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The Gastropod *Terebra santana* Loel & Corey, 1932, from the Lower Miocene Vaqueros Formation, Southern California, Belongs in the Cerithiid Genus *Clavocerithium* s.s.

by

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Abstract. Re-examination of the primary type material and numerous other specimens of the gastropod *Terebra santana* Loel & Corey, 1932, which is locally very abundant in the lower Miocene Vaqueros Formation of California, reveals that the species is a cerithiid belonging to the genus *Clavocerithium sensu stricto*. This is the first report of *Clavocerithium* s.s. in the New World and its first record in rocks younger than Eocene. *Clavocerthium* (*Clavocerithium*) *santanum* is reported for the first time from the Vaqueros Formation in the upper Sespe Creek area, Ventura County, southern California.

INTRODUCTION

LOEL & COREY (1932), in their monographic study of the lower Miocene Vaqueros Formation in California, named and briefly described the gastropod *Terebra* (Subgenus = ?) *santana* LOEL & COREY (1932:236–237, pl. 47, figs. 8a, 8b, 9, 10, 11). They reported that this Vaqueros Formation species is very abundant wherever present. SCHOELLHAMER *et al.* (1981), BLUNDELL (1983) and DANIEL (1989) also reported very abundant specimens of this gastropod from various outcrops in the southern California area. These reports of such great abundance of a *Terebra* suggested that it had been misidentified as to genus, because modern *Terebra* is a predatory gastropod and makes up a small part of the populations of modern molluscan communities; one would expect it to be similarly uncommon in the fossil record. John G. Vedder and Wendell P. Woodring *in* SCHOELLHAMER *et al.* (1981) put the genus name in quotation marks when referring to "*Terebra*" *santana* because they had reservations about using this genus name.

The purpose of this report is to show that Loel & Corey's *Terebra santana* is a cerithiid and not a terebrid. Examination of the holotype and three paratypes of *T. santana*, as well as numerous other specimens from southern California, revealed that this species belongs to the cerithiid genus *Clavocerithium* Cossmann, 1920.

The locally great abundance of Loel & Corey's species fits in well with what is known about cerithiids. Modern species are very abundant in places like tidal flats. For example, I have observed scattered, densely packed patches of *Certhium stercusmuscarum* Valenciennes, 1832, on the tidal sandflat at San Felipe, Baja California, Mexico. BRUSCA (1980) and SCHMIDT (1987) reported that this species is extremely common on tidal flats in the northern Gulf of California, and specimens aggregate in gigantic clumps wherever a semihard sandy substrate is available. The specimens of *Clavocerithium* (*C.*) *santanum* (Loel & Corey) in the Vaqueros Formation are always in the nearshore-marine lower part of the formation, where there is gradation with the coastal-plain deposits of the underlying Sespe Formation. The specimens of *C.* (*C.*) *santanum* in the lower Vaqueros Formation are probably associated with tidal flats and nearshore storm-related lag deposits that developed in this zone of gradational nonmarine and marine environments. One of the paratypes of this species was reported by LOEL & COREY (1932:79) as possibly coming from an estuarine deposit.

Abbreviations used for catalog and/or localities are: CSUN, California State University, Northridge; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section, UCMP, University of California Museum of Paleontology (Berkeley). Localities cited in this report are described under "Localities Cited."

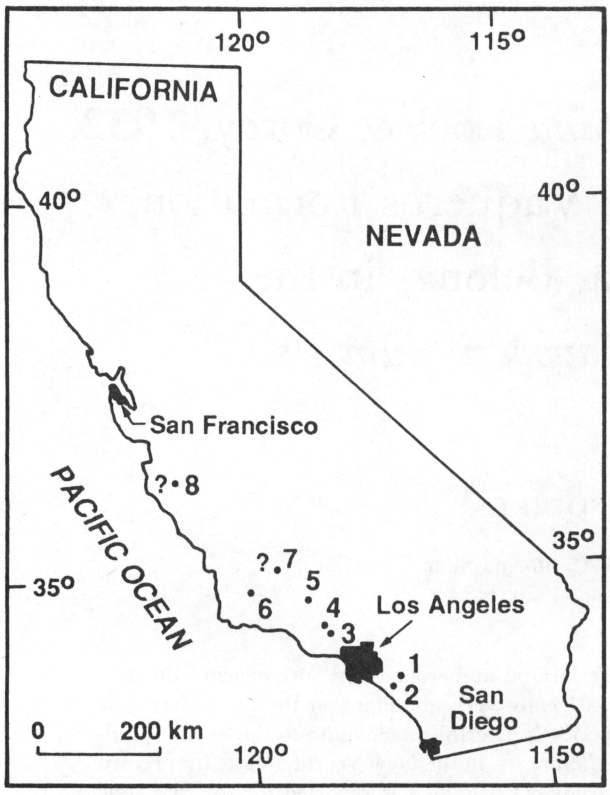


Figure 1

Geographic distribution of *Clavocerithium* (*C.*) *santanum* (Loel & Corey, 1932). Localities are numbered from south to north. (1) Santa Ana Mountains, Orange County; (2) San Joaquin Hills, Orange County; (3) Big Mountain, north side of Simi Valley, Ventura County; (4) Oak Ridge area, Ventura County; (5) Upper Sespe Creek, Ventura County; (6) Near Buellton, Santa Barbara County; (7) Eagle Rest Peak area, Kern County; (8) Junipero Serra Peak region, Monterey County. Question mark ("?") denotes tentative identification by LOEL & COREY (1932). The upper Sespe Creek area (No. 5) is a new report for this species.

COMMENTS ON GEOGRAPHIC DISTRIBUTION

LOEL & COREY (1932) reported that this species, *Clavocerithium* (*C.*) *santanum,* ranged from Orange County to Santa Barbara County, southern California. They also reported that the species may be present in central California, as far north as Monterey County (Figure 1). The type locality (locality UCMP 6128) is in Arroyo Trabuco in the southern part of Plano Trabuco, southern Santa Ana Mountains, Orange County. The exact location of this UCMP 6128 is not known, but I visited the general area and found specimens of *C.* (*C.*) *santanum* in greenish-gray to reddish-gray exposures of very fine-grained sandstone that apparently are in the zone of intergradation between the lower part of the Vaqueros Formation and the upper part of the Sespe Formation.

Other workers (SCHOELLHAMER *et al.*, 1981; DANIEL, 1989) have confirmed the presence of *Clavocerithium* (*C.*) *santanum* in the Santa Ana Mountains. DANIEL (1989) found several beds in Hicks Canyon in the Santa Ana Mountains, where specimens constitute as much as 50% of the rock. I visited this area and also found scattered, densely packed concentrations at locality CSUN 1185 (Figure 2).

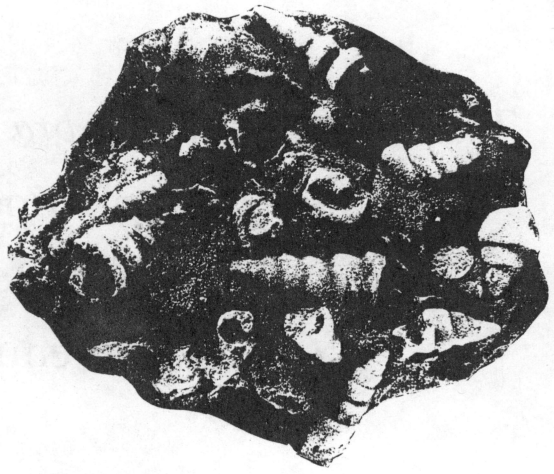


Figure 2

A hand specimen (hypotype LACMIP 12102) showing the dense packing of *Clavocerithium* (*C.*) *santanum* (Loel & Corey, 1932) at locality CSUN 1185, Hicks Canyon, northern Santa Ana Mountains, Orange County, southern California. Magnification is ×1.1.

BLUNDELL (1983) reported this species from several localities in the Big Mountain area, north side of Simi Valley, southern California. His specimens are stored in the CSUN collection. Only at locality CSUN 555 are the specimens sufficiently well preserved to be identified as *Clavocerithium* (*C.*) *santanum.* All of the specimens that Blundell collected from other localities in the area are poorly preserved and could only be identified as certhiaceans. LOEL & COREY (1932) did not report their species from the Big Mountain area.

REID (1978) and SQUIRES & FRITSCHE (1978) reported abundant specimens of the potamidid gastropod *Potamides sespeenis* Loel & Corey, 1932, from numerous CSUN localities in the Vaqueros Formation, upper Sespe Creek area, Ventura County, southern California, but upon reexamination the specimens from CSUN 428 proved to be *Clavocerithium* (*C.*) *santanum.* This is the first documented report of this species from this area. At most of the other localities, specimens are poorly preserved and could only be identified as certhiacean. *Potamides sespeensis,* with its distinctive noded ornamentation and spiral ribbing, was collected from localities CSUN 159 and 401. BADGER (1957) tentatively reported this species from the Sespe Creek area. His collections are now stored at LACMIP; the specimens are poorly preserved but appear to be *C.* (*C.*) *santanum.*

SYSTEMATIC PALEONTOLOGY

Family CERITHIIDAE Fleming, 1822

Subfamily CERITHIINAE Fleming, 1822

Genus *Clavocerithium* s.s. Cossmann, 1920

Type species: By original designation *Cerithium lacazei* "Vasseur" Cossmann, 1897, 1898, upper? Eocene of the Lower Loire River area, Brittany, northwestern France. See HOUBRICK (1978) for a discussion of the authorship of this species.

Clavocerithium (*Clavocerithium*) *santanum* (Loel & Corey, 1932)

(Figures 3–12)

Terebra (Subgenus = ?) *santana* LOEL & COREY, 1932:236–237, pl. 47, figs. 8a, 8b, 9, 10, 11).
Terebra santana Loel & Corey, 1932: KEEN & BENTSON, 1944:200.

Supplementary description: Shell small in size (up to 26.5 mm height), elongate, high-spired, approximately 11 whorls, solid. Suture distinct, slightly channeled. Protoconch low, conical? shape. Upper spire whorls straight sided to slightly convex for the first 3 to 15 mm in height (usually just the first 6 mm), grading into tabulate whorls, lower spire whorls and body whorl prominently tabulate, rarely convex; each whorl taller than the previous whorl. Upper and middle spire whorls with 4 to 5 moderately heavy, equidistant spiral ribs (rarely preseved), anteriormost spiral rib situated in sutural area. Penultimate and body whorls smooth. Aperture oblique, small, approximately 1/6 to 1/4 of shell length. Columella concave with central oblique plait that coincides in position with columellar side of anterior canal; thin to moderately thick columellar callus detached along outer side. Outer lip sinous, and growth lines on body whorl sinuous. Anterior canal short but distinct, slightly reflexed backward.

Type material and type locality: Holotype, UCMP 31608 and paratypes, UCMP 31609 and 31610, all three from locality UCMP 6128, Trabuco Canyon, Santa Ana Mountains, Orange County, southern California; paratype, UCMP 31611, locality UCMP A-253, Wiley Canyon, Oak Ridge area, Ventura County, southern California.

Geologic range: Early Miocene.

Distribution: Vaqueros Formation, southern California, and tentatively central California: Santa Ana Mountains, Orange County (LOEL & COREY, 1932; SCHOELLHAMER *et al.*, 1981; DANIEL, 1989); San Joaquin Hills, Orange County (LOEL & COREY, 1932); Wiley Canyon in Oak Ridge area and near mouth of Grimes Canyon, eastern Ventura County (LOEL & COREY, 1932); Big Mountain, northern Simi Hills (BLUNDELL, 1983); upper Sespe Creek, Ventura County (herein); western Santa Ynez Mountains, Santa Barbara County (LOEL & COREY, 1932); tentatively the Eagle Rest Peak area, San Emigdio region, southern Kern County, south-central California (LOEL & COREY, 1932); and tentatively the Vaqueros Creek area, Junipero Serra Peak region, Monterey County, north-central California (LOEL & COREY, 1932).

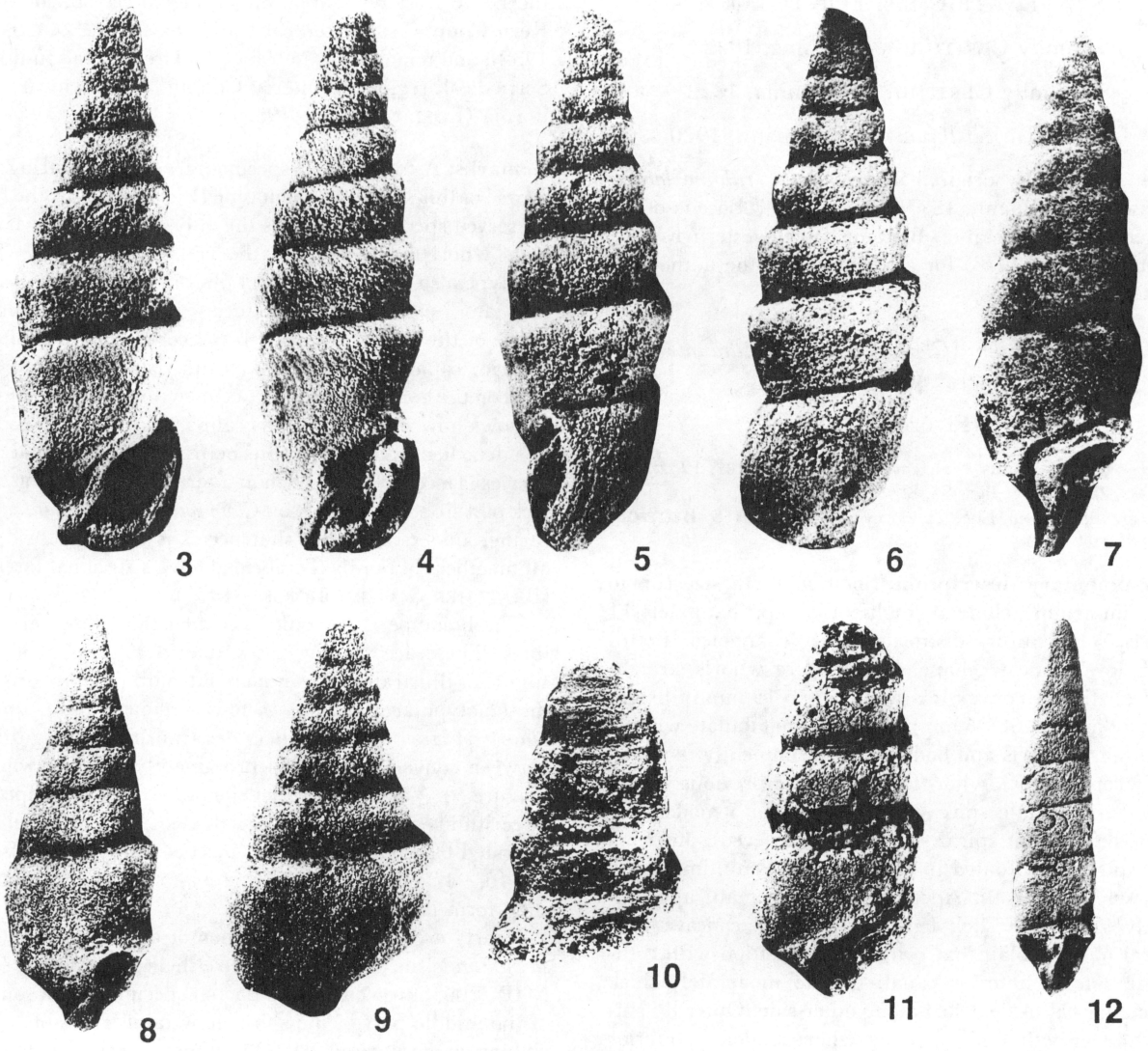
Remarks: A total of 340 specimens were seen during the course of this study. The holotype (Figures 3–6) is the best preserved specimen, but it is the only specimen that has a body whorl narrower than the penultimate whorl. The holotype also shows the central plait in the aperture better than any other specimen. Figure 4 illustrates the coincidence of this central plait with the columellar side of the anterior canal. The columellar callus is fairly well developed on the holotype, but the specimen illustrated in Figure 7 shows how pronounced this callus can be. The presence of a detached columellar callus helps to determine that this species is a certhiid rather than a terebrid. In addition, the lack of a siphonal fasciole on *Clavocerithium* (*C.*) *santanum* further underscores that the species is not a terebrid, as all members of family Terebridae have a siphonal fasciole (BRATCHER & CERNOHORSKY, 1987).

The holotype is the only specimen that shows growth lines. These are readily discernible in Figures 3–5, and Figure 5 illustrates the sinuous outer lip. The whorls on the holotype are tabulate. A few specimens have convex whorls (Figure 7), and others are transitional (Figure 8) between convex whorls and prominently tabulate whorls (Figure 9). Variation in shell form is common in species of cerithiids (HOUBRICK, 1978; KAY, 1979), and well-illustrated examples are shown in HOUBRICK (1978:pls. 2, 13, 16, 94). His plate 94 shows examples of variation of shell form in *Clavocerthium*.

Nearly every observed specimen of *Clavocerithium* (*C.*) *santanum* is smooth over the entire shell. At locality LACMIP 7700, however, several partial specimens that consist of the middle part of the spire show faint traces of spiral ribbing on the spire whorls. One of these specimens (Figure 10) shows four spiral ribs. The spiral rib in the sutural area is, in most cases, the only spiral rib that is preserved (Figure 11). Abrasion of shell sculpture, therefore, is a major factor in the studied specimens. The abrasion may have taken place during post-mortem transport by waves and/or currents.

No specimens of *Clavocerithium* (*C.*) *santanum* were found that show any traces of spiral or axial ribbing on the exteriors of the more anterior spire whorls or on the body whorl. These whorls are judged to have originally been smooth. The presence of growth lines on the penultimate and body whorls of the holotype suggest that this particular specimen underwent minimal post-mortem transport, otherwise the growth lines would have been worn off. The whorls of this specimen show no spiral ribbing or other external ornamentation.

It is also possible that hermit crabs could have lived in the shells. Modern certhiid shells commonly serve as homes for hermit crabs. For example, dead specimens of *Ceri-*



Explanation of Figures 3 to 12

Figures 3–12. *Clavocerithium* (*C.*) *santanum* (Loel & Corey, 1932). Figures 3–6: holotype UCMP 31608, locality UCMP 6128, apertural, oblique apertural, lateral, and abapertural views, ×3.8; Figure 7: hypotype LACMIP 12103, locality LACMIP 7700, oblique apertural view, ×3.1; Figure 8: hypotype LACMIP 12104, locality CSUN 1185, apertural view, × 2.6; Figure 9: hypotype LACMIP 12105, locality CSUN 1185, abapertural view, ×3.3; Figure 10: hypotype LACMIP 12106, locality LACMIP 7700, abapertural view of middle spire, ×3.1; Figure 11: paratype UCMP 31611, locality UCMP A-252, apertural view, ×2.9; Figure 12: hypotype LACMIP 12107 locality, LACMIP 7700, apertural view, ×3.5.

thium stercusmuscarum in the northern Gulf of California are commonly inhabited by hermit crabs (HARTSHORNE *et al.*, 1987; FÜRISCH & FLESSA, 1987). Nearly all the specimens that I observed of this gastropod on the tidal sandflat at San Felipe were occupied by hermit crabs. Some of the abrasion of the shells of *Clavocerithium* (*C.*) *santanum* could have taken place during movements associated with the hermit crabs.

Only about 15% of the studied specimens of *Clavocerithium* (*C.*) *santanum* have retained their apertures, and only a few of these specimens show the fragile outer lip, the very fragile detached columellar callus, and the central plait on the columella. These features, especially the central plait on the columella, could have been worn off if the shells served as homes for hermit crabs.

Most of the specimens of *Clavocerithium* (*C.*) *santanum* that are in the LACMIP collection from locality LACMIP 7700 consist only of the upper spire. Many of these are like other specimens of this species found elsewhere in that the upper spire whorls are straight sided for the first 3 to

6 mm in height and grade into tabulate whorls beyond that height. On a few specimens from locality 7700, however, the upper spire whorls remain straight sided for up to 15 mm in height (Figure 12), and the rest of the shell (presumably with tabulate whorls) is missing. Specimens with such long and slender upper spire whorls were detected only at this locality.

Previously, *Clavocerithium* (*Clavocerithium*) comprised only *C.* (*C.*) *lacazei* (COSSMANN, 1897:pl. 11, figs. 15, 17; 1898:15; 1920:94–95, pl. 3, figs. 24–25; WENZ 1940:762, fig. 2208; HOUBRICK, 1978:121, pl. 93, figs. 1, 2) from the upper? Eocene at Bois Gouët, Brittany, northwestern France. The exact age of these fossil beds has been much disputed, and assigned by various authors to either the middle Eocene or late Eocene (DAVIES, 1975:186).

On the basis of comparisons with several LACMIP specimens of *Clavocerithium* (*C.*) *lacazei* from Bois Gouët, as well as with the published illustrations of this species, *C.* (*C.*) *santanum* differs in having (1) a smaller shell, (2) whorls more tabulate (although a few specimens have convex whorls similar to those in *C.* (*C.*) *lacazei,* (3) four rather than 12 spiral ribs on middle of spire, (4) a detached columellar callus, (5) no axial ridges on upper whorls, and (6) a columellar callus that is not just restricted to the parietal area.

Clavocerithium (*Clavocerithium*) *santanum,* which is only the second species in the typical subgenus, is the first report of this subgenus in the New World, fossil or Recent, and the first early Miocene report.

Indocerithium Chavan, 1952, is the only other known subgenus of *Clavocerithium.* HOUBRICK (1975, 1978) reviewed *Indocerithium,* which is distinguished by an outer lip that extends one-third onto the previous whorl, and reported the subgenus to range from early Pliocene to Recent. Only three species are assigned to this subgenus, and two are extinct. All are from Indonesia and/or the Philippines and are associated with coral-reef biotopes.

The name *Clavocerithium* is a Latin neuter noun, and the species name *santana* must be changed to *santanum.*

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CSUN 401. SW ¼ of section 33, T6N, R21W, U.S. Geological Survey, 7.5-minute, Topatopa Mountains, California Quadrangle, 1943, upper Sespe Creek area, Ventura County, southern California (SQUIRES & FRITSCHE, 1978:fig. 2C). = LACMIP loc. 16342.

CSUN 428. In extreme NW corner of section 26, T6N, R22W, U.S. Geological Survey, 7.5-minute, Lion Canyon, California Quadrangle, 1943, upper Sespe Creek area, Ventura County, southern Caifornia (SQUIRES & FRITSCHE, 1978:fig. 2B).

CSUN 555. NE ¼ of the SW ¼ of section 20, T3N, R 18W, U.S. Geological Survey, 7.5-minute, Simi, California Quadrangle, 1943, Big Mountain, north side of Simi Valley, Ventura County, southern California (BLUNDELL, 1981:pl. 1). =

CSUN 1185. Along steep ridge, at elevation of 860 ft. (265 m), near head of Hicks Canyon, ^{37}33100 m N and ^{4}34700 m E (1000-meter Universal Transverse Mercator Grid, 1927 datum), U.S. Geological Survey, 7.5-minute, El Toro, California Quadrangle, 1968 (photorevised 1982), northern Santa Ana Mountains, Orange County, southern California (DANIEL, 1989: appendices B2 and C4). = LACMIP loc. 16508.

LACMIP 7700. Cliff west of old adobe in SW part of Plano Trabuco, N40°W of old adobe, 34 m above stream bench in 1-m-thick bed of hard ledge-forming slimy sandstone, in places almost a coquina (LACMIP records), U.S. Geological Survey, 7.5-minute, Cañada Gobernadora, California Quadrangle, 1968 (photorevised 1988), southern end of northern Santa Ana Mountains, Orange County, southern California.

UCMP 6128. "At base of bluff, west of the S end of the remnant hill which is on the lower plain, west side of Plano Trabuco" (LOEL & COREY, 1932:57), U.S. Geological Survey, 7.5-minute, Cañada Gobernadora, California Quadrangle, 1968 (photorevised 1988), southern end of northern Santa Ana Mountains, Orange County, southern California.

UCMP A-253. "N side of first large gulch on E side of

Wiley Canyon, center of S side of section 36, T4N, R19W, lowest invertebrate fossilferous bed (possibly estuarine deposition)" (LOEL & COREY, 1932:79), south side of Santa Clara River, Oak Ridge area, U.S. Geological Survey, 7.5-minute, Piru, California Quadrangle, 1952 (photorevised 1969), Ventura County, southern California.

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