PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
FOURTH SERIES

Vol. XXXI, No. 13, pp. 341–347 May 20, 1963

INTERPRETATION OF THE INVERTEBRATE FAUNA FROM THE UPPER PLEISTOCENE BATTERY FORMATION NEAR CRESCENT CITY, CALIFORNIA

By

Warren O. Addicott
345 Middlefield Road, Menlo Park, California

This paper documents an assemblage of late Pleistocene invertebrates occurring as a basal fossiliferous lens on the Crescent City platform, an emergent wave-cut terrace on the northern California coast near the Oregon border. This is the only recorded late Pleistocene invertebrate fauna in northern California north of the San Francisco Bay district, although extensive areas of similar and probably contemporaneous wave-cut terraces occur along the coast between Crescent City and San Francisco. Fossils were collected from a sea cliff exposure west of Crescent City which is located near the southern edge of a broad marine terrace extending nearly thirty-five miles along the coast from the mouth of Smith River to a point south of Crescent City. The Crescent City fauna lived in a moderately shallow-water, nearshore-shelf environment of both rocky and sand-covered bottom. Subsequent redistribution and mixing by current or wave action brought together an assemblage of diverse ecological types. Composition of the assemblage, principally mollusks, indicates marine water temperatures not appreciably different from conditions offshore from Crescent City today. Study of topographic maps and the sailing chart of the area suggests that the fauna lived on or adjacent to a prominent northwesterly trending offshore reef which extended some seven or eight miles in a northwesterly direction from the late Pleistocene coastline.

Diller (1902) published an early account of Pleistocene terraces developed near Crescent City, in which comments by W. H. Dall concerning the stratigraphy and paleontology of Pliocene and Pleistocene deposits were presented. However, first mention of Pleistocene fossils from this area was made by Maxson (1933), who designated deposits capping the Crescent City platform as the Battery formation. Maxson did not describe or list the fauna, but did compare it with the upper San Pedro of southern California. Subsequently Back (1957), in a paper on the water resources of the Smith River plain (= Crescent City platform), noted the occurrence of four invertebrates from the Battery formation which were identified by Dr. Leo G. Hertlein.

A reconnaissance of sea-cliff exposures of the Crescent City platform and overlying deposits from Battery Point at Crescent City, northwestward some three and one-half miles to Point St. George, was made in November, 1958. The terrace platform was traced northwestward along the coast to a point where it passes beneath beach and sand dune cover near the north end of Point St. George. Fossils listed in table 1 were collected from a fossiliferous lens in sea cliffs at Crescent City. Although burrowing pelecypods, possibly *Zirfaea,* have made characteristic pockets in the terrace platform in several areas, no additional fossiliferous deposits were located in the Battery formation. However, in a subsurface study of the Battery formation made from records of wells drilled to this important local acquifer, Back (1957) states that fossil material has been recovered from basal gravels in at least one water well.

The terrace platform is eroded into rock of Mesozoic and Pliocene age. Mesozoic rocks consist principally of grey, massive, well-indurated sandstone with some pebble conglomerate. They have been identified as the Dothan formation of Jurassic age (Maxson, 1933). The Pliocene Point St. George formation is a light-grey, fossiliferous claystone containing abundant valves of *Macoma nasuta.* In the vicinity of Point St. George both formations strike northwesterly and dip toward the northeast. Dips measured in the Pliocene beds range from 12 to 20 degrees and are considerably more gentle than in the underlying Jurassic sandstone. Variation in elevation of the wave-cut terrace surface along sea cliffs west of Crescent City is largely a function of underlying rock type. On either end of Point St. George, which is formed of well-indurated Mesozoic sandstone, there is a lowering in elevation of the terrace surface where it crosses onto less resistant Pliocene claystone. Locally, this can amount to a change in elevation from around 50 feet to an average of about 20 to 25 feet. This slope has a definite northeasterly direction. It continues under the Smith River plain according to data from water wells and a seismic refraction survey in the area (Back, 1957). This inshore, northeasterly slope of the terrace platform

and the southwesterly slope of the ocean floor from the nearshore zone of rocks and sea stacks, suggest that during late Pleistocene time the area from Battery Point to Point St. George was an offshore reef. The reef apparently extended several miles in a northwesterly direction from the late Pleistocene shore and may have measured up to a mile in width. Inspection of topographic maps suggests that the maximum shoreline angle of the late Pleistocene sea which eroded the Crescent City platform was between 80 and 120 feet with reference to present sea level. A portion of the highest reaches of this wave-cut terrace and the associated shoreline angle is preserved on Castle Rock located 3,000 feet offshore from the southern tip of Point St. George. This rock must have been partially emergent in late Pleistocene time, yet it was at least six miles from the shore line. Because the shoreline angle along the inner edge of the Smith River plain occurs rather uniformly at the same elevation, the apparent northeasterly slope of the terrace surface suggested by local data in the Crescent City area does not appear to be evidence of tilting or deformation of the terrace surface. Rather, it is a function of rock type and relative position from the shoreline angle.

The Battery formation is composed principally of grey, limonitic-stained sand with a basal gravel bed. In sea cliffs near the western edge of Crescent City, a basal boulder bed is developed above the beveled surface of Jurassic sandstone. Some yellow-grey sandy clay was observed in exposures in this area. The Battery formation is capped everywhere by a few feet of dark-brown soil. Scattered shell debris noted in terrace deposits at Battery Point near the foot of 6th Street was not suitable for collecting purposes. The assemblage listed in table 1 is from a sea cliff exposure on a small point near the west limits of Crescent City. This locality appears to be the same as that from which Back (1957) collected four different molluscs. The fossils occur in a lens or pocket of yellow-grey, gravelly, calcareous sand beneath a large sandstone boulder measuring nearly four feet in diameter. Most of the fossil material was badly broken and showed signs of considerable abrasion. The larger fragments and few whole specimens were fragile and extremely difficult to collect. A hundred feet or so west of this locality the terrace surface is channeled into an outcrop of dark grey to black shale. In this area, large fragile specimens of *Schizothaerus capax* were particularly abundant.

Along the boundary of the Coast Guard reservation on Point St. George, large shell mounds or kitchen middens were noted. Principal invertebrate constituents of the mounds were, in order of abundance, *Mytilus californianus, Protothaca staminea, Balanus* sp., and *Tegula funebralis.* Other forms observed were *Hinnites multirugosus, Thais lima, Thais lamellosa, Dendraster* sp., *Acmaea mitra, Acmaea* sp., and various bones.

TABLE 1. *Fossil invertebrates from the upper Pleistocene Battery formation at Crescent City, California.*

Pelecypoda

Macoma nasuta (Conrad)
Macoma irus (Hanley)
Mytilus californianus Conrad
Protothaca ruderata (Deshayes)
Protothaca staminea (Conrad)
Saxidomus giganteus (Deshayes)
Schizothaerus capax (Gould)
Zirfaea pilsbryi Lowe

Gastropoda

Acmaea persona Eschscholtz
Lepeta concentrica (Middendorf)
Margarites? sp.
Odostomia sp.
Thais lamellosa (Gmelin)

Cirripedia

Balanus cf. *B. nubilis* Darwin

Foraminifera

several unidentified species

This assemblage is dominated by large, thick-shelled pelecypods such as *Saxidomus giganteus, Schizothaerus capax,* and *Protothaca.* The fossiliferous lens, viewed in relationship to the basal gravels of the Battery formation in this area, unquestionably represents an assemblage brought together and modified by current or wave action. Its preservation as an isolated fossiliferous deposit within essentially barren outcrops of the Battery formation seems to be a direct result of the sheltered location in a pocket beneath a large boulder. Because of indications of considerable transportation, such as the badly fragmented and abraded condition of the shells, the apparently dominant thick-shelled pelecypods may not be truly representative of the fauna which existed at this locality during late Pleistocene time. They do represent a sand-bottom association which probably was developed upon a relatively smooth substrate of Point St. George claystone, a large area of which adjoins the fossil locality to the northwest. Invertebrates which characteristically inhabit areas of rocky ocean bottom along the open coast are represented by *Acmaea persona, Mytilus californianus, Margarites?* sp., *Lepeta concentrica,* and *Balanus* cf. *B. nubilis.* It is probable that the two ecological groups lived in close proximity, the rocky bottom forms living on the reef and the pelecypod association on a relatively flat sandy bottom adjoining the reef. This condition appears to be repeated today offshore from Crescent City. Water depth in the area during late Pleistocene time was no greater than about 80 feet judging from the apparent difference of elevation between the terrace platform and the shoreline angle.

Analysis of late Pleistocene water temperatures requires a relatively large number of species in order to be reliable. However, from the general aspect of the small association from the Battery formation it appears that marine water temperatures during the late Pleistocene were not significantly different from those occurring offshore today. With the exception of one gastropod, *Lepeta concentrica,* all species have geographic ranges along the Pacific Coast of North America which include the Crescent City area. The

extra-limital species, according to Burch (1945), ranges as far south as the Puget Sound area in Washington, a few hundred miles to the north. It seems doubtful to the writer that this can be construed to indicate cooler water temperatures during the late Pleistocene than at present for two reasons. First, temperature data presented by Ricketts and Calvin (1948), show that the waters of Puget Sound, a vast protected inland body of marine water, are not significantly cooler than waters offshore from Crescent City in spite of the higher latitude. In fact, the northern California and Oregon coast is a well known area of seasonal upwelling of cold water which creates a strong anomaly in the northerly thermal gradient along the Pacific Coast. Second, there is the possibility that collecting has not been adequate to conclusively establish the southern endpoint of range of this gastropod.

The Crescent City fauna is the only recorded occurrence of marine late Pleistocene invertebrates between the San Francisco district (Arnold, 1903, Dickerson, 1922, Weaver, 1949, Johnson, 1962) and Cape Blanco in southern Oregon (Diller, 1903 and Martin, 1916). An identified fauna of more than 40 invertebrate species from the late Pleistocene terrace deposits at Cape Blanco (Addicott, in press), is similar in aspect to the fauna from the Battery formation at Crescent City. However, extensive collections from Tomales Bay, located 30 miles north of San Francisco, represent a protected coast environment with an element of warm water mollusks. Species comprising this element are restricted geographically to areas south of Point Conception today. Although there are many areas between the San Francisco district and Crescent City in which elevated marine terraces are well developed (Higgins, 1961), no marine fossils have been reported from them. There are, however, many indications of mollusk borings in the surfaces of wave-cut terrace platforms along the Sonoma County coast in northern California (Bauer, 1952). This is an anomalous condition with reference to the widespread, abundantly fossiliferous mantle of contemporaneous marine terraces along the southern California and Baja California coast described by Valentine (1961) and others. It also differs from shallow-water conditions offshore from the local area today, judging from the commonly occurring shells along northern California beaches cast up by heavy surf and storm waves. The probable explanation is that modification and redistribution of originally fossiliferous deposits by wave or current action was so extreme as to destroy most obvious traces of fossils or to concentrate them in local areas which are concealed beneath nonmarine deposits covering these terraces.

The age assignment of late Pleistocene for the Battery formation is based upon the modern aspect of the fossil assemblage, the apparent absence of deformation, and comparison with similar and probably contem-

poraneous emergent wave-cut terraces along the Pacific Coast from Mexico to Canada which locally, at least, can be demonstrated to be post lower Pleistocene.

LOCALITY DESCRIPTION

Exposure in sea cliff 600 feet west of the intersection of Modoc Street and Airport Drive at the western limits of Crescent City, Del Norte County, California (NW. quarter of the NE. quarter, section 30, T. 16 N., R. 1 W., Humboldt Base and Meridian, Crescent City quadrangle). Lens of fossiliferous sand overlying truncated surface of grey weathering, hard Mesozoic sandstone approximately 22 feet above sea level. Collected November, 1958, by the author.

LITERATURE CITED

ADDICOTT, W. O.

(In press) A late Pleistocene invertebrate fauna from southwestern Oregon. *Journal of Paleontology.*

ARNOLD, RALPH

1903. The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California. *California Academy of Sciences Memoirs*, 3: 420 pp., 37 pls.

BACK, WILLIAM

1957. Geology and ground-water features of the Smith River plain, Del Norte County, California. U. S. Geological Survey, Water-Supply Paper 1254: 76 pp., 7 pls.

BAUER, F. H.

(MS.) Marine terraces between Salmon Creek and Stewarts Point, Sonoma County, California. (Unpublished M.A. thesis, University of California, 273 pp., 16 pls., 1952).

BURCH, J. Q. (ed.)

1945–1946. Distributional list of the west American marine mollusks from San Diego, California, to the Polar Sea. Conchological Club of Southern California, pt. 2, 2(55–63): pagination by issue.

DICKERSON, R. E.

1922. Tertiary and Quaternary history of the Petaluma, Point Reyes, and Santa Rosa quadrangles. *Proceedings of the California Academy of Sciences*, ser. 4, 11:527–601.

DILLER, J. S.

1902. Topographic development of the Klamath Mountains. U.S. Geological Survey, Bulletin 196:69 pp.

1903. Description of the Port Orford quadrangle (Oregon). U.S. Geological Survey, Geological Atlas, Port Orford Folio, no. 89:6 pp., 4 maps.

HIGGINS, C. G.

1961. San Andreas fault north of San Francisco, California. *Geological Society of America Bulletin* 72(1): 51–68.

JOHNSON, R. G.

1962. Mode of formation of marine fossil assemblages of the Pleistocene Millerton Formation, *Geological Society of America Bulletin* 73(1):113–130.

MARTIN, BRUCE

1916. The Pliocene of middle and northern California. *University of California Publications, Bulletin of the Department of Geology*, 9(15):215–259.

RICKETTS, E. F., and J. CALVIN

1948. Between Pacific tides, 2nd ed. Stanford University Press, 365 pp., 46 pls.

SVERDRUP, H. U., M. W. JOHNSON, and R. H. FLEMING

1942. The oceans, their physics, chemistry and general biology. New York, Prentice–Hall, 1087 pp., illus.

VALENTINE, J. W.

1961. Paleoecologic molluscan geography of the Californian Pleistocene. *University of California Publications in Geological Sciences*, 34(7): 309–442.

WEAVER, C. E.

1949. Geology of the Coast Ranges immediately north of the San Francisco Bay region, California. *Geological Society of America Memoir* 35:242 pp., illus.