Preliminary environmental assessment of a Pleistocene marine deposit near Isla Vista, California

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Summary

Previous studies of the fossiliferous Pleistocene marine deposit near Isla Vista, California have yielded a faunal description of at least 138 mollusc species. These collections only sample the western 0.8 km of the deposit where it nears beach level, probably because of the deposit's less accessible 3-4 m height in its eastern extent. My study samples the eastern 2 km of the exposure, and uses 47 molluscan elements to determine if there is any change in faunal composition or depositional source from the western UCSB campus to Devereux Slough. Preliminary results suggest the entire deposit represents a single fine sandy to muddy sublittoral environment. The abundance of disarticulated pelecypods, shell fragments, and the absence of shells in life position, suggest the fauna was transported and rapidly deposited.

Introduction

A fossiliferous Pleistocene marine deposit is exposed in the marine terrace near Isla Vista, California (Figure 1) and rests with angular unconformity on the Pliocene Sisquoc Formation (Fig 2). The unit consists of two visually distinct, unconsolidated, silty-sand deposits referred to here as yellow brown and gray sediment. Both sediment types contain abundant fossil molluscs, foraminifera, and fragmentary remains of arthropods and echinoderms within the first meter above the contact with the Sisquoc Formation. The deposit is exposed from the western edge of the University of California, Santa Barbara campus to Devereux Slough, an approximate distance of 2.5 km.

Previous research has dated the Pleistocene unit to approximately 45,000 years using uranium series and radiocarbon analysis of a fossil solitary coral found in the terrace (Keller, 2000). Similar dates were also derived from potassium luminescence of feldspar in terrace sands (Spencer and Owen, 1999) and from oxygen isotope signatures from *Olivella biplicata* (Trecker et al., 1998).

Terrace fossil collections were made by Wright (1972) and by the Southern California Paleontological Society from a 0.8 km zone west of Isla Vista to Devereux Slough (Peska, 1987). Foraminiferal studies were also done west of Isla Vista (Barrick, et al., 1989). None of these studies included the eastern extent of the deposit nor did they explicitly record faunal data from the two sediment colors. My ongoing study extends collections approximately 2 km east of the previous study area to determine if the fauna is laterally consistent and to determine if there is any variation in the fauna between the different sediments that may indicate different depositional sources or events. To address these questions, I made collections from two localities within the original collection area (sites 6 and 7), plus five more (sites 1-5) along the 2 km eastern stretch of the terrace (Figure 1). Site 2 was investigated in detail and divided into top, middle, and bottom sections. Site 7 was divided into top and bottom sections based on a natural plane of weakness. At sites 1

and 7, only yellow-brown sediment was present within the fossiliferous zone. At all other sites, fossils were in gray sediment, although yellow-brown unfossiliferous sediment was present above gray unfossiliferous sediment (Figure 2). The fauna and sediment type at each of the seven sites were compared and used to interpret the ecology and the environmental source of the deposit. The results and interpretations presented here are preliminary and are subject to change.

Faunal Characteristics

Previous studies collectively suggest a molluscan fauna of at least 138 taxa (Wright, 1972; Peska, 1987). In the present study, a total of 47 taxa were found in the seven collection sites including 26 species of gastropods and 21 species of pelecypods (Tables 1 and 2). Of these 47 taxa, only 4 are common to abundant in all sections of all seven sites: *Macoma nasuta, Nutricola tantilla, Olivella biplicata,* and *Alia carinata*. *Bittium spp., Cryptomya californica,* and *Margarites pupillaria* are common to abundant at all sites, but are absent from the lower 20 cm of site 7. *Tellina modesta* is abundant at site 2 and common in sites 6 and 7, but rare or absent in sites 1, 3, 4, and 5. *Protothaca stamina* is abundant in sites 1, 3, 4, 5 and 7, but absent or rare in sites 2 and 6. *Saxidomus nuttalli* is common in site 1 but rare or absent in all other sites.

The most abundant molluscs in the Isla Vista terrace deposit are common in soft-bottom marine environments with sandy to muddy substrate. *Cryptomya californica* is often commensal with mud shrimp and *Urechis sp*., extending its siphons into their burrows instead of to the surface. *Macoma nasuta* is noted for its tolerance of high salinity and stale-water environments and is very common in mudflats and lagoons. *Nutricola tantilla* is common in the top two centimeters of sandy mud. *Protothaca stamina* is a quiet water species that never lives in shifting sand. *Olivella biplicata* is also a common sandflat gastropod (Ricketts, et al., 1985).

Other common species, including *Alia carinata* and *Margarites sp*., are found on low intertidal rocks (Smith and Carlton, 1975). Rare species, including *Mytilus sp., Littorina sp., Crepidula spp*., and others also live on solid substrate, suggesting a rocky shore element is also present (Ricketts, et al., 1985) but these taxa are neither dominant nor are they characteristic of the terrace deposit.

Most of the pelecypods are disarticulated. However *Cryptomya californica* is commonly found articulated at sites 6 and 7. Occasionally, *Macoma nasuta, Protothaca stamina* and *Nutricola tantilla* are also found articulated. None of the species found in the Pleistocene unit are in life position. However, the upper 10 cm of the Sisquoc Formation contains numerous rock-boring *Penitella sp*. and *Platyodon sp*. in life position.

Sediment Characteristics

Two visually distinct sediments, yellow-brown and gray, are present in the Isla Vista terrace (Figure 2). The yellow-brown sediment is 0.5- 1.5 m thick and the gray sediment is 0.3 – 1.5 m thick (combined thickness of the deposit is approximately 0.5 – 2.5 m). Both sediments are fossiliferous where within 1 m of the contact with the Sisquoc Formation. At sites 1 and 7, the yellow-brown sediment is in contact with the Sisquoc Formation (Figure 2) and contains fossil material. At all other sites, the gray sediment is in contact with the Sisquoc and contains fossils up to 1m above the contact. At sites 2 and 3, the fossiliferous gray sediment is overlain by unfossiliferous gray sediment.

Yellow-brown unfossiliferous sediment overlies the unfossiliferous gray sediment at sites 2 and 3 and the fossiliferous sediment at sites 4, 5 and 6 (Figure 2).

While the sediments are visually distinct, the grain size distribution is similar at most sites (Tables 3 and 4). In sites 1, 2, 4, 6, and 7, the median grain size is medium sand. At site 3 the median grain size is fine sand and at site 5 the median grain size is coarse sand. However, much of the coarser material in the sediment consists of broken shells and tar aggregates, and the sediment itself is finer than the median grain size suggests (Table 3).

Local accumulations of tar are more frequent in the gray sediments than in the yellow-brown sediments and are often associated with hyper-concentrated, clast-supported shell deposits. Where tar is absent or unconcentrated, shells are matrix supported. In all locations, shells are randomly oriented and are present in higher concentrations than expected in life.

Discussion

Based on current habitat associations, the most abundant taxa in the Isla Vista terrace deposit inhabited a soft-bottom marine environment with sandy to muddy substrate. Rare rocky substrate taxa suggest hard substrate was available but not abundant in the source habitat. While a majority of the fauna certainly lived in fine-grained sediments, it is unclear from my collections whether the fauna occurred in an intertidal or a subtidal setting. However, foraminifera collected 31-256 m west of Camino Majorca suggest a shallow (0-5 m) subtidal environment (Barrick et al., 1989). This is consistent with Wright's interpretation of the terrace deposit as inner sublittoral (Wright, 1972) and the deposit's source was most likely offshore based on the combined faunal evidence.

The recorded sedimentology of the Isla Vista terrace deposit also suggests a fine sand to mud substrate. Fine sandy and muddy substrates occur in protected embayments or offshore below wave turbulence (Valentine, 1961) further indicating the fossil assemblage originated in a quiet water environment. This is consistent with modern habitat associations.

There is lateral variation in the distribution of several species, which may range from very abundant to entirely absent across sample sites. This lateral variation could result from slight differences in sediment characteristics, from depth of oxygen penetration, or from the distribution of non-fossilized members of the community (Little, 2000). The variation seen in the terrace deposit could reflect this patchiness. Further analysis of lateral variation is necessary.

Neither the faunal composition nor the median sediment size vary greatly between the two sediment colors. Thus, the observed color difference may not represent different source environments or different depositional events, but rather different concentrations of tar accretions or differential weathering. Portions of the cliff containing gray sediments are more affected by wave-cut erosion and exposures are renewed continuously. In contrast, where yellow-brown sediment is present, erosion is less frequent and the cliff face has well-developed superficial weathering. The continuity of the fossiliferous sediment regardless of sediment color further supports the interpretation that the different colors do not represent different sources or different events. Any faunal differences between the two sediment colors may be due to local variation in the deposit.

The Pleistocene unit was rapidly deposited over an existing hard substrate as evidenced by numerous rock-boring *Penitella sp.* and *Platyodon sp*. found as whole shells in life position in the upper 10 cm of the Sisquoc. Rapid deposition is further supported by the random orientation, disarticulation of pelecypods, amount of shell fragments, and the abrupt decrease in shell numbers away from the contact with the Sisquoc Formation.

Conclusion

The present preliminary results cannot differentiate between subtidal and intertidal fine sandy to muddy environmental sources because of the faunal similarities between the mollusks in both environments. However, evidence from previous foraminiferal studies suggest the source environment was subtidal. The consistency between the fauna and sediment type indicate that mixing of sediments from other environments has not occurred.

The absence of significant differences in fauna and sediment size between the two sediment colors suggest that the different colors are not the result of different depositional events or different environmental sources. While lateral variation is present, the deposit appears to sample a single environment from the western end of the UCSB campus to Devereux Slough.

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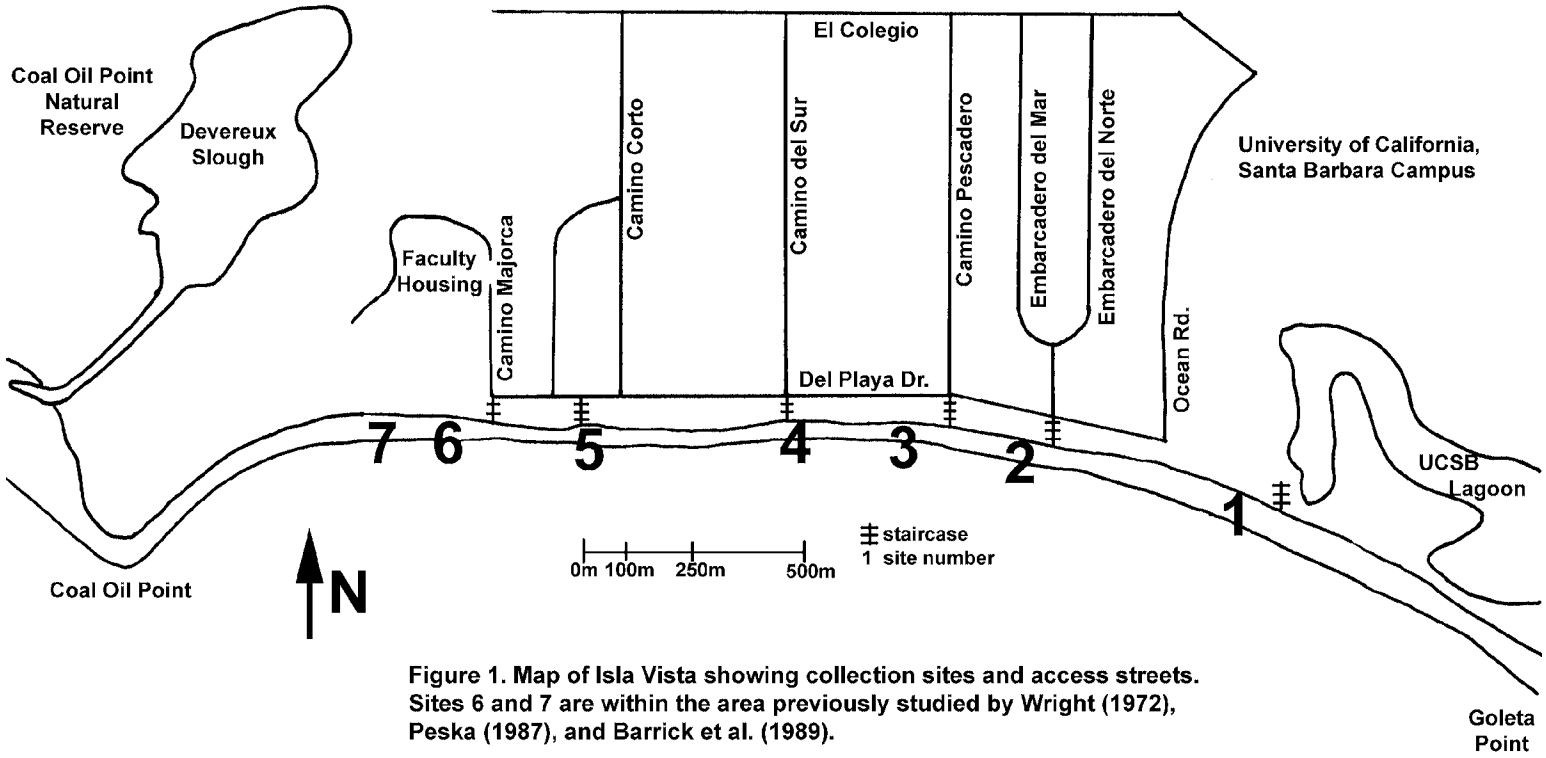

Figure 1. Map of Isla Vista showing collection sites and access streets. Sites 6 and 7 are within the area previously studied by Wright (1972), Peska (1987), and Barrick et al. (1989).

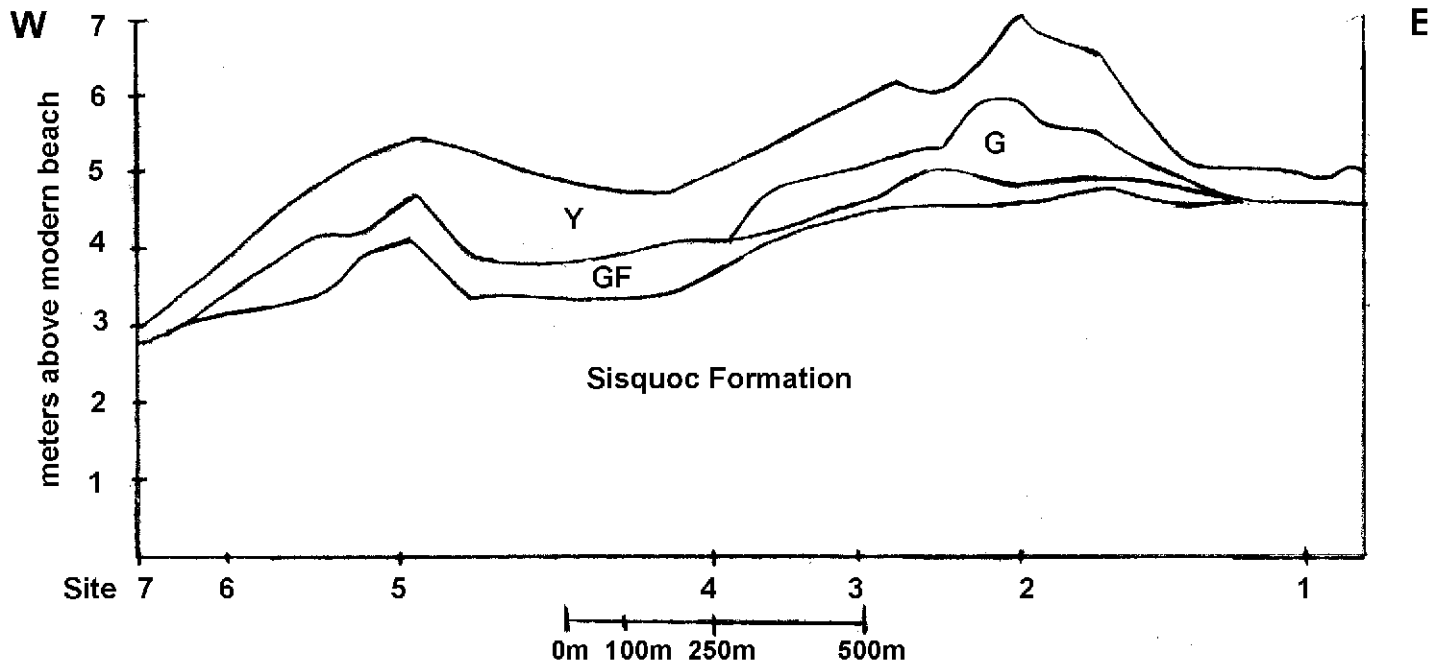

Figure 2. Diagramatic cross section of the Isla Vista terraces with 1,200x vertical exageration. Y= yellow-brown, G= gray, GF= gray fossiliferous. A distinction between yellow-brown fossiliferous and yellow-brown unfossiliferous has not yet been mapped.

Table 1. Preliminary list of gastropods from Isla Vista terrace near Goleta, California. A= abundant, C= common, R= rare. Sites 6 and 7 are within the area collected by Wright (1972).

	Site 1	Site 2			Site 3	Site 4	Site 5	Site 6	Site 7		Wright, 1972
Gastropoda		Top	Middle	Bottom					Top	Bottom	
Acteocina sp.	R	R	R	R	R			R		R	
Alia carniata	C	C	C	C	C	C	C	C	C	C	A
Bittium spp.	A	A	A	A	A	C	R	C	A		A
Calliostoma sp.				R	R						R
Calyptraea sp.	R							R		C	R
Crepidula adunca	R	R	R			C	C	R		R	R
Crepidula plana		R	R	R			R		R	R	
Epitonium sp.										R	
Fusitron oregonis			R								R
Littorina planaxis			R		R	R	R			R	R
Mangelia sp.		R	R	R			R	R			R
Margarites pupillaria	C	C	C	C	C	C	C	R	C		
Margarites sp.			R								
Megatebennum sp.									R		R
Nassarius mendicus			R				R				C
N mendicus v. cooperi			C				R				
Nassarius perpingus	R		C	C				R			R
Nassarius sp.	R			C	R	R	R	C	C	C	R
Notoacmea sp.								R			
Ocenebra lurida							R				R
Ocenebra spp.	R				R	R	R	R	R	R	R
Olivella baetica		C	C	R				R			C
Olivella biplicata	C	C	C	C	C	C	A	C	C	C	A
Olivella sp.			C								C
Polinices lewisii									R		R
Turitella sp.	R	R									R

Table 2. Preliminary list of pelecypods from Isla Vista terrace near Goleta, California. A= abundant, C= common, R= rare. Sites 6 and 7 are within the area collected by Wright (1972).

	Site 1	Site 2			Site 3	Site 4	Site 5	Site 6	Site 7		Wright, 1972
Pelecypoda		Top	Middle	Bottom					Top	Bottom	
Clinocardium sp.								R			R
Cryptomya californica	A	A	A	A	A	A	C	A	C		C
Glans sp.										R	
Lucinisca nuttalli	R	R	R	R			R				R
Macoma expansa			R								R
Macoma indentata										R	R
Macoma inquinata	C						C				C
Macoma nasuta	A	A	A	A	A	A	A	A	A	A	A
Mytilus sp.			R					R		C	R
Nuculana taphria	R		R								R
Nutricola tantilla	A	A	A	A	A	C	C	C	A	R	
Penitella turnerae								R			
Platyodon cancellatus			R		R					C	C
Protothaca staminea	A	C	C		A	A	A	R	C	A	C
Saxidomus giganteus										R	A
Saxidomus nuttalli	C		R		R	R	R				
Solen sp.	R	R	R	R							R
Spisula sp.									R		
Tellina bodegenis			R					R			
Tellina modesta	R	A	A	C	R		R	C	C	R	R
Tresus nuttalli	C		R		R	C		R	R		A

Table 3. Preliminary sediment data reported as percent volume of various sediment grain sizes present at each collection site. Large shells were removed from the sample before seiving. Particle sizes phi -2.00 to 2.00 are primarily shell fragments and clumps of tar.

Site 1		
Phi Value	% volume	Cumulative % volume
-2	7.8	7.8
-1	9.7	17.5
1	19.4	36.9
2	9.7	46.6
3	19.4	66
4	14.6	80.6
>4	19.4	100

Site 2		
Phi Value	% volume	Cumulative % volume
-2	5.1	5.1
-1	8.9	14
1	13	27
2	2.6	29.6
3	32	61.6
4	32	93.6
>4	6.4	100

Site 3		
Phi Value	% volume	Cumulative % volume
-2	8.5	8.5
-1	2.8	11.3
1	8.5	19.8
2	2.8	22.6
3	21	43.6
4	28.2	71.8
>4	28.2	100

Site 4		
Phi Value	% volume	Cumulative % volume
-2	7.7	7.7
-1	7.7	15.4
1	15.4	30.8
2	12.3	43.1
3	15.4	58.5
4	23	81.5
>4	18.5	100

Site 5		
Phi Value	% volume	Cumulative % volume
-2	23.5	23.5
-1	17.6	41.1
1	23.5	64.6
2	4.7	69.3
3	7.1	76.4
4	11.8	88.2
>4	11.8	100

Site 6		
Phi Value	% volume	Cumulative % volume
-2	18.1	18.1
-1	7.2	25.3
1	12	37.3
2	6	43.3
3	14.5	57.8
4	24.1	81.9
>4	18.1	100

Site 7		
Phi Value	% volume	Cumulative % volume
-2	10.4	10.4
-1	10.4	20.8
1	14.6	35.4
2	4.3	39.7
3	17.3	57
4	20.6	77.6
>4	22.4	100

Table 4. Preliminary sediment data showing the percentage of phi values 3.00, 4.00 and > 4.00 (medium sand, fine sand and silt). At these sizes, shell fragments and tar aggregations are absent and a better comparision of sediment size between sites can be made.

Phi Value	3.00	4.00	> 4.00
Site 1	36.20%	27.30%	36.20%
Site 2	45.45%	45.45%	1.00%
Site 3	27.20%	36.40%	36.40%
Site 4	27.10%	40.40%	32.50%
Site 5	23.20%	38.40%	38.40%
Site 6	25.50%	42.50%	32.00%
Site 7	28.70%	34.20%	37.10%