Transitional Pre-Desert Phase in San Diego County, California
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Reports

Transitional Pre-Desert Phase in San Diego County, California

Abstract. *Excavations at site U.C.L.J.-M-15 at Agua Hedionda Lagoon in southern California have provided a radiocarbon date of 7070 B.C. for a transitional phase between the San Dieguito and the La Jolla complex. The many radiocarbon dates taken from sites in San Diego County demonstrate a somewhat greater age than was hitherto generally expected for the three cultures in the area. The age of the most recent culture, the Yuman-Diegueno, has been extended to about 1000 B.C. The La Jolla shows an extremely long period of occupation spanning roughly 1000 B.C. to 7070 B.C. The third group, the San Dieguito, a pre-Desert culture, is still undated. Samples are now in process and should, judged from the new La Jolla dates, give a date earlier than 7000 B.C. for the earliest phases of the San Dieguito.*

It is possible that both a hunting and a gathering tradition were carried separately into the New World (*1*). However, in 1959, Meighan's summary of the earliest California cultures that were thoroughly known demonstrated that all of these cultures contained projectile points as well as milling stones (*2*).

In the interval between 1959 and 1963, excavations on early La Jolla complex sites in San Diego County produced data which demonstrated a pre-Desert artifact assemblage in the lowest horizons of the sites. Additionally, other site areas such as Lake Mojave, Lind Coulee, Death Valley 1, and Lake La Conte were presenting us with correlation data for a widespread pre-Desert culture horizon.

In a paper for the 1962 Great Basin Anthropological Conference, Meighan offered a concise definition of the attributes necessary to define a pre-Desert culture: (i) age greater than 8000 years, (ii) absence of milling stones as significant components of the economic tools, and (iii) specialized economy showing dependence on relatively large projectile points for big game (*3*).

Investigations into the early archaeology of the Great Basin are producing evidence of a pre-Desert culture. In addition, new radiocarbon dates demonstrated that these people were hunters and were probably contemporaneous with the earliest peoples living in North America. As a result of these new data, the University of California at San Diego reanalyzed the earlier archaeological work on the early coastal sites of southern California from the standpoint of radiocarbon dates, reviewed the geologic and geographic detail of archaeological sites, and examined the artifact typology of the three known cultures in the area.

The oldest dated complex in southern California is the San Dieguito, a pre-Desert culture, characterized by an artifact assemblage which contains no grinding tools or other objects which could be used for the preparation of cereal grains and other wild plant foods (*4*). The San Dieguito is clearly older than the La Jolla, as evidenced by the known stratigraphy and radiocarbon dates. There has also been a general consensus in regard to estimates of the age of the San Dieguito complex. Warren and True estimated the age as between 8000 and 11,000 years old (*5*), while Meighan gave an estimate of 7500 to 9500 years old (*2*).

As a consequence of its artifact typology and its implied age, it is generally assumed that the San Dieguito falls within the hunting culture horizon (that is, pre-Desert) of the Southwest (*6*). The San Dieguito lithic technique is primarily percussive, and many of the smaller tools demonstrate a fairly refined percussive technique; these characteristics indicate a long period of development. Some small amount of pressure flaking occurred and can be discerned in the construction of the small "effigy" or "crescent" stones. Also, a rather delicately made projectile point has recently been recovered on the Harris site (the San Dieguito type site) at a low level in the San Dieguito stratum. The point has a straight base and is in the shape of an elongated isosceles triangle. It shows pressure work as well as indications that it was hafted by the use of natural asphaltum, some of which is still present on the base. The highest percentage of implement types in the artifact assemblage are scrapers in a variety of sizes and shapes. Also among the more numerous artifacts are what have been described as knives. These also vary in size, and many of them, as has been pointed out by some investigators, fall within the lanceolate shape and sizes of those of both the Folsom and Clovis cultures (*5*). It is therefore likely that the thin bi-faces were used as lance or dart points, while the thick or humped types were probably used as knives (Fig. 1). No evidence of human remains has been found in association with San Dieguito material. Consequently, we have no idea of the type of burial practices performed by the San Dieguito, nor do we know anything about their physical appearance.

Although a large number of artifacts have been recovered from the three best-known sites, no appreciable amount of food-bone material and only a very small amount of shell have appeared. The artifact assemblage is indicative of a hunting people dependent in part on a diet of game animals (Fig. 1). This lack of food-bone material seems paradoxical in the light of the types of artifacts present. There are, however, a number of possible explanations for this, the most probable of which is that the conditions for preservation of such materials as bone and wood in coastal sites, like San Diego County, are poor. Only under very special circumstances are organic materials of any kind preserved in the oldest sites (*7*). On the basis of the new radiocarbon data taken at the Agua Hedionda Lagoon site (U.C.L.J.-M-15), the appearance of a transitional phase of the San Dieguito complex on or near the southern California coast occurred a short time before 7000 B.C.

In January of 1963, samples of shell were removed from the two lowest stratigraphic levels in site U.C.L.J.-M-15 for radiocarbon dating. This site is located on the north side of Agua

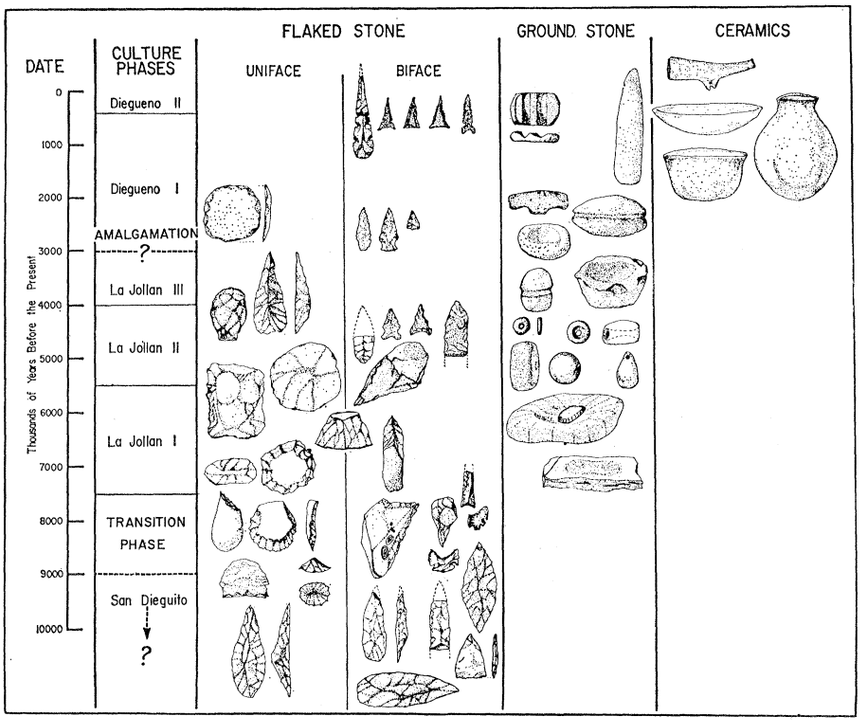

Fig. 1. Schematic representation of artifact sequences tentatively divided into culture phases.

Hedionda Lagoon just south of the city of Carlsbad, California. A random sample of surface artifacts was collected, and comparisons were made with the study collections in the laboratory at the University of California at San Diego. Examination indicated that the surface collection represented phase II, or the intermediate phase, of the La Jolla complex. I have tentatively divided the three known cultures thus far discovered in the San Diego area into phases based on distinct typological changes which are in turn related to a chronology developed from a sequence of radiocarbon dates. All were samples taken from sites in San Diego County (Fig. 1) (*8, 9*).

Unlike many of the previously excavated La Jolla sites, the coastal site U.C.L.J.-M-15 was nearly untouched by major erosional agents. Reexamination of those sites whose age has been estimated by the radiocarbon method at 7000 years old and older showed them all to be located in coastal areas subject to the erosional agents of wave action, wind, gravity, and cutting by lagoonal tributaries. Three of these sites are on the edge of sea cliffs and the last is on a low-level terrace badly cut by a lagoonal tributary. All dated (at their bases) between 5280 and 5580 B.C. (*8, 9*). A test pit further demonstrated this new site to be of unusual depth, measuring nearly 2 meters. The average La Jolla site varies between 1 and 1.5 meters.

An assemblage of La Jolla phase II artifacts was found on the surface of the site. This middle or intermediate phase of the complex has a time span of about 1500 years, falling approximately between 2050 and 3550 B.C. The combination of the unusual depth of the midden and the discovery of intermediate-phase artifacts at the surface supports the possibility that this is the oldest La Jolla site thus far discovered. That there was no major evidence of surface erosion further supported this contention.

A topographic survey was conducted and one quadrant of the site was covered with a grid pattern of 2-meter squares, and excavation of alternating blocks began. Block A-12 was preserved intact for the selection of radiocarbon samples. A-12 was positioned over the point of greatest midden depth, roughly in the center of the occupied area. The artifact assemblage recov-

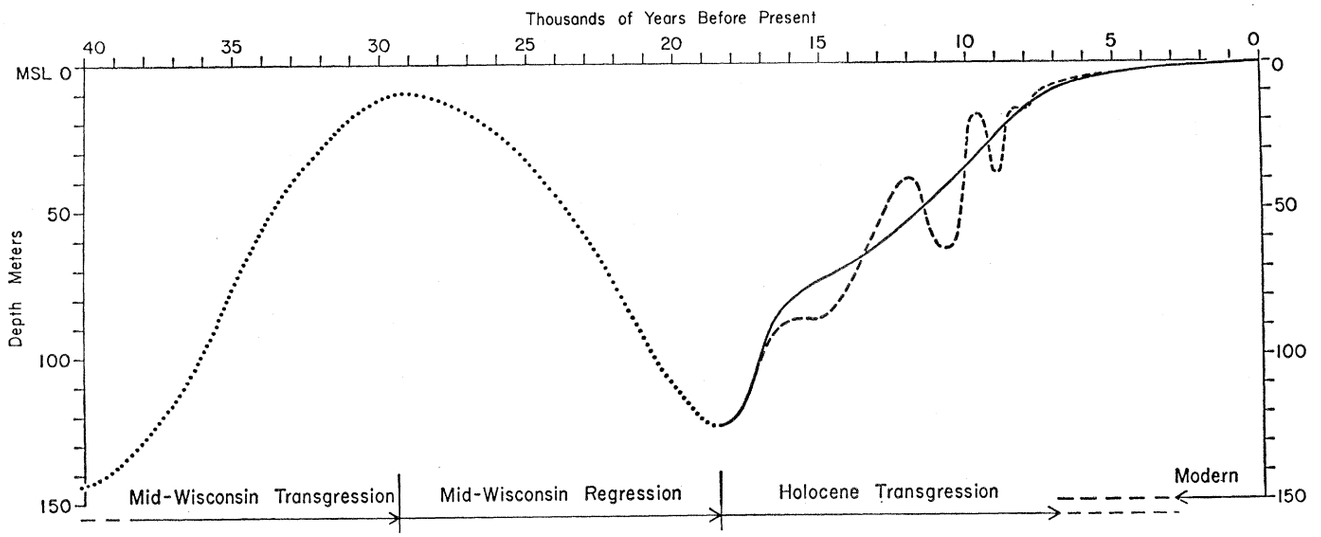

Fig. 2. Late-Quaternary fluctuations of sea level, from compilation of published and unpublished radiocarbon dates and other geologic evidence. Dotted curve estimated from minimal data. Solid curve shows approximate mean of dates compiled. Dashed curve slightly modified from Curray (1960, 1961). Probable fluctuations since 5000 years before the present are not shown here. After Curray, 1965.

ered confirmed the original estimate of age.

The first variation in typology appeared at 13 to 14 decimeters. At this level milling stones no longer appeared, and there was a total absence of milling or grinding tools below 13 dm (*10*).

The artifact assemblage from 13 to 17 dm showed a distinct change in part of its mineralogical content, as well as in typology. Fairly large amounts of small felsite flakes began to appear, and the base of a large projectile point or bi-face was recovered. The technique and pattern appeared similar to those of San Dieguito material, a resemblance confirmed by laboratory comparison with San Dieguito material recovered from the type site. Intermingled with these artifacts were choppers, scrapers, and hammerstones typical of La Jolla phase I (Fig. 1). No variation in the profile occurred and there appeared to be an unbroken continuity of occupation from this lowest level up through the overlying midden to the surface.

The sample taken from the lowest level with milling stones (13 to 14 dm) gave a date of 5470 B.C. The second sample, from the lowest depth of the midden (16 to 17 dm) gave a date of 7070 B.C. According to Hubbs, the 7070 B.C. date provides a "breakthrough" date for the beginning of shellfish-gathering along the mainland coast of California (*9*). Although earlier dates have been obtained from middens on Santa Rosa Island, California, the earliest previous pertinent date on the San Diego coast was 5580 B.C. There was a paucity of charcoal throughout the midden and, in addition, a lack of cold-water molluscs. This evidence suggests temperatures for the period 7500 to 9000 years ago about as warm as at present, possibly a little warmer.

The antiquity of the basal date at U.C.L.J.-M-15, plus the occurrence of green felsitic implements of the San Dieguito type, indicates that U.C.L.J.-M-15 at the base is a transition phase between the San Dieguito and the La Jolla. This transitional phase of the La Jolla and the San Dieguito may be related to the "Pauma Complex" (*11*) which was discovered further inland and contains the suggestion of a similar mixing of San Dieguito and La Jolla within its artifact assemblage at its lowest levels. The lack of milling stones in the lowest levels is consistent and lends additional support to this hypothesis.

The presence of Agua Hedionda Creek within 3 km of the ocean precludes any need to postulate any major change in precipitation. This helps explain the long and continuous occupation of the lagoon and creek. The lack of indications of submergence of the midden area offers a strong argument against any postglacial sea stand of more than 2 meters above the present level.

A third date was obtained by testing another species of shell sample from the 13- to 14-dm level. This was done primarily as a check against the first samples. The check sample was dated by the radiocarbon method as 5500 B.C. It thus correlates closely with the first sample.

Perhaps the most difficult problem is that these hunting groups were most likely rather small in number, as indicated by the lack of material recovered. Climatic changes in the last ten millennia are another factor, and the destruction of even fairly well-established sites would have been great over such a long period. In the San Dieguito River area are two San Dieguito sites almost completely reduced by erosion. Intermingled with the San Dieguito artifacts on these sites are La Jolla and Diegueno artifacts. As these sites were exposed on elevations and undoubtedly reoccupied by the later La Jolla and Diegueno, the consequent intermingling of all three typologies has led to some erroneous conclusions. It now seems probable that the Pacific Coast area in northern San Diego County, California was occupied by a people with a transitional pre-Desert culture between 7000 and 9000 years ago. On the basis of this probability, it may be concluded that the pre-Desert culture preceded the development of the Milling Stone Complex in southern California and that it had the general distribution postulated by Meighan and others. The evidence indicates that a pre-Desert hunting tradition (the San Dieguito) arrived in San Diego and Imperial counties around 10,000 to 11,000 years ago. By 7070 B.C. part of its more adventurous elements had settled on or very near the area of the present coastline.

Sea level at this period was 18 to 38 m (10 to 22 fathoms) lower than it is at present (Fig. 2) (*12*). The 10-fathom line, which would represent the shoreline 9000 years ago, is presently about 0.8 km from shore. Tectonic instability played no role in sea level change in this area, therefore it can be discounted (*13*).

Additionally, new dates calculated by the radiocarbon method support the dates taken on the Channel Islands, over which there has been considerable controversy. These new dates inferred an occupation of those islands well beyond the dates previously taken from early California coastal sites. The hiatus which occurs between many of the radiocarbon dates on the Channel Islands and the oldest dates taken from coastal sites can be partially explained by the circumstances brought about by sea level transgression in the last 9,000 or 10,000 years. No evidence of true pre-Desert culture has been reported on the southern California coast. It seems very probable that the first arrivals ranged and camped along a shoreline that is now 18 to 38 m below sea level. The Channel Islands dates would therefore be remnant preservations of this earliest occupation. Climatic changes were occurring quite rapidly in the period between 8,000 and 10,000 years ago (*13*). Sea encroachment was also more rapid during this period. The destruction of primary occupation areas on the coast (although this was too slow to be apparent to anyone within a single generation) forced the occupants inland to the areas near shore by 7070 B.C. and onto the sites which have been dated between 5050 and 7070 B.C.

Radiocarbon evidence from the Agua Hedionda site tends to indicate that the first occupants had already entered a transitional phase between a hunting and a milling culture. The necessity for the creation of large projectile points (that is, continuance of the hunter tradition) on the coast is abrogated to a large extent by the abundance of faunal material in the marine shoreline ecologies which produced more than sufficient protein. On the other hand, the more inland areas may well have retained a pre-Desert culture longer because the climatic and physiographic changes inland were slower and less dynamic than those on the coast. Environmental variation, therefore, may well have been the major factor which led to the transition of the hunting culture into the Milling Complex.

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21 December 1966

Venus: Atmospheric Evolution

Abstract. *Because of the high temperatures prevailing in the lower atmosphere of Venus, its chemistry is dominated by the tendency toward thermodynamic equilibrium. From the atomic composition deduced spectroscopically, the thermodynamic equilibrium composition of the atmosphere of Venus is computed, and the following conclusions drawn. (i) There can be no free carbon, hydrocarbons, formaldehyde, or any other organic molecule present in more than trace amounts. (ii) The original atomic composition of the atmosphere must have included much larger quantities of hydrogen and a carbon/oxygen ratio* ≤ 0.5. *(This ratio is now almost precisely 0.5.) (iii) The present atomic proportions of the atmosphere of Venus are so unique that an evolutionary mechanism involving two independent processes seems necessary, as follows. Water, originally present in large quantities, has been photodissociated in the upper atmosphere, and the resulting atomic hydrogen has been lost in space. The resulting excess oxygen has been very effectively bound to the surface materials. (iv) There must be some weathering process, for example, violent wind erosion, to disturb and expose a sufficient quantity of reduced surface material to react with the oxygen produced by photodissociation.*

The bulk of contemporary evidence indicates that the surface of Venus, and the greater part of its atmosphere, are at high temperatures (*1–4*). Chemical reactions must occur with such rapidity that thermodynamic equilibrium should be approximated closely. Beneath the clouds of Venus, endothermic reactions, energized, for example, by solar radiation or electrical discharge, should be rare; in any case the products of such reactions will be rapidly degraded. We have described elsewhere (*5*) a computer program appropriate to these circumstances. It assumes an ideal gas of known temperature, pressure, and atomic composition, and computes, by minimizing the free energy of the system, the molecular distribution which obtains at thermodynamic equilibrium. There are only a small number of well-known compounds which comprise the bulk of such equilibrium mixtures. Any other compound of interest may be included in such computations, but no significant error results from its omission. Our calculation method does not depend explicitly on the equilibrium constants of specific reactions. Only the free energy of each compound at the temperature considered need be known, provided there exists at least one reversible reaction pathway between each of the compounds and the major constituents. If no such pathway exists (as may happen in special cases), the compound is prohibited from entering the calculation by omitting it from the input data.

Our initial intent in applying this program to the atmosphere of Venus was to test whether the atmosphere is close to thermodynamic equilibrium, to determine whether certain materials hypothesized for Venus are thermodynamically plausible, and to predict the presence in significant quantities of molecules not yet detected spectroscopically. In the course of the calculations, however, some unexpected results emerged which are relevant to the evolution of the atmosphere of Venus.

All possible atomic proportions of the elements C, H, and O can be exhibited in an equilateral ternary diagram (Fig. 1). Any nitrogen abundance can be represented as a projection on this diagram, since under Cytherean conditions it remains almost entirely N_2 and does not significantly influence the proportions of C, H, and O. The surface pressure used in these calculations is 50 atm; the temperature, 700°K (*2, 3, 6*). The atomic composition is derived from molecular spectroscopy.

Volume mixing ratios adopted include $[CO_2]$, a few percent (*7*); $[H_2O]$, between 10^{-4} and 10^{-6}, the larger value probably prevailing in the lower atmosphere (*8*); and $[N_2] \cong 0.95$. A measurement of $[CO] \sim 10^{-6}$ (*9*) has been reported, and upper limits on O_2, NO_2, N_2O, NH_3, CH_4, C_2H_4, C_2H_6, and HCHO have been established (*10*). The calculations show that equilibrium is rather insensitive to changes in these abundances, and variations by an order of magnitude would have little influence on the conclusions.

Given the temperature and pressure, an estimate of the abundance of a compound defines a closed curve or one intersecting the axes on the ternary diagram; an upper limit on abundance necessarily excludes an area of the diagram. On Venus (Fig. 1) the amount of water limits the overall composition to a narrow band along the C—O border. Upper limits on $[NH_3]$ and $[CH_4]$ exclude the greater part of the reducing regions, and the upper limit on $[O_2]$ eliminates almost all of the oxidizing regions. If the value for $[CO] \sim 10^{-6}$ is accepted as characteristic for the atmosphere as a whole, the equilibrium atmospheric composition lies at a point on the ternary diagram which can be distinguished from the CO_2 point only when the diagram is magnified ten thousandfold.

It is possible that much of the CO reported spectroscopically arises from CO_2 photodissociation in the upper atmosphere of Venus (*9, 11*). If any major fraction of the reported CO is a constituent of the lower equilibrium atmosphere, there can be no free oxygen on Venus ($[O_2] < 10^{-25}$). If all the reported CO is produced by photodissociation, or if this difficult observation has given a spuriously high CO abundance, there may be a trace of free oxygen on Venus ($[O_2] \leq 8 \times 10^{-5}$).