdalena in the west and the Sierra de la Giganta, a volcanic range with peaks up to 1,175 m, that runs parallel to the Gulf from San Ignacio to Bahía de la Paz. Lower mountain ranges border the Pacific coast. In the Cape region, south of La Paz, the granitic Cape Mountains, the Sierra de la Victoria, reach 900 m with some higher peaks. The Llano de Magdalena, or Magdalena Plain, east of Bahía Magdalena, overlies a deep sedimentary basin similar to the Great Valley of California. The La Paz Fault separates the basin and the Sierra de la Giganta from the Cape region.

CLIMATE

The climate of Baja California Sur is affected by air masses and marine currents from both the Pacific Ocean and the Gulf of California. The Central Desert is hot and dry, while the Cape region has a hot, semi-arid steppe climate; these climates are designated as Bwh and Bsh, respectively, in the Köppen-Geiger System (Köppen and Geiger, 1954). The California Current flows southward along the west side of the peninsula and has water temperatures around 16°C. The cool current generates coastal fog and cooling winds as far south as Cabo San Lucas. Precipitation varies with topography. The Central Desert averages less than 10 mm of rain per year, although some years may be totally dry. The mountains of the Cape region may have up to 25 mm of rain per year, mainly from frontal storms that come from the Gulf of California in the summer and tropical cyclones that arrive from the Pacific Ocean in late summer and early fall. The summer storms track northeasterly across the peninsula, while the winter storms cross Baja California from the northwest.

VEGETATION

The arid Central Desert supports a variety of uniquely adapted plants (vegetation of the physiographic provinces after Coyle and Roberts, 1975). *Larrea* (creosote bush) and *Pedilanthus* (candelilla) have resin-coated leaves. *Agave* (century plant) and *Idria* (cirio) have clusters of blade-shaped leaves at the base or top of each stem. *Fouquiera* (ocotillo or palo adán) and several cacti like *Opuntia* (cholla) have small leaves or spines. Seasonal effects are seen in *Bursera* (torote or elephant tree), *Jatropha* (lomboy) and other deciduous trees that leaf out only after rainfall or during the rainy season. In the Magdalena Plain, where the desert flora grades into the coastal scrub community, the density of vegetation becomes greater. Stands of cactus, such as *Pachycereus* (cardón), *Lophocereus* (old man cactus) and cholla, as well as *Prosopis* (mezquite), *Cercidium* (palo verde), palo adán, elephant tree and lomboy are common. Thorn forest species, including many in the Mimosaceae like mezquite, line the bajadas and adjacent plains.

The semi-arid steppe of the Cape region supports a lowland flora with cardon, *Cyrtocarpa* (ciruelo), *Erythrina* (coral tree), palo verde, and *Tecoma* (palo de arco), while an oak, pine woodland or bosque flourishes in the mountains. The dominant trees of the bosque are the oaks, *Quercus devia* and *Q. tuberculata*, and the pines, *Pinus monophylla* (piñón) and *P. cembroides*. Local habitats also have distinctive communities. Freshwater wetlands may have dense stands of *Arundo* (giant reed or carrizo), *Juncus* (rush) and *Typha* (cattail). Mangroves thrive adjacent to marine environments along which *Rhizophora* (red mangrove) colonizes the shallow embayments and extends the mangrove community into open water. *Avicennia germinans* (black mangrove) occupies the landward fringe adjacent to the red mangrove, while *Maytenus phyllanthoides* (mangle dulce) spreads across saline soils and *Laguncularia racemosa* succeeds on higher ground above the saltwater table. Salt pans and tidal flats may have thick growths of *Salicornia pacifica* (pickleweed or glasswort), possibly the most representative of the Chenopodiaceae (cheno-ams) in the pollen record.

PALYNOLOGY AND STRATIGRAPHY

ENFERMERÍA

This mangrove wetland largely fills an embayment of La Paz bay about 15 km north of the city (Figure 2). Both Enfermería and a smaller mangrove at Balandra, to the north, were studied. Enfermería contains the longest sedimentary section found in the area to date, as initially described by Padilla-Arredondo and others (1985). Core segments were collected for pollen analysis and radiocarbon dating to a depth of 4.25 m (Figure 3). The Holocene sediments were deposited over a coral platform and consist of 3.0 m of estuarine silt and silty clay grading upward into silty peat. The peat is covered by a veneer of pebbles and shells and, in turn, is overlain by 1.25 m of mangrove peat. Radiocarbon ages were determined for 2.5 cm thick core increments at 3.75 m (8,465 ± 315, SI-6129), 2.75 m (5,100 ± 145, SI-6128), and 1.75 m (4,035 ± 80, SI-6127). At Balandra, coring located a coral platform, dated at 24,850 ± 275, that underlies the mangrove stratigraphy just below sea level (Pedrín-Avilés *et al.*, 1992). The overlying sediments above the coral are mostly peat, but with a thin sand layer at 1.0 m. Sediments at 2.25 m were dated at 4,120 ± 100 (SI-6126). A shell hash found nearby at the base of the bajada gravel on the verge of the mangrove and 0.5 m above sea level has a uranium-series age of 3,000 yr BP (Sirkin *et al.*, 1990).

In the Enfermería estuarine silts, pollen concentrations are low, but a red mangrove, cheno-ams dominated assemblage may mark early Holocene flooding of the estuary by the sea (Figure 3). A subsequent increase in red mangrove reflects continuing sea level rise. Thorn forest taxa, particularly in the Mimosaceae and including mezquite and *Caesalpinia*, and torote enter the record in the lower sediments. Palo de arco appears somewhat later, and torote and *Celtis* (hackberry) are common in the uppermost assemblages. Cheno-ams and Gramineae (grass) pollen are more prominent toward mid-core, where sediment has been dated at 5,100 yr BP. At this level, a decrease in red mangrove may be evidence of a progradational event, possibly related to uplift of the coast relative to sea level.

Above the pebble layer at 1.25 m at Enfermería and above the sand layer at 1.0 m at Balandra, which covered estuarine sediments sometime after 4,000 BP, the deposition of mangrove peat indicates lower sea level relative to the land. At Enfermería, there are successive maxima of white mangrove, grass, black mangrove, composites and cheno-ams in the upper peat. Uplift appears to have restricted the embayments, allowing coastal vegetation to colonize the marine sediment substrate. More extensive plant growth and sediment trapping in the intertidal zone were contributing factors in the subsequent accumulation of peat and the correspondingly

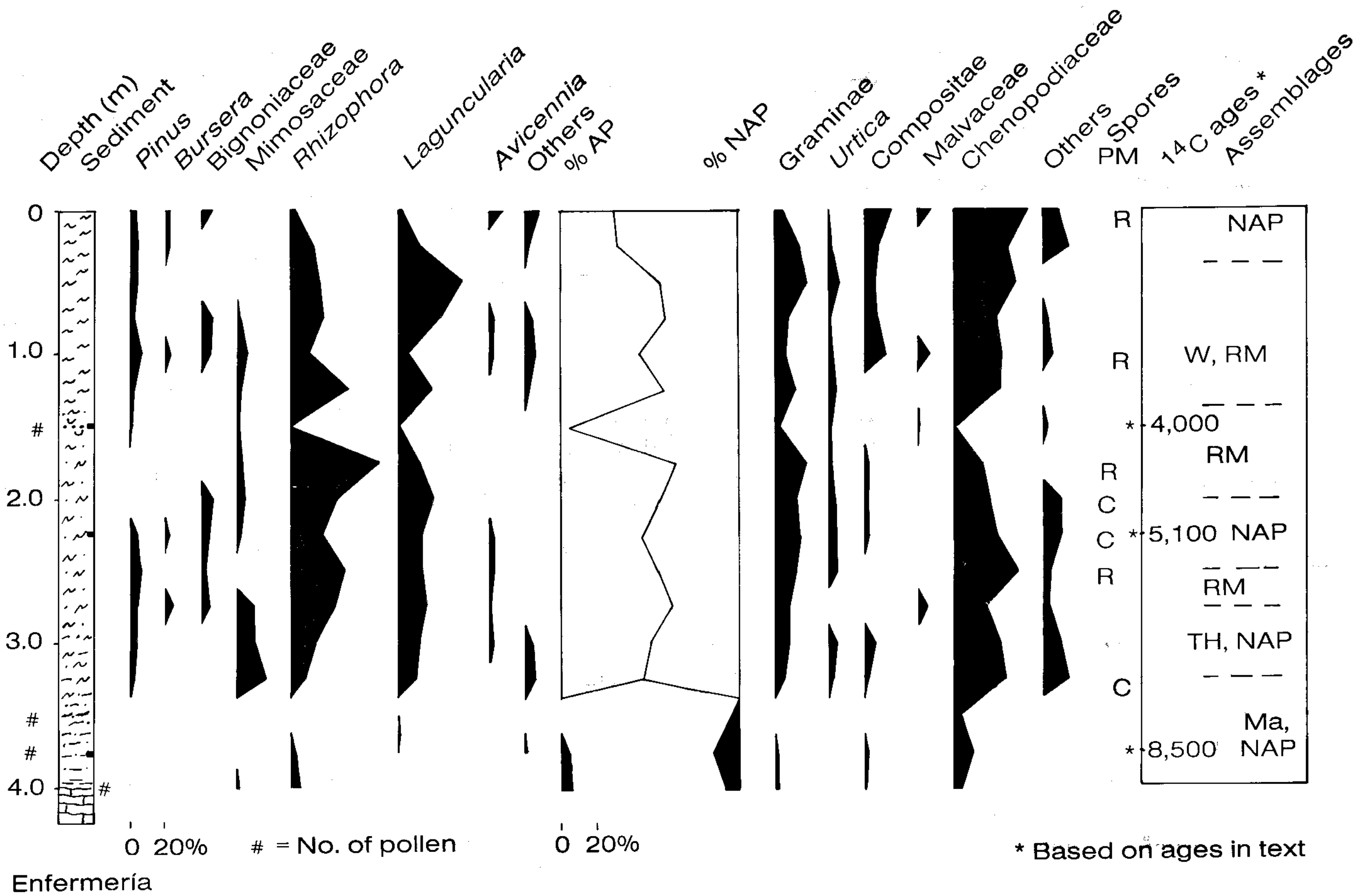

Figure 3.- Pollen diagram for Enfermería. Pollen data **abbreviations**: Misc., others—traces of pollen of local origin; U—unknowns; MA—mangroves; RM—red mangrove; O—oak; Pi—pine forest; Th—thorn forest. Baja California Sur mountain vegetation assemblages in parenthesis. Pollen Scale: Percent of pollen sum; #—actual pollen count. Spores: I—*Isoetes*; P—Polypodiaceae, fern spores; M—miscellaneous spores. Spore abundance: A—abundant (>10 specimens per count); C—common (>5 specimens per count); R—rare (1 per slide). Sediment column symbols:

Sand Shells Peat Silt Clay Coral Sandy peat Silty peat

higher concentrations of pollen. Red mangrove continued to colonize the nearshore of the embayments, and upland species succeeded on the landward sides of the mangrove.

In the core samples of this area, mangrove and nonarboreal pollen (NAP) assemblages are most prominent and appear to alternate in dominance from the basal, mangrove-NAP assemblage, beginning prior to 8,500 BP, to the succeeding thorn forest-NAP zone. The next red mangrove dominated spectra are replaced by an NAP-rich assemblage around 5,100 BP, after which red mangrove resumes prominence. The earlier of the two red mangrove increases may be related to eustatic sea level rise, rather than progradation, and may not be represented by a comparable event in the pollen records in sites located above sea level. Black mangrove and NAP are abundant in the upper pollen zone with ragweed and cheno-ams. The latest red mangrove expansion into the bay may be in response to modern sea level rise. In the surface sample, the pollen spectrum is dominated by marsh and field taxa which account for 68% of the pollen total. Mangrove pollen comprise 12%, while upland and thorn forest taxa are only 5% of the total combined (Table 1).

SANTIAGO

The Santiago wetland lies in the Tertiary foothills in the village of Santiago, east of the Cape mountains (Figure 2). A 2.35 m sedimentary section of lake clay capped by a thin layer of peat was collected and analyzed for pollen content. Based on relative pollen data, three pollen zones are tentatively established (Figure 4). In general, pine, oak and NAP, mainly grass, composite and cheno-ams, dominate the record, while both rush and cattail exhibit distinct mid-and upper profile maxima.

In the early NAP zone, grass, cheno-ams and composite are most abundant. The arboreal component is mainly pine,

Table 1.- Pollen spectrum for Enfermería surface sample.

VEGETATION	%	(DOMINANT)
Upland	3	
Thorn	2	
Plantation	6	
Mangrove	12	
Marsh, field	68	(Cheno-am)

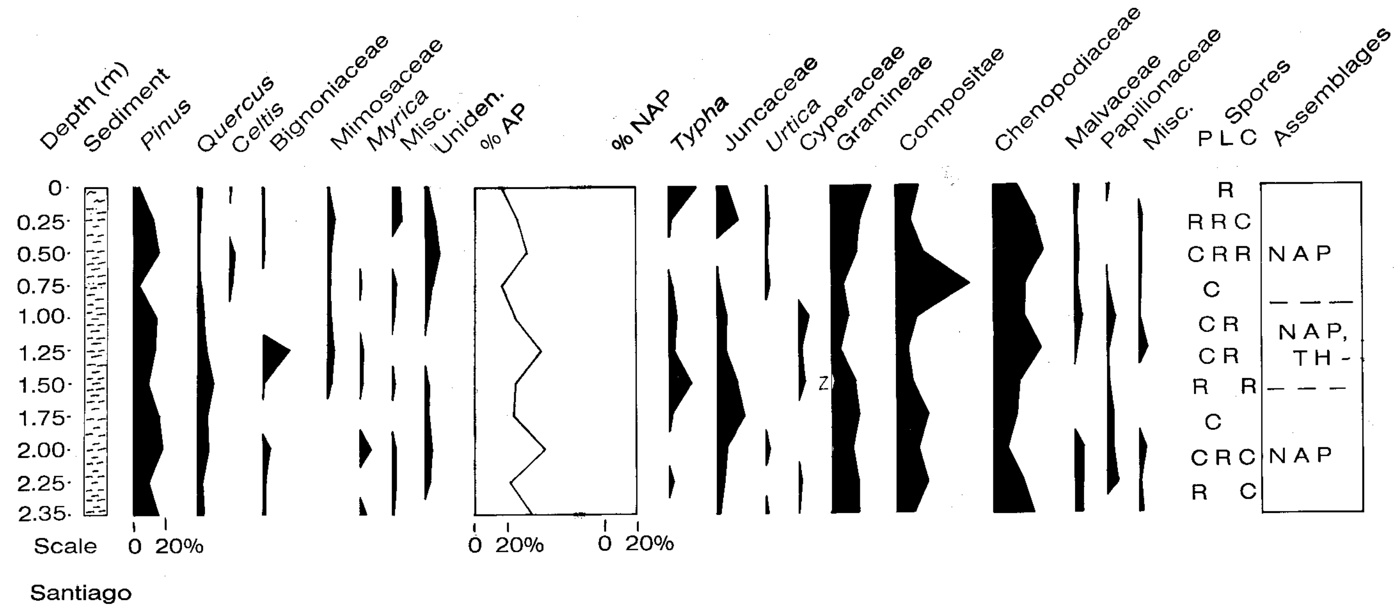

Figure 4.- Pollen diagram for Santiago. Explanation as in Figure 3.

with oak and minor palo de arco, torote, and *Myrica* (myrica). Rush and pollen in the Malvaceae and Papilionaceae are initially minor in the NAP, along with traces of *Urtica*, cattail, and Cyperaceae (sedge). Rush peaks late in the early NAP zone, and cheno-ams and cattail increase in proportion with relative decreases in values for grass and composite pollen in the mid-core NAP-Thorn zone, which is based largely on increases in thorn forest taxa. Trees that show significant increases are oak, palo de arco, *Acacia* (acacia) and mezquite, while pine remains dominant. A moderate increase in oak precedes a short-term rise in palo de arco.

The upper NAP zone has an early composite peak and subsequent increases in cattail, rush and grass. The rise in composite pollen may be associated with land clearing and agriculture. The cattail-rush component may indicate wetter conditions, possibly related to increases in rainfall and surface water. Hackberry enters the record in this zone, while oak and pollen of the Bignoniaceae and Mimosaceae are substantially diminished. Other late Holocene taxa include palo de arco, *Eucalyptus* and torote in the AP and traces of Papilionaceae and Malvaceae in the NAP. Fern spores are common in all of the spectra. An analysis of the surface pollen assemblage shows that 81% of the pollen is from marsh and field taxa, mainly in grass, cheno-am, composite and rush (Table 2). Upland and thorn forest taxa comprise only 11% of the assemblage.

Table 2.- Pollen spectrum for Santiago surface sample.

VEGETATION	%	(DOMINANT)
Upland	7	
Thorn	4	
Plantation	4	
Mangrove	-	
Marsh, field	81	(Grass, etc.)

LA LAGUNA

A 1.10 m core was taken in a small wetland high in the Sierra de la Victoria of the Cape mountain ranges (Figure 2). Although a short sedimentary section was obtained, samples pooled for radiocarbon dating from the basal peaty sands are dated at 9,015 ± 110 yr BP (SI-6612). The pollen record suggests a four-part zonation with NAP dominance overall on high percentages of grass, rush, sedge, and composites. Arboreal pollen are mainly pine and oak with minor thorn forest species (Figure 5).

The basal pine, oak pollen zone contains a small percentage of *Picea* (spruce) and traces of mezquite and hackberry. The NAP are grass, rush, sedge and composite. A rise in Bignoniaceae pollen and a short-term spike in Mimosaceae pollen are the basis for the succeeding pine, thorn pollen zone. Pine diminishes significantly in the oak, NAP pollen zone, while grass, rush and sedge increase proportionately.

In the uppermost zone, pine is again dominant and spruce reappears. Grass and rush decrease, while composite and cheno-ams increase. *Zea* (maize) appears in the upper part of this zone. The composite rise, an indication of land clearing, correlates with the appearance of maize. Spores are well represented throughout the samples. *Isoetes* spores are abundant in both the basal and upper zones. Fern spores are common above the basal spectra, and club moss spores are found in the lower sediments. In the surface sample, pine is the dominant taxon and comprises 50% of the pollen. The most prominent pine is identified locally as *Pinus cembroides*. Marsh and field vegetation account for 46 percent of the pollen sum, mainly due to the abundance of grass (Table 3).

POLLEN ZONES AND ENVIRONMENTS

The pollen records from the three sites in this study are

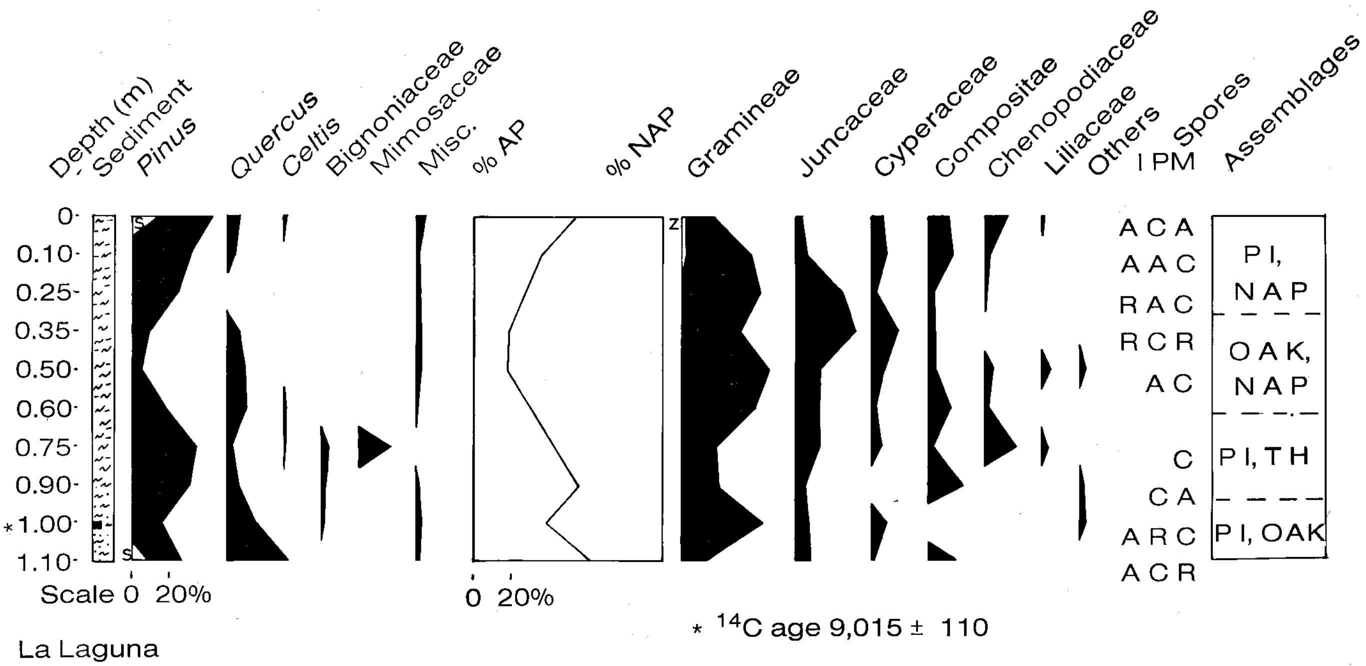

Figure 5.- Pollen diagram for La Laguna. Explanation as in Figure 3.

zoned to emphasize the dominant pollen or natural plant groups, like mangroves or thorn forest, that are found in the region today. The zonations differ due to local vegetation and the influence of outside factors like relative sea level change. For example, the upland vegetation of the Cape mountains bosque contrasts markedly with the mangroves of the coastal embayments. The La Laguna pollen data show a dominance of pine and oak in the basal zone; at Enfermería, mangroves and NAP comprise this zone; and NAP is prominent in the Santiago record. Overall, the Santiago record of NAP, NAP-Thorn, and NAP in succession is more like the La Laguna zonation of Pine-Oak, Pine-Thorn, Oak-NAP and Pine-NAP, than the red mangrove-NAP oscillations interpreted for the Enfermería pollen record.

While a more precise correlation of the pollen zones is not appropriate, there are a few common factors that have some application to the evaluation of climatic change. The assumption that a pine, oak community represents cooler climatic conditions than a thorn forest community, is based on the altitudinal stratification of forests observed in western Mexico, as summarized in Sirkin (1985), and in Baja California Sur, according to Sirkin and others (1984). Increases in pine and oak in the early segments of the mountain and lowland pollen records may be interpreted as an indication of climatic cooling,

Table 3.- Pollen spectrum for La Laguna surface sample.

VEGETATION	%	(DOMINANT)
Upland	50	(Pine)
Thorn	1	
Plantation	4	
Mangrove	-	
Marsh, field	46	(Grass)

while increases in thorn forest taxa relative to pine and oak might reveal the onset of warmer and dryer conditions, particularly when accompanied with decreases in wetland taxa. Dominance of hydrophilous NAP may be associated with wetter conditions due to increased rainfall, resulting in increased soil moisture and more extensive wetlands, while NAP and thorn dominance may reflect warmer and wetter conditions.

As applied to the Baja California Sur record, the warmest climatic episode seems to have been around 3,000 years ago, as indicated by increases in NAP in the three pollen records, an increase in thorn taxa at Santiago—age inferred—and the pine decline at La Laguna. The upper zones of the pollen records show continued NAP dominance at Enfermería and Santiago, but a dramatic rise in pine, a reappearance of spruce and a decrease in rush at La Laguna. These data suggest cooler and dryer conditions during this interval.

The Enfermería record contains the thorn-NAP rise, but with subzones rich in red mangrove. Variations in mangrove pollen have been related to fluctuations in sea level. Red mangrove dominance has been interpreted as an indication of relative sea level rise, where increases may be equated to eustatic rise or local crustal movement (Sirkin, 1985). At Enfermería, red mangrove succeeds the thorn-NAP association and the subsequent NAP rise. Red mangrove dominance also follows the progradational event that has been dated as younger than 4,000 yr BP. The 3,000 year old shell hash at Balandra may have been raised above sea level at that time.

The pollen record of Baja California Sur can be compared with the record in the west Mexican coastal plain (of Sirkin, 1985) in that five similar pollen zones can be identified and the associated climatic fluctuations may be inferred (Table 4). In zone 1, mangrove dominates in the coastal areas of

Table 4.- Comparison of pollen zones, pollen assemblages and inferred climates, western Mexico, Baja California Sur and southwestern Mexico, after references cited in the text. Explanation of abbreviations in Figure 3.

Age BP (x1,000 yr)	Pollen Zones	West Mexico	B.C.S.	Climate:W Mex., B.C.S.	SW Mexico
0				Cooling	Cool, moist
		MA	MA		
		Pi, NAP	Pi, NAP	Warming	
1				Wet	
					Temperate
2	5	Pi, MA	RM	Cooling	Hot,dry/wet
3					Hot, wet/dry
				Subtropical	
				Wet	
4		Th			
			RM		Max. Hot
		Pi			
5	4	NAP, MA	NAP	Warm	Cool
			(O, NAP)	Wet	Dry
	3	MA	MA		
6					
	2	Pi, O	Th, NAP	Warm	Cool
		Th	(Pi, Th)	Dry	Wet
7					
8	1	MA		Cool	
9			MA, NAP	Cool	
			(Pi, O)	Wet	
10					

both regions; pine and oak are dominant in the upland in Baja California Sur. Zone 2 is based on the rise of thorn forest pollen with pine and thorn in the upland of Baja California; pine, oak and thorn are prominent in the west Mexican record. In Baja California Sur, the increase in red mangrove in zone 3 suggests relative sea level rise, while in west Mexico, this zone is indicated in the influx of an open-water marine planktonic silicoflagellate, *Dictyocha*. Records from both regions indicate relatively higher sea levels in the coastal sites, but no correlative indicators are recognized in the upland stratigraphy. Oak, thorn and pine increases are noted in the uppermost zone, with pine rising later in this interval.

Climatic conditions during the early Holocene, as inferred from the palynologic data of zone 1, were cooler than present, varying from cool and dry for western Mexico, to cool and wet for the Baja California Sur upland. This cool interval may be compared with the cool to cold interval recognized in the Gulf of California core sediments and associated with the end of the last glacial stage (Heusser, 1982; Sirkin, 1982). Heusser (*op. cit.*) cited pollen evidence for expanded grasslands and upland vegetation, including increases in pine and limited desert vegetation as indicative of colder conditions near the end of the last glacial, followed by a warming trend in the Holocene as indicated by an increase in oak. Additionally, Sirkin (1982) recognized a spruce-juniper zone with composites following a zone of increased pine as marking the end of the Pleistocene in the Guaymas Basin, as well as late Pleistocene pine and NAP zones, signifying cool and cool moist climatic conditions in core sediments from south of Baja California Sur. Increases in pollen of lowland forests signify a subsequent climatic warming trend in the Gulf of California region. Alternatively, the cool interval may be correlated with the cool and dry to cool, moist climate that has been proposed for the Middle America Trench region of 8,000 years ago (Habib *et al.*, 1970). A warm, dry trend begins early in zone 2 in west Mexico and Baja California Sur around 7,000 years ago, and continues through zone 4 and the early part of zone 5 to a maximum between 3,000 and 4,000 years ago. Relatively subtropical conditions are interpreted in zone 5 around 3,000 years ago for west Mexico and Baja California Sur, while southwestern Mexico is reportedly hot and dry (Habib *et al.*, 1970; González-Quintero, 1980). More moderate conditions prevail in the southwest after 1,500 yr BP. The west Mexican record suggests a cooling-warming-cooling fluctuation from 2,000 yr BP to the present with the latter portion shown in the increases in pine and NAP and a late appearance of spruce in the southern Baja California mountains.

CONCLUSION

The pollen record of Baja California Sur compares favorably with that of western Mexico, and provides information on the changes in pollen assemblages and vegetational associations over a 10,000 year interval in the coastal regions, where the effects of sea level rise have influenced the pollen content, and in the upland where forest taxa dominate. The upland pollen record provides evidence of cooler climates as well as evidence of agriculture. Climatic conditions are inferred from the pollen data and in general show regional warming to a maximum around 3,000 years ago, followed by moderating conditions. The Baja California Sur and west Mexican records correlate with that of southwestern Mexico, where late Holocene climates are somewhat warmer.

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