Karrow

A Late Pleistocene Terrace Faunule from Near La Jolla, California

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(1 Plate)

INTRODUCTION

IN THE SPRING OF 1970, the senior author while on temporary leave at the Scripps Institution of Oceanography, undertook a study of the raised Pleistocene terraces near La Jolla, California. The purpose of the investigation was to obtain material suitable for radiometrically dating the various terrace deposits.

In the course of reviewing the pertinent literature, reference to a low emergent terrace at Scripps Institution, which has received little notice in the published literature, was found in the unpublished Master's thesis of W. B. MERSELIS (1962). Merselis described the location and morphology of the terrace and shorecliff but did not record the presence of fossils in the terrace sediment. Because of the accessibility of the site, the clarity of the geological relationships, and the common difficulty elsewhere in locating clearly exposed sites where the ancient shoreline angle can be defined, the site, the fossiliferous terrace sediment, and the enclosed fossils, are herein described.

GEOLOGY OF THE SITE

As described by Merselis, the raised shoreline angle (the intersection of the shorecliff and wave-cut bench) is 167 m north of the Scripps Pier (Figure 1); the terrace slopes southward and disappears below the present beach level directly north of the Pier. Conglomerate near the contact between the Ardath Shale and Scripps Formation of Eocene age (KENNEDY & MOORE, 1971) underlies the Pleistocene terrace deposit. Slickensided vertical fault surfaces, showing strike-slip movement, cut through the conglomerate a few meters south of the shoreline angle in a northwesterly direction, and are probably related to the Rose Canyon fault, which is known to trend offshore in this vicinity (KENNEDY & MOORE, *op. cit.*). The displacement and relative age of the faults might be determined by locating their intersection offshore with the Miocene Scripps dike dated at 10.9 ± 1.1 million years (KENNEDY & MOORE, *op. cit.*); the dike trends southwestward offshore from its outcrop, located about 450 m north of the terrace site. The alteration of the Eocene rocks along faults and the resulting differential erosion perhaps served as the agents to create a small promontory, into which small sea caves are developing, at the terrace site (Figure 2). The faults do not cut the Pleistocene terrace sediment, exposed in the ceilings of the caves and in the present shorecliff. In both types of exposures, metazoan invertebrates are preserved and occur meagerly in the interstices of the coarse terrace sediment.

MERSELIS (1962) measured the altitude of the raised shoreline angle as 21 feet (6.4 m), and noted that the terrace slopes southward at a relatively steep slope of four degrees. He also noted that the coarse rubble of the terrace sediment diminishes in size from an average of one foot (30 cm) diameter at the shoreline angle to about three inches (8 cm) at a distance of 170 feet (52 m) to the south. Although he recorded the common occurrence of pholad borings in the terrace boulders, he did not note the presence of preserved fossils.

Above a few meters of terrace sediment are more than 10 m of fine-textured alluvial and colluvial sediments, mostly buff to light brown in color (Figure 3). At intervals through these overlying sediments, reddish-brown zones and charcoal occur. These, a formerly-exposed hearth near the base of the alluvium, and artifact-bearing levels in the upper 2 m, have aroused archaeological interest, through which the cliff has become known as the Scripps site (SELLARDS, 1960), or the SIO Cliff Site (HUBBS et al., 1962). CARTER (1957, p. 241) and other authors have also discussed the archeological aspects of this site.

PALEONTOLOGY

The terrace sediment ranges from boulder gravel to silt and sand, partly cemented by iron oxide. Extraction of the sparse fossil fauna was a difficult and slow process, involving part-time effort over a period of several weeks. Because of the limited time available, only a few specimens were recovered; specimens were frequently broken during recovery from the matrix.

The molluscan taxa, together with ecological notes based largely on FITCH (1953) and MCLEAN (1969), are given below.

Mollusca

Gastropoda

1. *Lacuna unifasciata* Carpenter, 1857. Intertidal to sublittoral, on eelgrass, algae. 2 specimens.
2. *Thais emarginata* (Deshayes, 1839). Intertidal, on rocks near mussel beds. 1 specimen, lacking spire.
3. *Tegula* cf. *T. funebralis* (A. Adams, 1855). Intertidal on rocks. 10 + fragments, some of which may represent *T. gallina* (Forbes, 1852), a species commonly associated with *T. funebralis* in the midtidal zone.

Bivalvia

1. *Mytilus* cf. *M. californianus* Conrad, 1837. Upper intertidal zone, on exposed rocks, but also may occur sublittorally (Berry, 1954; Chan, 1973). Numerous fragments.
2. *Ostrea lurida* Carpenter, 1864. Intertidal, in sheltered inlets and bays, attached to hard substrates, common on mudflats. Numerous valves.
3. *Hinnites multirugosus* (Gale, 1928). Low intertidal to sublittoral attached to rocks and other hard substrates in bays and along open coasts. 2 fragments.
4. *Pseudochama exogyra* (Conrad, 1837). Mid-intertidal, along open coasts, rarely in bays or protected coastal waters, attached to rocks or other hard substrates. 2 valves.

In addition to the mollusks, several fragmental echinoid spines, which are referable to *Dendraster* sp. indet., a few echinoid test fragments, and several fragmental plates of barnacles, *Balanus* sp.?, were recovered.

All the identified molluscan taxa are known to be living at the latitude of the terrace site, and these species are common constituents of the modern Californian faunal province. Two major molluscan life associations are apparently represented in the meager collection. An exposed, rocky shore element is characterized by the presence of the *Mytilus, Tegula* and *Thais*. The common occurrence of *Ostrea* suggests that elements associated with this species were present in sheltered inlets or bays along the coast.

DISCUSSION

The environment indicated by the fossil fauna is consistent with what can be deduced of the paleogeography of the site. The site was in an exposed position at the base of a high cliff, rather like the present shore cliff. At the higher level of the terrace, the Scripps dike was not likely exposed by erosion as it is today, and the slight protection from the northwest afforded the present beach, was not likely available then. Nearby to the southeast was an embayment in the coast, now occupied by a low urbanized bench, the probable source of the taxa representing a protected environment.

The age of this raised terrace remains a matter of speculation. The fresh, unaltered, condition of the fossils suggests they are suitable for dating by various means. Radiocarbon dates on charcoal in the overlying alluvium range from about 1 000 years B.P. near the top, through about 3 000 years at a depth of about 1.3 m, 21 500 years at about 4.9 m depth, and > 34 000 years at a depth of about 6.6 m (HUBBS *et al.,* 1962, 1963). The indicated age for the terrace fauna is, therefore, some unknown but substantial age greater than 34 000 years. Any reasonable extrapolation downward of the indicated rates of accumulation of the alluvium indicates an age on the order of 70 000 to 100 000 years at the base. Radiocarbon dating of the fossil shells has not been attempted because of the widely held view that marine shell dates over 30 000 years are not trustworthy. A preliminary attempt to apply amino acid dating has suggested equivalence to the lowest terrace of the Palos Verdes sequence near Los Angeles (P. E. Hare, personal communication). Fossiliferous marine deposits on the lowest Palos Verdes terrace, the Palos Verdes sand, have been dated by the helium:uranium method as 95 000 to 130 000 years (FANALE & SCHAEFFER, 1965) and by the open system uranium-series method as 70 000 to 110 000 years (SZABO & ROSHOLT, 1969). The validity of the latter method has been questioned by KAUFMANN *et al.*, (1971), and the range of results by the various methods does not inspire confidence.

Remnants of a higher raised terrace, also bearing well-preserved fossil shells, occur 5.6 km north of the Scripps site at Torrey Pines State Park and are considered correlative with the Nestor Terrace (VALENTINE, 1960). Shells from the Torrey Pines terrace, with an altitude of about 20 m, were radiocarbon dated at > 50 000 years (HUBBS *et al.*, 1965). Corals from the Nestor terrace at Point Loma have been assigned a tentative age of 125 000 ± 5 000 years on the basis of the Th^{230}/U^{234} method (KERN, 1973b). Although some workers have considered the Torrey Pines terrace to be of Sangamonian age, HUBBS *et al.*, (1965) have suggested it was formed in the second last interglacial stage, and that lower and younger terrace remnants would probably be found in protected coastal sites. The Scripps terrace is likely in that category.

Marine sediment on other terraces occurring at similar elevations in the San Diego area have been referred to the Bay Point Formation, with an estimated age of 100 000 ± years (KENNEDY & MOORE, 1971). However, in view of strong evidence of Pleistocene faulting and warping, (EUGE *et al.*, 1973; KENNEDY & MOORE, 1971; KERN, 1973a; PETERSON, 1970), correlation on altitude alone is not reliable. Dependable correlation will require actual dating of the various terrace segments, largely by methods still being developed and refined.

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Explanation of Figures *1* to *3*

Figure *1*: Shoreline angle (almost out of picture above seated man's head) and cemented terrace rubble overlying Eocene sandstone and conglomerate on a small promontory. Scripps Institution in right background.

Figure *2*: View of other (south) side of small promontory. Raised terrace extends from sharp angle at left end of promontory to about 1 m below drainpipe. Background cliff beyond promontory is Eocene sandstone.

Figure *3*: Colluvial and alluvial sediments on the raised terrace, which is barely visible at top of lowest dark zone at left of face. Raised terrace dips below the present beach near the right side of the picture. View of cliff face south of area shown in Figure *2*.