Was There a Quaternary Land Bridge to the Northern Channel Islands?

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INTRODUCTION

It has long been assumed that a Pleistocene land bridge once connected the Northern Channel Islands to the mainland (Fig. 1). However, this assumption has been questioned in recent years (see Johnson 1972, 1973, 1978, and Wenner and Johnson 1980). Of the two principal lines of evidence cited in support of a land bridge, one is paleontologic and the other is geologic. The paleontologic evidence consists of island elephant remains coupled with the belief that elephants do not swim or could not swim to the islands. However, we now know that elephants swim well, and the short distances required for them to cross a narrowed Santa Barbara Channel during low sea-level periods were within their swimming capacities (Johnson 1972, 1978, and in prep.). But the fact that elephants could swim to the islands does not prove that they did, so the general geologic and glacio-eustatic evidence for a bridge was reviewed; this evidence, however, was found wanting (see geologic discussions in Wenner and Johnson 1980, and Johnson 1978). We, therefore, thought that geologic evidence for or against a bridge ought to be obtained from seismic reflection profiles in the eastern Santa Barbara Channel, the area where the bridge was presumed to have existed. Upon careful examination and re-examination of the sub-bottom stratigraphy and structure as revealed through the seismic profiles, our belief is that there was no Quaternary land bridge. The remainder of this paper shows why we reached this conclusion.

LOCATION OF PROPOSED BRIDGE

Emery (1960) and Howell (1976) provide two rather graphic bathymetry maps of the seafloor of the well-known California Continental Borderland, which includes all the California Channel Islands as well as various submarine banks and interlying basins out to the continental slope. There was little deformation of this entire area during the Quaternary so that, except for local areas of sedimentation, these maps also represent the general configuration of the seafloor during the Quaternary. A perusal shows the area between West Anacapa Island and the mainland as the only likely area for such a land bridge. It is also the area where all proponents of a land bridge have placed it (Fig. 1).

Figure 2 shows the bathymetry of the eastern Santa Barbara Channel. It is now the area of shallowest water (236 m) between the Northern Channel Islands platform and the mainland. One can readily visualize a tectonic ridge, now buried in sediments, connecting the islands with the mainland to the east.

SEISMIC PROFILES

Late Pliocene and Early Pleistocene

The black lines on Figure 2 are the locations of seismic profiles. Figure 3a is the most westerly profile and shows the existence of a tectonic structure, the Anacapa Ridge (unidentified sediments in Figure 3a are due to blockage by seismic signals). This ridge consists of

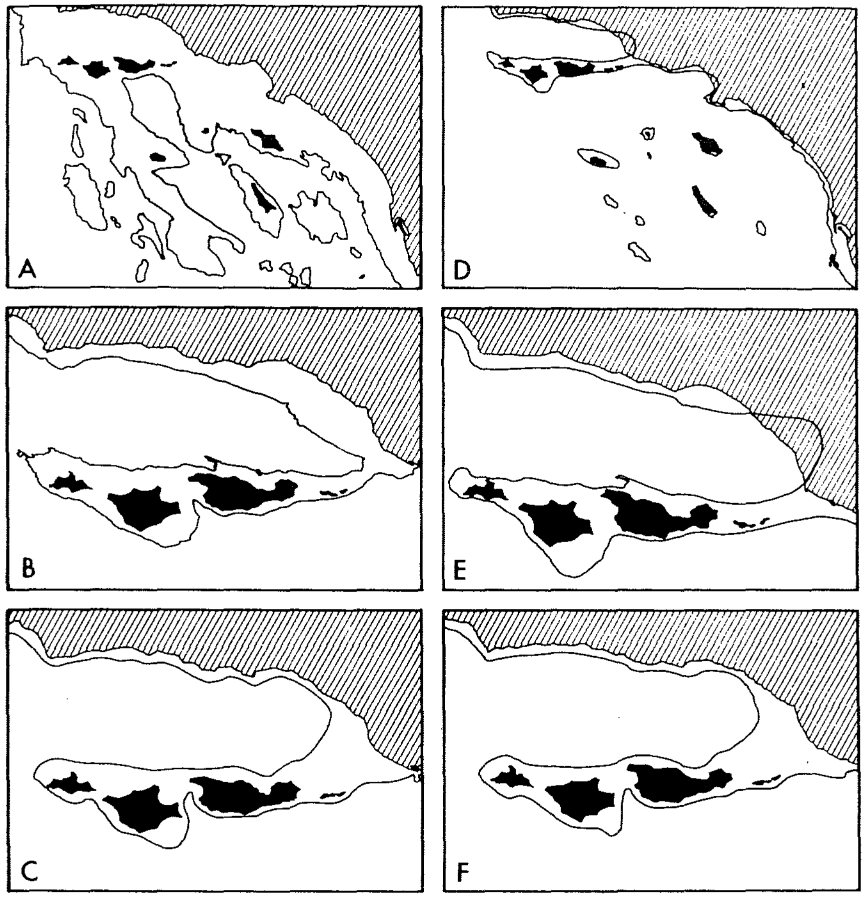


FIGURE 1. *Reconstruction of Channel Island land bridges by various authors. A–early Pleistocene (Clements 1955), B–early Pleistocene (Van Gelder 1965), C–Pleistocene (Chaney and Mason 1930), D–middle Pleistocene (Valentine and Lipps 1967), E–possibly middle to late Pleistocene (Remington 1971), F–late Pleistocene (Stock 1943).*

middle Miocene volcanics and Monterey Formation strata and was uplifted during late Miocene to early Pliocene time. On the north side of the ridge, upper Pliocene and Quaternary strata (the Pico, Santa Barbara, and San Pedro Formations) buttress against the flank of the ridge. Except for a slight north dip of the deepest horizons, the strata are horizontal, testifying to minimal tectonic deformation of the area in Pleistocene time. The contact between the horizontal strata of the Santa Barbara Formation and the crossbedded strata of the San Pedro Formation is a very prominent feature which can be recognized at depths close to 400 m on all profiles in the area. The age of the Santa Barbara Formation ranges from very late Pliocene to early Pleistocene. The contact with the San Pedro is of early Pleistocene age. Figure 3b again shows the Anacapa Ridge, but structurally lower than in Figure 3a, with sediments extending nearly to the crest. The contact between the Santa Barbara and San Pedro Formations is again apparent at an

FIGURE 2. *Bathymetric map of the eastern Santa Barbara Channel, California, showing seismic reflection profiles OC-1, P-14, and P-16 (see Figure 3; more profiles are shown in Figure 5). Contour interval is 300 ft (92 m; after Emery 1960).*

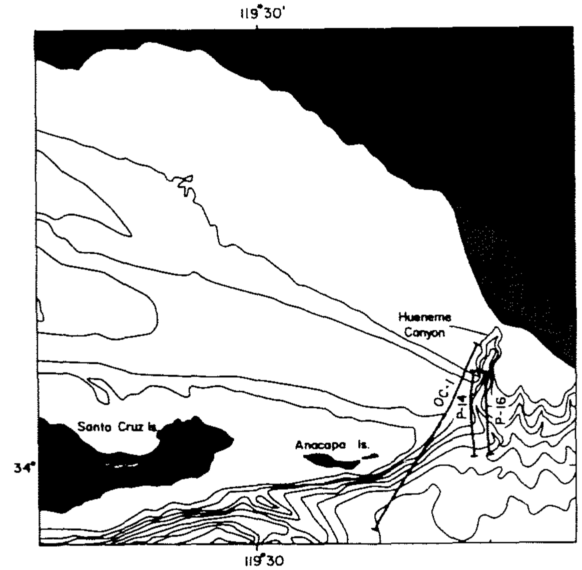
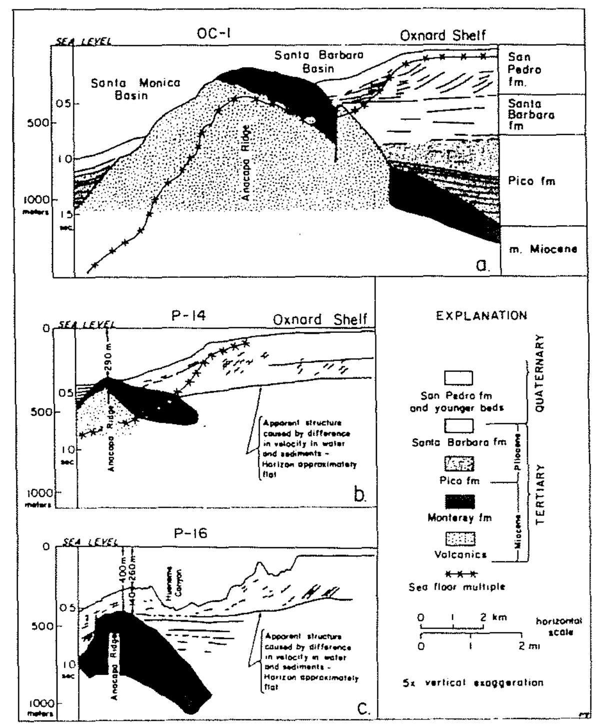


FIGURE 3. *Three seismic reflection profiles (a, b, and c) across the eastern end of the Santa Barbara Channel, California.*



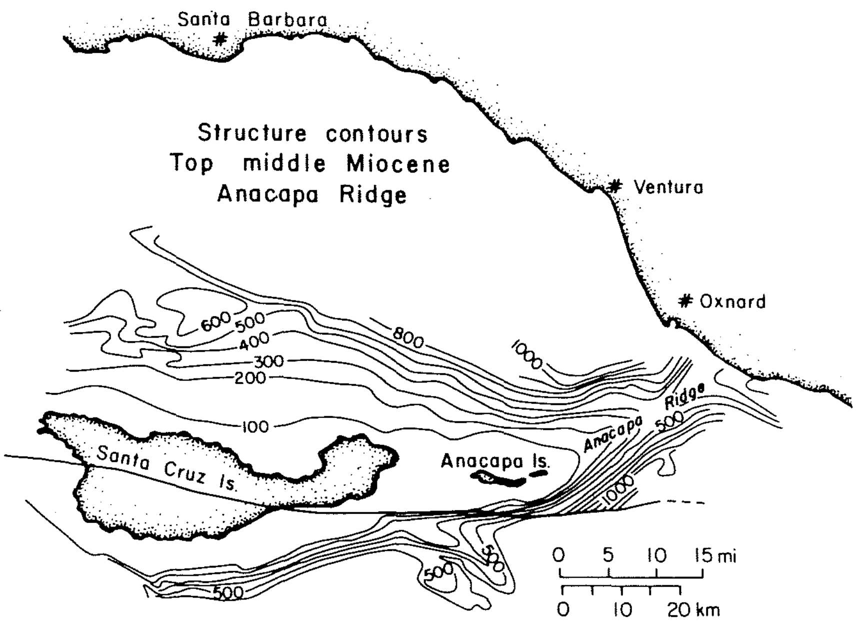


FIGURE 4. *Map of the contoured Miocene surface, eastern Santa Barbara Channel, California.*

approximate depth of 400 m. Figure 3c shows the most easterly seismic profile, with the crest of the ridge at a depth of 400 m, only slightly higher than the Santa Barbara-San Pedro contact and buried in sediments derived from the Oxnard shelf.

From the above profiles and other data, a map of the top of the Miocene was contoured (Fig. 4) which shows a saddle on the ridge at a depth of slightly greater than 400 m. It shows that there is a ridge connecting the Northern Channel Islands platform to the mainland, but the essential question is: did it ever act as a land bridge?

Figure 5 is a composite profile northeast of Santa Cruz Island. The northern part shows the Santa Barbara-San Pedro contact at approximately 400 m depth. The southern part shows three terraces, an upper one at 100 m depth, presumably of Wisconsin age, an intermediate terrace poorly developed here but better on other profiles in the area, and a lower one at a depth of 200 m. Note that the Santa Barbara-San Pedro contact buttresses into the slope of the lower terrace. The terrace material is, therefore, roughly the time equivalent of the upper part of the Santa Barbara Formation, that is, of very early Pleistocene age. The top of the terrace is at a depth of 200 m, indicating that sea level has risen 200 m since formation of the terrace. The saddle on the ridge to the mainland, now at a depth of 400 m, was thus at a depth of 200 m in early Pleistocene time. Not only was this far too deep for elephants to walk across, they probably had not yet arrived in North America in their journey from Siberia (and even if they had, *Mammuthus columbi*, the species which colonized the islands, did not evolve until much later; see Wenner and Johnson 1980).

Since inception of sedimentation of the San Pedro Formation, the central part of the ridge became blanketed by sediments and therefore could not have acted as a land bridge. Any

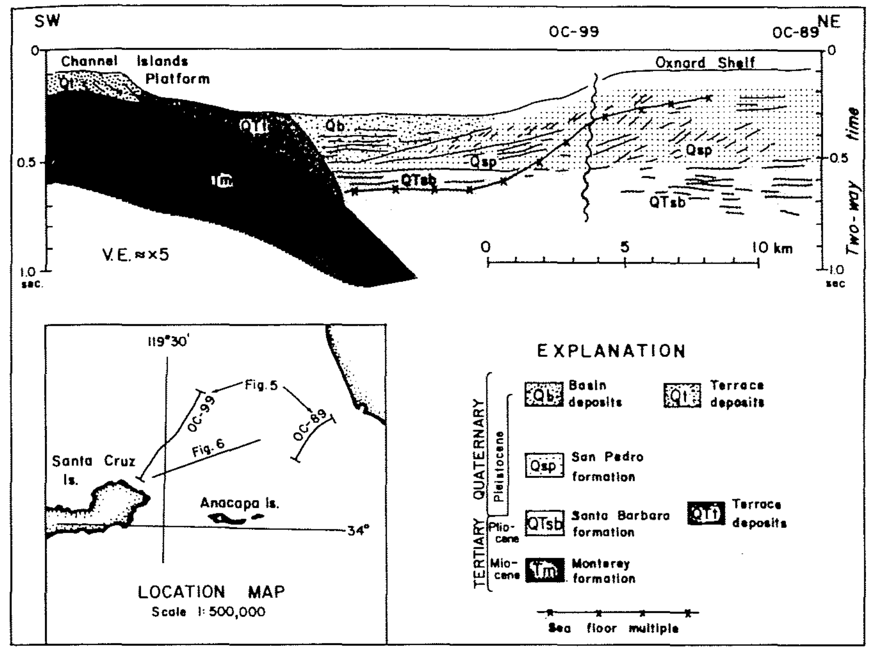


FIGURE 5. *Composite of two seismic reflection profiles taken northeast of Santa Cruz Island, California.*

subsequent mainland connection would have to have been across the sedimentary blanket of the Oxnard shelf and the present narrow channel where the seafloor appears nearly level with the top of the lower terrace. That such a land connection did not exist is demonstrated by Figure 6, which shows the lower terrace in more detail, though in a different location than Figure 5. Note that the top is an erosional surface, part of which cuts Monterey Shale. Visible on the extreme left of Figure 6 is the toe of the next higher (presumably intermediate) terrace. A thin layer of bottomset beds of this terrace extends across the wave-cut lower terrace, over its fore-edge, and down into the adjoining channel. From these relationships we can determine that the seafloor in the channel at the time the foreset beds were laid down was 137 m below the top of these beds and 120 m below the erosional surface on the terrace, and probably deeper when the terrace was cut. Again, elephants could not have walked to the island at that time.

Middle and Late Pleistocene

The preceding discussion has focused on water depths in the Santa Barbara Channel during early Pleistocene time. Since this is earlier than the time of arrival of mammoths in California, and considerably before the insular population *M. columbi* evolved as a species, channel conditions in the middle and late Pleistocene are equally, if not more, relevant to our investigation. In this regard, the two upper (intermediate and highest) terraces provided a measure of water depth over the channel during time of low sea-level stands subsequent to the formation of the deepest terrace. It is assumed that in a sequence of submarine terraces, the age of individual terraces becomes younger upward, since a terrace would be destroyed by wave action during

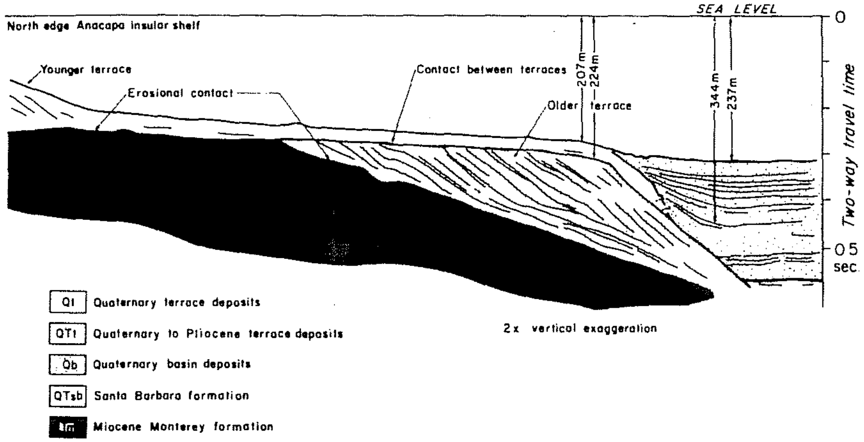


FIGURE 6. *Detail of lower terrace shown in Figure 5.*

subsequent lowering of sea level. Thus, sea level was never lower than the lowest terrace subsequent to erosion of its top. The level of the seafloor during formation of the higher terraces is unknown, but from Figure 5 it can be concluded that at no time during the Quaternary was the water depth in the channel less than 100 m. The best estimates of the lowest sea-level stand during Wisconsin stage is 130 m, giving a channel depth of 100 m if the seafloor was no lower than at present.

CONCLUSIONS

In light of the above information gleaned from sub-bottom seismic reflection profiles across the narrow eastern end of the Santa Barbara Channel, we conclude that at no time during the Quaternary was the water depth between the islands and the mainland less than 100 m, and that, therefore, no land bridge existed.

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The geological interpretation is based on seismic profiles obtained by the U. S. Geological Survey during various cruises on the research vessels *Valero IV, Oil City,* and *Polaris* in the period 1966 to 1970.

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