*THE FIRE AREAS ON SANTA ROSA ISLAND, CALIFORNIA**

By Phil C. Orr† and Rainer Berger‡

SANTA BARBARA MUSEUM OF NATURAL HISTORY, SANTA BARBARA, CALIFORNIA, AND INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS AND DEPARTMENT OF ANTHROPOLOGY, UNIVERSITY OF CALIFORNIA (LOS ANGELES)

Communicated by Carl L. Hubbs, September 6, 1966

In about 3 km of sea cliffs, up to 30 m high, and badlands on the NW coast of Santa Rosa Island, California (Fig. 1) (34°N Latitude; 120°11'W Longitude), there are found approximately 100 red fire areas. The base of the cliffs is composed of resistant Rincon shales of Miocene age capped by unconsolidated Pleistocene alluvium deposited as fanglomerates emanating from the canyons of the island. As described previously,[1] the Miocene shales are topped by the Santa Rosa Island formation composed of the oldest Garanon member, the intermediate Fox, and the most recent Tecolote member.

The Fire Areas.—A major characteristic of the fire areas is their brilliant to dull brick-red appearance, easily recognized in the buff clays of the Tecolote in which almost all the fire areas occur (Fig. 2). None are observed very far upstream in the canyons beyond *ca.* 800 m. The stratigraphic correlation of the fire areas in the sea cliff is made relatively easy by the undisturbed horizontal layers of the Tecolote, as determined by on-foot and helicopter measurements. Only a few fire areas have been recognized in the other location on Santa Rosa, near China Camp on the south coast. On Santa Cruz Island, a few fire areas can be seen near Christies Ranch. One site on the mainland has been found on the Hollister Ranch, 65 km west of Santa Barbara, and others, by Hubbs, in the vicinity of La Jolla.[2]

There is a certain uniformity in the structure of the fire areas irrespective of their stratigraphic position in the height of the sea cliff. One type is a U-shaped pit about 60 cm in diameter and depth, of which the lower 20–30 cm are reddened clay. The other is found in the shape of a saucer generally 3.50–5 m in diameter with similar reddening. The most intensive red coloration is in the center, with the brightness gradually changing to a dull rich brown at the rim. The shape of the pits in the vertical has been ascertained in numerous cases in the face of the cliff. Occasionally, fire areas appear as elliptical or circular features on the horizontal top surface of the cliff after the overburden has been eroded away. Infrequently a thin horizontal band can be seen in the face of the cliff. This is thought to be due to erosion of fire areas by rain, which washed away and spread the brick-red clay, as will be discussed later.

Within the fire areas, bands of dark soil containing charcoal are often found. One of the very first fire areas discovered, found in 1946 in the face of the sea cliff at an elevation of some 25 m, appeared to have a ring of stones associated with it as is often found with man-made hearths. However, due to the lack of suitable equipment, this site could not be inspected before the cliff caved in. No other fire area of this type has been found since, although sandstones burnt red in the fires were observed occasionally. The extent of the number of fire areas lost to the sea cannot be estimated today.

FIG. 1.—Northwest coast of Santa Rosa Island, California. The fire areas are found in the face of the sea cliff and the canyon walls near the ocean.

During many years of investigation of the Santa Rosa fire areas, 24 were found to contain bird bones, 14 dwarf mammoth bones, and 5 bird and mammoth bones together. On the basis of 100 counted fires, this indicates that more than one third contain bones; but the real percentage may be considerably higher. The size of the bones found varies from large dwarf mammoth bones to small fragments of centimeter size from birds. A full description will be discussed in detail elsewhere.[3]

Causes of the Fire Areas.—Since there are no signs of volcanic activity on Santa Rosa, this cause for the reddened soil portions, as volcanic activity may occur elsewhere, can be immediately ruled out.

Another possible factor is the action of lightning starting grass or forest fires and the effects of spontaneous combustion. However, the prevailing stability of the air masses which dominate the Pacific Coast makes lightning activity along the immediate coast very unlikely. During the Wisconsin, the weather conditions of Santa Rosa were probably similar to those of Monterey today,[4] where there is rarely any lightning activity (0.1 strike per year[4]).

The direct formation of the fire areas by lightning action is very unlikely since fulgurites have never been found. Also, the amount of energy dissipated during a strike is much too small to produce the extensive heating required.[6] Furthermore, lightning would be expected to prefer the hills of the island's backbone, which reach 476 m in height, but where no signs of lightning impacts or fires are found.

A number of other causes for the origin of the fire areas may be advanced. Crook and Harris[7] have suggested the presence of Pleistocene man near Lewisville, Texas, based on their explanation of fire areas or "hearths." This theory has been questioned by Heizer and Brooks[8] on the grounds that these fire areas may be caused by burnt wood-rat nests. On Santa Rosa, however, rats have never been found.

It is equally very difficult to present a satisfactory explanation for chemical action

Fig. 2.—Typical fire area in the face of the sea cliff. The obscuring layer washed down by the winter rains has been removed.

resulting in the red color of the fire areas, because the properties of the ground water are not unusual and cannot account for such intensive localized oxidation.

The possibility of ignition by self-combustion of accumulated dry matter on Santa Rosa is held to be unlikely, as the presence of extensive fog banks dampens the island every late afternoon throughout the year.

Grass and Forest Fires.—While the likelihood of natural fires on Santa Rosa appears to be small, this possibility should not be completely ruled out. The examination of an accidentally caused grass and brush fire in Wreck Canyon on Santa Rosa which burned an area of several hectares showed all the grass and leaves consumed. Two years later, the only trace of the fire was a few scorched stems of the larger bushes. At no point was it found that any portion of the soil had turned red.

In the case of a forest fire, even if there are accumulations of combustibles, they are usually not confined to circles with a diameter of 0.60–5 m and the three-dimensional character observed on Santa Rosa. It is equally hard to see why a single smoldering tree should burn to its portion below the surface of the ground and not leave traces in the shape of its trunk or major roots. There are no geologic reasons why the red fire areas on Santa Rosa should accumulate red-burnt soil by some process in the particular shape observed. Another problem is why trees should have burned only in that particular 3-km section of Santa Rosa, and not in other areas which on ecological grounds should have permitted forest growth just as well.

After the great Refugio forest fire, one of the largest in California history, the effects of the disaster were carefully studied. The fire destroyed almost 350 km of dense chaparral and live oak in the Los Padres National Forest behind Santa Barbara between September 6 and 15, 1955. The intensity of the fire was enough to shatter rocks, but of hundreds examined, only two had acquired a red layer about a millimeter thick. Even though the gullies in the area had been filled for years with dry wood, nowhere was there found burnt earth turned brick-red as on Santa Rosa.

Similarly, the Coyote forest fire in 1964 on the outskirts of Santa Barbara destroyed many square kilometers of forest and residential area. The intensity of the flames was sufficient to melt a small aluminum building attached to a greenhouse (melting point of aluminum, 660°). However, after the fire, shrubs and plants with their roots deep enough in the soil staged a remarkable comeback. Only two areas of exposure to greater heat were found to contain soil baked red: one under a stack of sawed and split oak for firewood and the other under a stack of construction timber. Both had continued to burn for several days and the ground had been turned red as far as the original outline of the wood or timber to a depth of a few centimeters. This suggests the necessity of hot (at least 650–800° range), confined, and continued burning to achieve the effect seen in the Santa Rosa fires, in similar soil. Finally, if forest or brush fires were the cause of the fire areas, such reddening should occur much more universally, which it does not.

Test Fires.—In order to determine the effect of fires on the actual Tecolote soil on Santa Rosa, several piles of driftwood were accumulated and burned in natural depressions at different levels of depth of the Tecolote. The first fire was kept burning for 72 hr. After the sea wind had blown away most of the ashes, the thickness of the red-baked soil was measured to be about 3 cm. Ten years later, the central red area of the fire is still visible, but traces of red earth have been washed down the gully by the rains. This mode of formation of a thin red layer may also have occurred in prehistoric time.

In another section of the Tecolote, a natural depression was deepened to *ca.* 60 cm, similar to a barbecue pit. Then a fire was started until a hot mass of glowing coals was formed. After a while, the coals were partially raked out and replaced by the front end of a pig, the forequarter of an elk, a large fish, and a variety of shell-

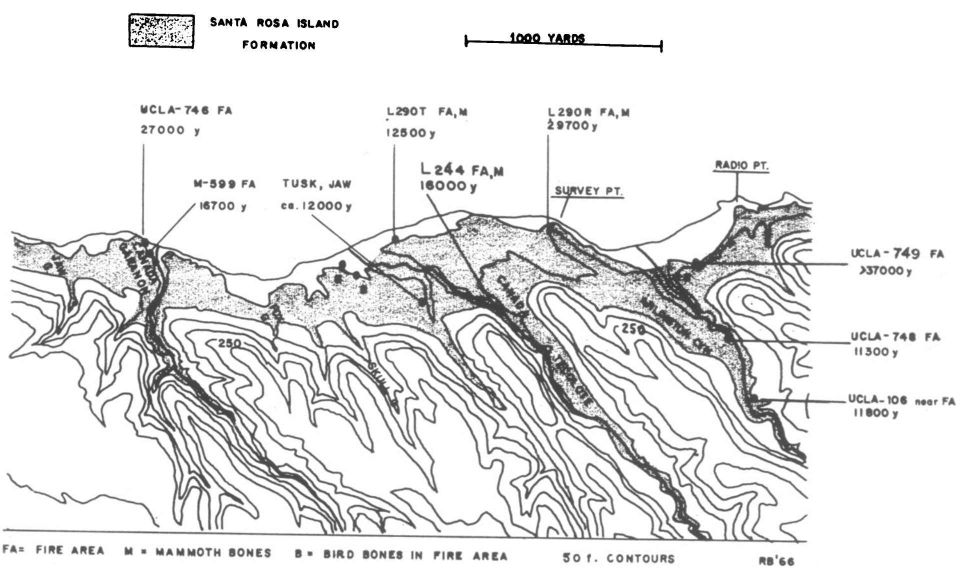

FIG. 3.—Map of the northwest coast of Santa Rosa Island where the fire areas occur.

fish including large abalone shells, which are in plentiful supply along the coast. In addition, several native rocks (Miocene sandstone) and some yellow jasper from the mainland were exposed to the heat of the pit as well as a large fossil bone from a dwarf mammoth. The contents were covered with coals, more wood, and finally earth. After 48 hr the ashes were removed and the portions of the pig and elk were found to be thoroughly charred, as could be expected. However, identifiable bones were still present, including the mammoth bone. The shells were completely destroyed by the fire but could be traced to small areas of white calcification because their position was known, indicating that the fire had reached a temperature of at least 825°C, at which calcium carbonate decomposes. Most of the native rocks had disintegrated beyond recognition, but the polished jasper survived the fire unharmed except that it had turned red. The area of the pit was burned a deep brick-red to a depth of 15 cm. While a lot of ash was found very little charcoal remained. Several additional fires were set, with the same general results.

Possibility of Man-Made Fires.—Lastly, there is left the possibility that the fire areas were made by man.[9] With the development of the radiocarbon dating technique, some 10 years after the first finds, measurements were carried out mostly on charcoal from these fire areas, with due care to exclude physical and chemical contamination. The location of the samples and some of the place names are found in Figure 3, but for reasons of clarity, not all fire areas have been marked. Interestingly enough, the number of fires in the more recent Tecolote is much greater than in the older strata. Starting from the lowest, the number of fire areas approximately doubles in 10,000-yr intervals.

In chronological order of the time of laboratory measurement, one of the first radiocarbon dates was obtained by Broecker *et al.* from a black and badly decomposed sample of cypress wood found in the alluvium of Tecolote Canyon about 800 m

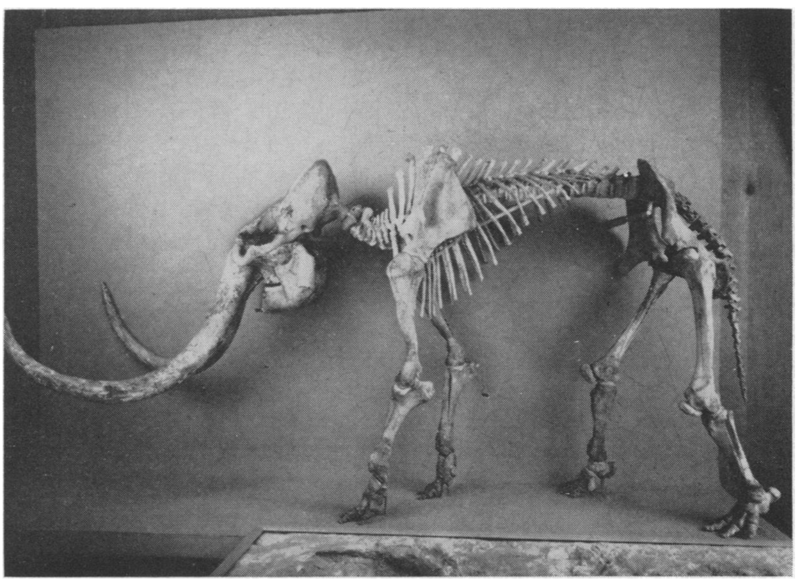

FIG. 4.—Composite skeleton of dwarf mammoth from Santa Rosa Island. The cranium is a plaster replacement. For skull without cranium see ref. 12. Height of skeleton *ca.* 2 m.

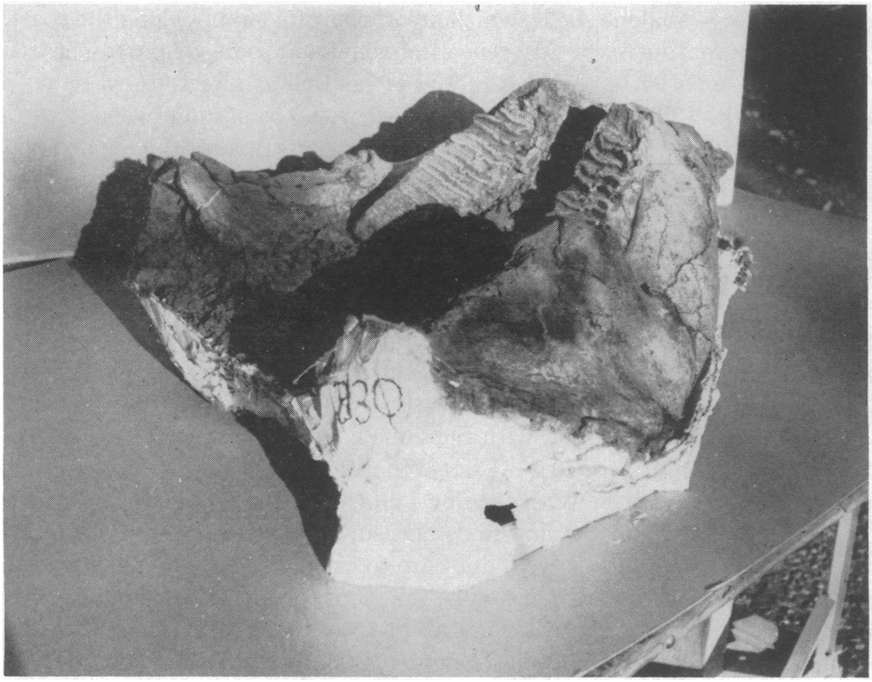

FIG. 5.—Jaw of dwarf mammoth burnt in fire area from mouth of Tecolote Canyon in the *ca.* 12,000-yr stratum.

inland.[10] This wood specimen lay stratigraphically about 1 m below a fire area and *ca.* 12 m below the top surface of the cliff of the canyon. The radiocarbon age of the wood was determined to be 15,820 ± 280 yr (L-244), later corrected to 16,000 yr old. Adjacent to the fire area, two mammoth skulls and bones were found in the same stratum. One of the skulls was badly weathered and was not collected. The other lacked tusks and the cranium, which had presumably been removed to extract the brain, pointing to man's presence on the island. The better-preserved skull was restored and used in the composite skeleton of a dwarf mammoth on exhibit in the Santa Barbara Museum of Natural History as illustrated in Figure 4. The Santa Rosa dwarf mammoths had first been described by Stock and Furlong[11] as *Elephas exilis* and classified by Osborn[12] as *Archidiskodon exilis*. Since the radiocarbon date originates from a location below the skulls, it does not date them directly. Rather the skulls are of more recent age, but on stratigraphic grounds not very much more recent.

Another radiocarbon date was measured by Broecker and Kulp[13] based on charred mammoth bones associated with numerous large and uncharred bones from the same animal. The site itself is a small flat *ca.* 3 × 4 m with a steep slope toward the sea cliff at Survey Point at a depth of 11.5 m from the top. Several weathered bones were collected on the flat in addition to those located in the soil of the slope. The majority of the burnt bones were found within the fire area outlined in red and black located in an ancient natural depression. The skeleton of the dwarf mammoth was disarticulated and partially lost due to the erosion of the sea cliff. The following bones were found: one tusk, one spinal vertebra, one metapode, three dorsal vertebrae, one tibia, one complete ulna and one fragment, two ribs, one burnt fibula, one radius, one femur head, one caudal vertebral fragment, one spinal axis, one tympanum, one right and one left pelvis, one scapula, a burnt sacrum, and miscellaneous rib and vertebral fragments, some burnt. Some of the well-preserved bones like the pelvis and portions of the hind feet were incorporated into the same composite skeleton mentioned earlier. The radiocarbon age was determined as 29,700 ± 3,000 yr (L-290R).

Another fire area containing charcoal and mammoth bones 2.75 m below the top surface of the cliff was measured at 12,500 ± 250 yr (L-290T). This site is located just east of the mouth of Tecolote Canyon.

At the edge of the Pleistocene beds from which many dwarf mammoth remains have been removed is the location of a fire area from which Hubbs collected charcoal 2.45 m below the surface. The age of the fire is 16,700 ± 1,500 (M-599) yr as measured by Crane and Griffin.[14]

The UCLA radiocarbon laboratory has dated charcoal from a fire area in direct contact with bones of a dwarf mammoth, 6.70 m below the valley terrace and 2.45 m above the modern stream bed of Arlington Canyon. The skeleton of the dwarf mammoth showed signs of butchering; the entire hindquarters and the left foreleg were missing. Removal by erosion can be completely excluded at that site. From the right foreleg, the lower half of the humerus had been separated by battering, and in an attempt to sever the entire humerus from the scapula, the head of the humerus had been badly battered. From the skull, which is preserved in a plaster cast at the Santa Barbara Museum, the cranium had been removed, presumably to obtain the brain. This destructive feature is also seen in the case of the other mammoth skulls found in the general area of the NW coast discussed here. Similar observations were made by Howell[15] at the Torralba site in Spain. The more recent Indians also removed the cranium of all the marine mammals hunted to obtain the brain. The present radiocarbon measurement places the mammoth and the fire area a few feet away in the same horizon at 11,800 ± 800 (UCLA-106) yr, near the end of the time of mammoths.[16] Further seaward, another fire area containing black soil and charcoal chunks has an age of 11,300 ± 160 (UCLA-748) yr at a depth of 3 m in the Tecolote member.[17]

In a location near Otter Point, charcoal was collected from a typical U-shaped fire area, about 60 cm in diameter and 2.75 m below the surface of the Tecolote. This fire area, 27,000 ± 800 (UCLA-746) yr, lies about 100 m west of a similar feature dated as M-599.

The oldest radiocarbon date was obtained from rich charcoal of an eliptical fire area about 1 m in diameter at a depth of 24.5 m in the Tecolote east of Arlington Canyon. The fire is removed by less than 2.5 m from the Miocene shale and is the deepest so far found. Its age is greater than 37,000 yr (UCLA-749),[17] and the implications are discussed in part II of this paper.

When the Santa Rosa fire areas are compared with hearths found by Movius[18] in the Upper Périgordian and Aurignacian at the Abri Pataud at Les Eyzies (Dordogne), certain similarities are discernible. While the geology at that site (talus slope of limestone cliffs) is completely different from Santa Rosa, basin-shaped hearths with fire-reddened bases are observed, some of similar dimensions to the Santa Rosa fires. Several of the Abri Pataud hearths show no particular immediate association with stones or artifacts by themselves, just as was found on Santa Rosa. But in the general context of the French site, they appear to be unmistakably of human origin, because many hearths are in levels holding thousands of manmade artifacts. Dating of the site by Vogel and Waterbolk[19] places the time span involved a few millenia prior to and after 30,000 years ago.

Thus on Santa Rosa the more recent fire sites containing evidence of man in the form of broken mammoth bones and shattered skulls can be linked with the fire areas in deeper stratigraphic layers because they possess many of the same characteristics and become progressively fewer.

This paper is dedicated to the memory of HERSCHEL CUTLER SMITH, a great friend of archaeology.

The authors wish to thank C. L. Hubbs and W. F. Libby for encouragement; J. B. Birdsell, E. W. Haury, R. E. Holzer, C. W. Meighan, L. S. B. Leakey, and J. R. Sackett for valuable suggestions and criticism; and A. Vail for general assistance in the field.

* This work was supported by the Trustees of the Santa Barbara Museum of Natural History, O. H. Truman of the Western Speleological Institute, and the National Science Foundation, GP-1893.

Part II of this paper is scheduled to appear in the December 1966 issue of these PROCEEDINGS.

† Santa Barbara Museum of Natural History, Santa Barbara, California.

‡ Institute of Geophysics and Planetary Physics, and Department of Anthropology, University of California, Los Angeles.

1 Orr, P. C., *Bull. Geol. Soc. Am.*, **71**, 1113 (1960).

2 Hubbs, C. L., G. S. Bien, and H. E. Suess, *Radiocarbon*, **4**, 204 (1962).

3 Orr, P. C., *The Prehistory of Santa Rosa Island*, in preparation.

4 Chaney, R. W., and H. L. Mason, in *Contributions to Pleistocene Paleontology of California*, Publication 415-I (Washington: Carnegie Institution of Washington, 1934), p. 1.

5 *Weather Bureau Technical Paper No. 19*, December issue (Washington: Government Printing Office, 1952).

6 Holzer, R. E., Dept. of Planetary and Space Science, UCLA, personal communication.

7 Crook, W. W., Jr., and R. K. Harris, *Texas Archeol. Soc. Bull.*, **32**, 327 (1962).

8 Heizer, R. F., and R. A. Brooks, *Southwest J. Anthropology*, **21**, 155 (1965).

9 Orr, P. C., in *Anthropological Papers, No. 26* (Salt Lake City: University of Utah, 1956), p. 74.

10 Broecker, W. S., J. L. Kulp, and C. S. Tucek, *Science*, **124**, 154 (1956).

11 Stock, C., and E. L. Furlong, *Science*, **68**, 140 (1928).

12 Osborne, H. F., in *Proboscidea* (New York: The American Museum Press, 1942), p. 1030.

13 Broecker, W. S., and J. L. Kulp, *Science*, **126**, 1324 (1957).

14 Crane, H. R., and J. B. Griffin, *Science*, **128**, 1117 (1958).

15 Howell, F. C., and the editors of *Life*, in *Early Man* (New York: Time, Inc., 1965).

16 Fergusson, G. J., and W. F. Libby, *Radiocarbon*, **6**, 318 (1964).

17 Berger, R., and W. F. Libby, *Radiocarbon*, **8**, 467 (1966).

18 Movius, H. L., Jr., *Am. Anthropologist* (Special Publication: Recent Studies in Paleoanthropology), **68** (2), pt. 2, 296 (1966).

19 Vogel, J. C., and H. T. Waterbolk, *Radiocarbon*, **5**, 163 (1963).