GEOCHRONOLOGY OF SANTA ROSA ISLAND, CALIFORNIA

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INTRODUCTION

Twenty-one years ago the Santa Barbara Museum of Natural History and the Western Speleological Institute started a long-term project of investigation on the geochronology of a small area on Santa Rosa Island. This research has resulted in more than 60 radiocarbon dates and several radium-uranium dates from a two square mile area on the northwest coast in which is recorded a continuum of Pleistocene events from the Third Interglacial high sea stands through the Wisconsin Glacial age and the entire 10,000 years of the Recent period. This study indicates changes in sea level, paleontology, paleobotany, archeology, climate, and geomorphology.

With the exception of two California Institute of Technology dates, all radiocarbon dates have been published by the laboratories involved, in Science and later in Radiocarbon. Except for the most recent dates they have also been published by Orr (various). Laboratories making the measurements are: Lamont Geological Observatory (L); University of Michigan–Memorial Phoenix Project Radiocarbon Laboratory (M); California Institute of Technology (CT); Scripps Institution of Oceanography (LJ); United States Geological Survey (W); and University of California at Los Angeles, Institute of Geophysics (UCLA). All of the specimens have been collected by the author, the majority in company with representatives of these laboratories.

Radiocarbon dates are usually rounded to the nearest 50 years with a plus or minus factor representing the statistical error. For the sake of brevity the plus or minus factor has been eliminated. Many of the dates in this paper have been rounded to the nearest 500 years, and in several instances a number of measurements have been lumped under one date.

CHRONOLOGY

Land Connection

Probably the question asked most frequently concerns the time of separation of the islands from the mainland. My studies have not answered this question; however, it can be stated definitely that a connection occurred in pre-Illinoian glacial times — possibly, and I think probably, as early as late Pliocene. Yet, all of the evidence that we have is that by Illinoian time through the end of the Wisconsin period the dwarf mammoth existed in apparent isolation on what are now the Northern Channel Islands.

Wave-cut Platform

Emerged wave-cut platforms are clearly shown on the northwest coast of the island up to an elevation of 1,000 feet on Farrel Mountain; the top of this mountain has been wave-cut to form a level tableland. Another well developed wave-cut platform occurs at about 750 feet, others at about 500, 350, and 250 feet, each with a terrestrial cover up to 100 feet in depth. The wave-cut platforms represent periods of higher-than-present sea level during which only the highest parts of the island chain would be above water. At its highest level, the sea would have completely covered San Miguel, the Anacapas, San Nicolas, and Santa Barbara islands, probably during the Aftonian or First Interglacial period of the Pleistocene.

Third Interglacial

During the Pleistocene there were four major advances of the ice, which resulted in lower sea level about the California Islands, and three meltings of the ice, which we call Interglacials, that resulted in higher-than-present sea levels. The last of these, the Third Interglacial, is known to have risen to a plus 100 feet, with a long standstill during which the Dume Platform (described by Davis, 1933) was carved out. This platform is characteristic along the southern California coast and is very prominent on Santa Rosa Island. We have no date for the 100 foot sea stand, but we know from radium-uranium dating (W. S. Broecker, personal communication) that at more than 200,000 years ago sea level stood at plus 25 feet and at more than 135,000 years ago it rose to a standstill of 75 feet; then it retreated, never to rise again above the present sea level except for a controversial short-period rise which probably occurred in post-glacial times.

The geology and paleontology have been discussed elsewhere (Orr, 1960b) in detail. At this time it is sufficient to mention that during the Garanon period, more than 200,000 years ago, most of the presently known marine mammals and birds were present as well as the dwarf mammoth and the "giant" mouse, *Peromyscus nesodytes*. Stock and Furlong (1928) first described a single species of dwarf mammoth. Presently, it appears that there may be more than one species, for the adult size ranges from a height of four feet in the early Wisconsin to a maximum of eight feet in the late Wisconsin. Stock and Furlong, both of whom worked on the island, described, from mixed bones, the species *Parelphas exilis*, as representing all of the mammoths of the island. Possibly this name should apply only to the partial skull, now at the Los Angeles County Museum.

The Interglacial, like each of the Glacials, was a period of fluctuating sea levels and temperatures, sometimes lower-than-present, at other times higher-than-present. However, the geological record in the merged sediments is one of drought, or at least warmer-than-present, with redeposited wind-blown silts in the Garanon, or middle phase, and great dunes of eolianite, consisting almost entirely of calcium carbonate, during the Fox period of 135,000 years ago (W. S. Broecker, personal communication). The land snail, fossil tree casts, and dwarf mammoth are the predominant fossils of this period. Some of these trees reached a diameter of about one foot, but generally they indicate a low brush-like cover.

Wisconsin Glacial Period

Radiocarbon has its practical limits at about 30,000 to 40,000 years, so there is a hiatus of nearly 100,000 years in our dates, though the strata, the fossils, and the geomorphic features have been preserved for eventual interpretation.

Somewhat more than 100 feet of terrestrial sediments, which Orr (1960b) has called the Tecolote member of the Santa Rosa Island formation, occur on the northwest coast near Arlington Canyon. From a fire area at a depth of 80 feet, Rainer Berger of the University of California, Los Angeles, and Orr secured charcoal specimens dated at more than 37,000 years (UCLA 749 in Berger and Libby, 1966). Just how much more, we do not know; but let us consider that at a depth of only 37 feet W. S. Broecker and I collected burned mammoth bone which was dated at 30,000 years (L 290-R in Broecker and Kulp, 1957). We cannot, of course, assume that the rate of deposition was the same all along this alluvial fan; but for the sake of an argument, we can project the total age of the Tecolote member to a minimum of 80,000 or 90,000 years, during which time the dwarf mammoth and the giant mouse are the only land mammals whose bones have been found. But man may have been present also.

This was a wet, cool, glacial climate, probably getting colder with a lower sea level as is indicated by a comparison of the geochronology worked out for the desert lake region of Nevada and Utah, first by Broecker and Orr (1958) and later expanded by Broecker and Kaufman (1965), and that for sea levels worked out by Curray (1960). These geochronologies show that there is a definite relationship, though a 500 year time lag occurs between the radiocarbon dates for the desert lakes and those for the oceans. This suggests that the lowest sea level occurred about 20,000 years ago. During this time from about 11,000 to 20,000 years ago, Santa Rosa Island increased its area and was connected to Santa Cruz and San Miguel islands as one great land mass. Actually there was probably an even greater length of time during which biological species were able to migrate within this island group.

About 30,000 B.P. (L 290-R in Broecker and Kulp, 1957) the heads of the alluvial fans had built up to approximately half of their present depth in the Tecolote-Arlington district, where we find the best evidence of Pleistocene man in the form of a burned and butchered mammoth. Here in the confines of a pit-like feature, charred bones of a dwarf mammoth were found, while on the outer edges of the pit unburned bones occurred. Here, as elsewhere on the island, certain bones (cervicles, last lumbar, and sacrum) are completely missing or badly damaged in a manner which is best explained as the result of butchering by man (Orr and Berger, 1966).

In our radiocarbon chronology we have another hiatus of 10,000 years between a fire area dated at 27,000 years (UCLA 746 in Berger and Libby, 1966), and a very similar fire area dated at 17,000 years (M 599 in Crane and Griffin, 1958); these two fire areas are only 100 feet apart and with about six feet of difference in depth. Both are believed to have been made by man; but whether they were or not, they indicate considerably more forested areas than remain today.

At 16,000 B.P. (L 244 in Broecker, Kulp, and Tucek, 1956) we find a definite forest of *Cupressus*, as evidenced by logs two feet in diameter, and by branches and roots buried under 40 feet of Tecolote member clays.

During the Iowan or lower Wisconsin (Pleistocene) all of the Northern California Islands were connected together; and therefore, the fossil plants reported by Chaney and Mason (1930) on nearby Santa Cruz Island are of interest. They reported a large assemblage including well preserved trunks of Douglas Fir, one of which has been dated at 14,200 years (Fergusson and Libby, 1963).

Sea level had continued to rise, though with numerous fluctuations, until about 11,000 B.P. (Broecker, Ewing, and Heezen, 1960) when narrow channels divided the great island mass into the

present members of the northern group. In general the period between 13,000 and 10,000 years ago was marked with several advances and retreats of the glaciers and corresponding transgressions and regressions of the desert lakes in Utah and Nevada. Fluctuation in the sea level and climate has left its mark on Santa Rosa Island by several black humus layers, the earliest containing a burned dwarf mammoth and a shell midden at about 12,500 B.P. (L 290-T in Broecker and Kulp, 1957; UCLA 141 in Fergusson and Libby, 1962; Orr, 1960a). This midden is so far the oldest dated shell midden in the world.

In their study of the desert lakes of Utah and Nevada, Broecker and Orr (1958) show great fluctuation in the lake levels which was due to pluvial conditions; two extremely high rises, which are known as Truman's Peaks, occurred at about 12,000 and 10,000 years ago with a low or dry period at 11,000. Curray (1960) shows similar sea level fluctuations, and a number of dated features on Santa Rosa support a wet-dry-wet climatic change during this time. There are a number of fire areas, one of which is in a midden-humus layer at 11,900 (Berger, Fergusson, and Libby, 1965); and somewhat above this level a well-made stone chopper at 11,800, near a butchered and burned mammoth was reported by Orr (1964). This is the last of the dated mammoths, though it is probably that some survived to as late as 10,000 years ago.

At 11,000 years (UCLA 748 in Berger and Libby, 1966) several fire areas occur. One, adjacent to an old arroyo cut at Arlington Springs, shows a change in stream gradient, probably on account of the lowering of sea level coupled with drought conditions. In the bottom of this cut, human bones were found, and dated at 10,000 years (L 650 in Orr, 1960a; L 650 in Olson and Broecker, 1961). Following this, the draw was refilled. That this is not just an accidental example is shown by another date of 9,000 (L 290-C in Broecker and Kulp, 1957) near the bottom of valley fill in Cañada Verde some miles to the east. Deposition in the valleys continued intermittently until about 750 B.P. (UCLA 745 in Berger and Libby, 1966).

Recent

During the 500 year period between 7,500 and 7,000 B.P. we have 11 radiocarbon dates. Generally the climate was drying rapidly and becoming more desert-like; on Santa Rosa, San Miguel, and San Nicolas it was a period of dune building. Sea level was from 30 to 60 feet lower than present which would place the sites of the Dune-dweller Indians from one-half mile to a mile and a half inland. Ocean temperatures were somewhat cooler than at present as is shown by the profusion of red abalone shells found in the middens. The human population had greatly increased, and villages of this culture are scattered over the island. Strong

orthwest winds formed dunes on the present coastline, but these re alternated with several layers of dark humus, indicating that ome forestation occurred.

From 5,000 to 4,000 years ago, the water in the mainland esert lakes rose slightly above the present level and well above ıe level which existed from 7,500 to 7,000 years ago. On Santa .osa a new Indian culture appeared that we call the Highlanders, s they deserted the beaches and lived on the high terraces from 00 feet to 1,000 feet above present sea level. They were primari- y seed gatherers, doing little fishing. With the climate being ıore moist than it is today, there was doubtless an abundance of corns, tubers, and seeds sufficient to feed a large population. .bout one-half of the Indian sites on the island belong in this ime span. Down in the sand dunes, trees and shrubs grew and eft their root casts and occasionally trunks of trees as evidence f forestation. Ocean temperatures were more like those of today udging from the fact that the red abalone had given way to the lack abalone and California mussel, though the Indians ate few f them and did little fishing but did use the circular fishhook hich has been dated at 4,800 years (UCLA 105 in Fergusson and ibby, 1962).

Seven radiocarbon dates span the period from 4,000 to 3,000 ears ago and indicate another climatic change to the dry side, hich probably eliminated all but a few relict forests of the High- ands and forced the people to take up fishing. This, too, was a eriod of dune building; the dunes built up over the older 7,000 ear old dunes and their 5,000 year old forests. Black abalone nd mussel, together with fish and sea mammals, were the primary iet, though some seeds or roots still existed as is shown by the umber of mortars and pestles found.

The drying period continued, and by about 2,500 B.P. (CT 40 n Orr, 1956) the Indians had almost completely ceased to use ıcorns or seeds as food. By 2,000 B.P. (CT 38 in Orr, 1956; I 1147 in Crane and Griffin, 1963) a new type of culture, the Canalino, was firmly established; and huge shell mounds were nade, primarily of the black abalone and California mussel, with some fish as well as marine mammals. At 1,200 B.P. (UCLA 103 n Fergusson and Libby, 1962) the great sea turtles were found.

Shortly after 750 B.P. a change in the climate occurred which stopped the deposition in the canyon bottoms that was begun ıbout 9,000 B.P.; a period of erosion began that is still going on oday. One arroyo of Skull Gulch has been cut since 330 B.P., and ı camp fire of that age has been exposed (Orr, in press).

Four hundred and twenty-four B.P. (1542 A.D.) Cabrillo, the irst white man, arrived on Santa Rosa and did not leave a trace. n 1602 Viscaino passed by the island without landing.

One hundred and fifty-four years ago, in 1812 A.D., a great earthquake frightened the Indians into leaving. In the early 1830's the first white man since Cabrillo's time arrived on the island and helped exterminate the sea otter and seals; however, it is doubtful if the otter hunters had any effect on the plant life. In 1839 some stock may have been introduced by Don Carlos Carrillo. By the mid 1850's, A. P. More had introduced horses, cattle, sheep, and pigs, without any quarantine period and with attendant introduction of mainland seeds and diseases. Deer and elk were introduced shortly after 1902 by the present owners, Vail and Vickers who, unlike their predecessors, make every effort to avoid overgrazing and to control the importation of diseases, insects, or noxious weeds.

SUMMARY

In one small area on Santa Rosa Island a wealth of datable material from Interglacial (Pleistocene) to Present is available. This material is undergoing a long term geochronometric study; and the dating of various events in climate, archeology, geology, paleontology, biology, and geomorphology is, in many cases, adaptive to comparisons with the other California Islands and with the immediate mainland. The connection of the Northern Channel Islands to the mainland occurred in pre-Illinoian time (Pleistocene), though the individual islands were connected to each other from as early as 20,000 years ago to about 10,000 or 11,000 B.P. Since then, they have remained separated from each other, implying that greater biological isolation has occurred since that time. Climate has varied, as has sea level which in turn greatly increased the island land mass by up to three times its present area. The extinction of some plants and of the mammoth may well be due to these factors, as well as to the advent of man during the Pleistocene.

During the historic period, the introduction of livestock resulted in the introduction of many European weeds to the detriment of the native grasses; and drought, coupled with overgrazing, resulted in much wind erosion. However, it will be noted that all of the sand dunes and arroyo cutting did not occur during historical times, but rather it was about 7,000 years ago and 3,000 or 4,000 years ago when the greatest of the dune building occurred.

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