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MEGAFAUNA OF THE UPPER MIOCENE CASTAIC FORMATION, LOS ANGELES COUNTY, CALIFORNIA

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MEGAFAUNA OF THE UPPER MIOCENE CASTAIC FORMATION, LOS ANGELES COUNTY, CALIFORNIA

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ABSTRACT—The upper Miocene Castaic Formation contains a megafauna of about 100 species, most of which are pelecypods and gastropods. Minor elements of the fauna are scaphopods, brachiopods, echinoderms, barnacles, bryozoans, and vertebrates. The occurrence of many of the species in the Castaic Formation represents a southward extension of their reported upper Miocene distribution. Eight of the species had not previously been reported from south of the Coalinga-San Luis Obispo region; twelve, from south of Santa Maria or the San Joaquin Valley. Twenty-six taxa which occur in the Castaic Formation have been reported from Pliocene or younger strata of the Pacific Coast of North America but had not been reported from Miocene strata. In addition to these range and distribution extensions, the fauna of the Castaic Formation is significant because it contains numerous taxa which are found today only in the Recent Panamanian Molluscan Province and which have not previously been recognized in late Tertiary strata of the California Coast Ranges. The Castaic Formation was deposited very near the northern limit of the late Miocene equivalent of the Recent Panamanian Molluscan Province.

INTRODUCTION

THE Castaic Formation consists of upper Miocene marine clastic sediments deposited northeast of the San Gabriel Fault at the eastern end of the Ventura basin (text-fig. 1). The formation is approximately 7000 feet thick and crops out in an area several miles wide and about 24 miles long parallel to the fault. The formation has been correlated with the Cierbo and Neroly Pacific Coast megafaunal "stages" or with Mohnian and Delmontian microfaunal stages (Durham, Jahns, & Savage, 1954, fig. 2; Paschall & Off, 1961, fig. 3).

The sediments of the Castaic Formation were deposited at the margin of the transgressing late Miocene sea. Three facies can be recognized in the formation. Along the western edge of the basin of deposition, northwest of the location of Castaic, the coarse-grained, unsorted, and unstratified clastics of the Violin Breccia were deposited adjacent to the active San Gabriel fault. Along the eastern side of the depositional area, sand and pebble- to cobble-gravel were deposited as onlapping basal sediments at the edge of the transgressing sea. Northwest of San Francisquito Canyon, the basal sediments were pebbly sand to cobble-gravel and were deposited in wedge- and bar-shaped bodies along a coast of relatively high relief. Southeast of San Francisquito Canyon the basal sediments were sand and minor amounts of gravel and were deposited in more laterally continuous bodies with less marked overlap along a coast of lower relief. The third facies is composed of alternating units of mudstone and sandstone deposited in mid-basin.

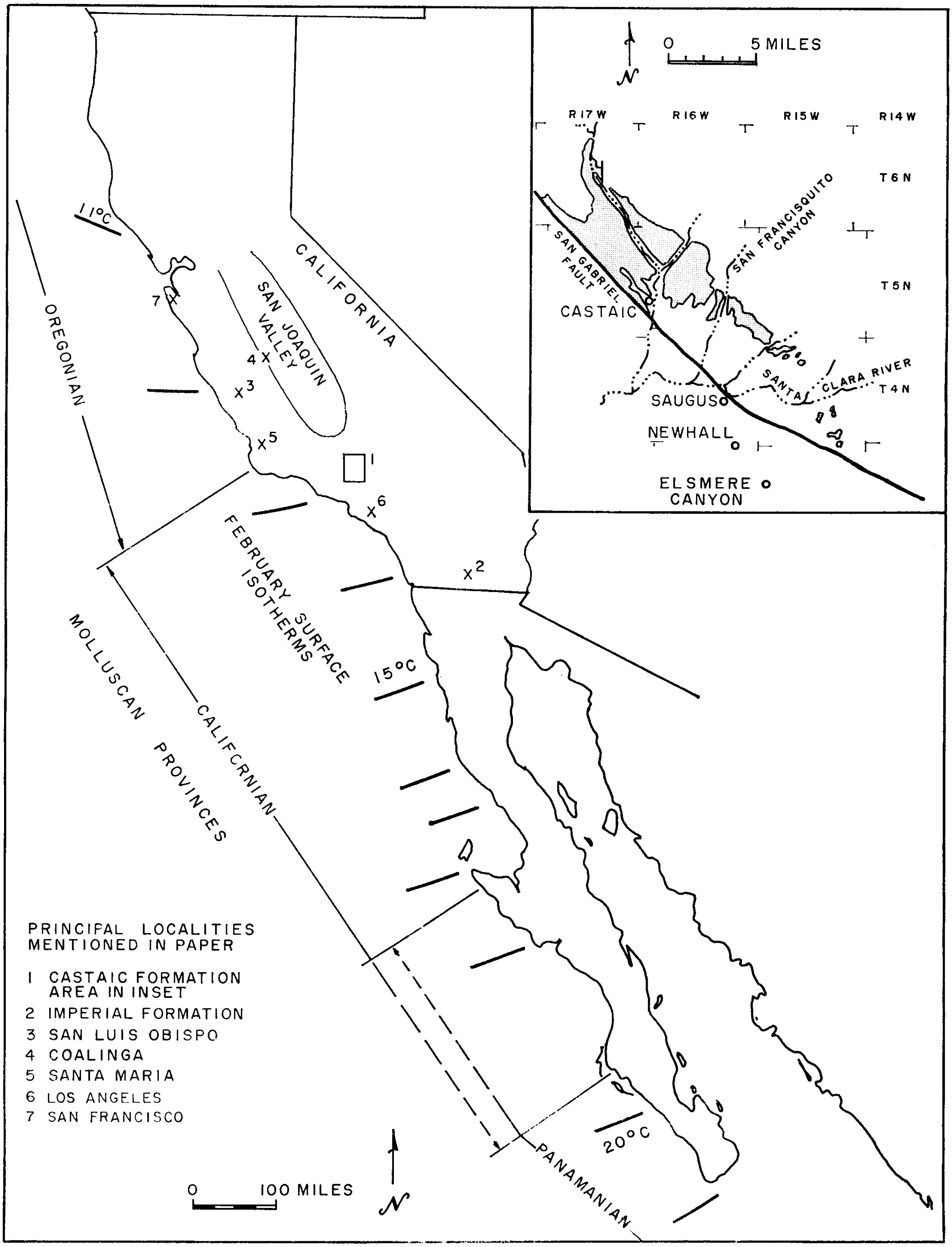
No megafossils have been found in the Violin Breccia. The mid-basin facies contains a very sparse megafauna. Megafossils are common in the basin margin facies and comprise the bulk of the fauna described in this paper.

Coarse-grained upper Miocene clastics bearing a megafauna of relatively shallow-water species, predominantly mollusks, are common in the California Coast Ranges. The fauna from this facies has been described extensively from central California, particularly from the San Francisco Bay, Coalinga, and San Luis Obispo areas. The Castaic Formation represents the southernmost exposure of this type of lithology in upper Miocene strata. For many of the species listed in this paper (see check list, text-fig. 2), the occurrence in the Castaic Formation represents a southward extension of their reported late Miocene distribution. The following species have not previously been reported from upper Miocene strata south of the Coalinga-San Luis Obispo region:

Anadara (*Anadara*) *trilineata trilineata* (Conrad), *Crenomytilus coalingensis* (Arnold), *Chlamys hodgei* (Hertlein), *Chama pellucida* Broderip, *Calliostoma spendens* Carpenter *diabloense* Clark, *Crepidula adunca* Sowerby, *Sinum scopulosum* (Conrad), and *Forreria carisaensis* (Anderson).

In addition, the following species have not previously been reported from upper Miocene strata south of the Santa Maria area or the San Joaquin Valley:

Glycymeris grewingki Dall, *Hinnites multirugosus* var. *crassiplicatus* (Gale), *Lucina* (*Here*) *excavata* Carpenter, *Miltha xantusi* (Dall), *Lucinoma acutilineata* (Conrad), *Amiantis stalderi* (Clark), *Clementia* (*Egesta*) *pertenuis* (Gabb), *Psammotreta* (*Florimetis*) *biangulata*



TEXT-FIG. *1*—Index map of Castaic Formation and principal localities mentioned in paper.

LOCALITIES ARRANGED IN GEOGRAPHIC ORDER FROM SOUTHEAST (LEFT) TO NORTHWEST (RIGHT)	1849	1626	1627	1663	2069	1623	234	230	231	232	233	1624	1671	1670	277	279	2097	2098	2090	2091	2075	2077	2107	2081	2082	2099	2100	2106	2096	2094	2093	2070	2071	2072	2092	2108	2083	2084	2085	2086	2087	2088	2089	2102	2103	2095	2104	2105	2101	2074
Pelecypods																																																		
Nuculana (Saccella) ochsneri (Anderson and Martin)	•			•																												•																		
Anadara aff. *A. (Anadara) montereyana* (Osmont)		•								•		•	•																																					
Anadara (Anadara) trilineata trilineata (Conrad)	•		•	•																																														
Glycymeris cf. *G. gigantea* (Reeve)																					•																													
Glycymeris grewingki Dall																			•						•		•									•				•					•			•		
Crenomytilus coalingensis (Arnold)				•										•																																				
Chlamys discus (Conrad)						•				•				•																																				
Chlamys cf. *C. hastata* (Sowerby)														•																																				
Chlamys hodgei (Hertlein)				•																																														
Chlamys parmeleei (Dall)				•																																														
Lyropecten estrellanus (Conrad)	•		•	•	•		•			•	•																																				•			
Lyropecten crassicardo (Conrad)								•	•	•		•	•			•					•	•	•		•		•	•	•		•		•		•	•	•	•	•	•	•	•	•	•	•	•	•			
Hinnites multirugosus var. *crassiplicatus* (Gale)				•	•																																													
Pododesmus cf. *P. macroschisma* (Deshayes)														•																																				
Spondylus sp.																																															•			
Crassostrea titan (Conrad)	•			•	•		•	•	•	•	•	•	•	•		•			•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•		•					•	•	•	•	•	•	•		•
Ostrea vespertina Conrad																•																															•			
Eucrassatella (Hybolophus) subgibbosa (Hanna)				•	•																																													
Chama pellucida Broderip				•																																														
Pseudochama sp.																												•																						
Lucina (Here) excavata Carpenter	•			•	•																																													
Miltha xantusi (Dall)	•			•																																														
Lucinoma acutilineata (Conrad)	•		•	•					•			•																																						
Trachycardium cf. *T. quadragenarium* (Conrad)	•			•	•																																													
Nemocardium (Keenaea) centifilosum (Carpenter)	•													•		•	•	•																																
Tivela diabloensis Clark	•			•																																														
Pitar (Lamelliconcha) sp.				•																																														
Dosinia sp.	•																														•																			
Amiantis stalderi (Clark)	•																																																	
Clementia (Egesta) pertenuis (Gabb)	•																																																	
Chione fernandoensis English	•		•	•																																														
Chione (Securella) elsmerensis English									•	•	•			•		•	•	•				•		•					•		•																•			
Spisula albaria (Conrad)	•																																																	
Psammotreta (Florimetis) biangulata (Carpenter)			•																												•																			
Macoma sp.	•																																																	
Macoma ? sp.		•								•					•																																			
Sanguinolaria cf. *S. nuttallii* Conrad																															•																			
Solen perrini Clark	•		•		•																																													
Corbula (Lentidium) luteola Carpenter																															•																			
Panope generosa Gould	•		•	•	•																																													
Periploma cf. *P. discus* Stearns													•																																					
Boring pelecypods	•				•		•																			•		•									•											•		
Gastropods																																																		
Patellid gastropods														•										•																										
Calliostoma coalingense Arnold	•				•																																													
Calliostoma splendens Carpenter *diabloense* Clark	•																																																	
Calliostoma sp.	•																												•																					
Tegula gallina (Forbes)												•																			•																			
Astraea cf. *A. (Pomaulax) gradata* Grant and Gale	•			•	•							•		•								•																												
Astraea sp.																																															•			
Liotia carinata Carpenter				•																																														
Nerita sp.																																		•																
Turritella cooperi Carpenter	•			•												•		•				•							•																					•
Turritella aff. *T. freya* Nomland	•				•																																													
Vermetidae				•										•		•								•		•					•						•					•						•		
? Bittium arnoldi Bartsch																•																																		
Calyptraea filosa (Gabb)	•																																																	
Trochita cf. *T. trochiformis* (Born)				•																																														
Crepidula adunca Sowerby	•			•								•																																						
Crepidula princeps Conrad	•			•																																														
Crepidula sp.	•			•																																														
Polinices uber (Valenciennes)																															•																			
Neverita reclusiana (Deshayes)	•		•	•	•					•	•			•		•			•												•														•					
Lunatia lewisii (Gould)													•																																					
Sinum scopulosum (Conrad)	•															•																																		
Ficus (Trophosycon) ocoyana (Conrad)	•				•				•			•		•		•																																		
Ocenebra cf. *O. topangensis* Arnold																																																•		
Forreria carisaensis (Anderson)	•																		•																															
Jaton eldridgei (Arnold)	•																																																	
Pyrene sp.																						•							•																					
Kelletia vladimiri Kanakoff	•				•														•																•															
Calicantharus fortis (Carpenter) *angulatus* (Arnold)	•																																																	
Anomalosipho sp.													•																																					
Nassarius cf. *N. stocki* Kanakoff	•				•					•				•																																				
Cancellaria cf. *C. fernandoensis* Arnold																																																	•	
Cancellaria hemphilli Dall	•																																																	
Cancellaria tritonidea Gabb	•				•														•																															
Cancellaria rapa Nomland	•																																																	
Olivella (Olivella) pedroana (Conrad)	•				•									•		•	•														•																			
Oliva spicata (Bolten)								•																																										
Marginella cf. *M. albuminosa* Dall					•																																													
Conus californicus Hinds	•				•							•																	•		•																	•		
Conus sp.																																							•											
Antiplanes sp.	•																																																	
Surculites (Megasurcula) remondii (Gabb)	•				•																																													
Lora oldroydi (Arnold)	•																																																	
Clavus (Clathrodrillia) elsmerensis (English)														•																																				
Clavus cf. *C. (Cymatosyrinx) hemphilli* (Stearns)														•																																				
Mangelia sp.	•											•																																						
Bulla sp.	•									•							•	•																																
Scaphander ? sp.										•																																								
Acteon cf. *A. boulderana* Etherington																															•																			
Scaphopods																																																		
Dentalium sp.										•				•																																				
Brachiopods																																																		
Terebratalia occidentalis Dall				•					•		•	•		•																																				
Echinoderms																																																		
Astrodapsis fernandoensis Pack										•			•	•						•	•					•	•				•	•			•		•	•	•	•	•			•	•	•		•		•
Cidarid spines					•									•																•																		•		
Bryozoans				•																	•																													
Barnacles – *Balanus*				•	•																				•																						•	•		•
Clionid ? borings	•				•		•	•	•	•	•	•	•	•		•			•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•		•					•	•	•	•	•	•	•		•
Vertebrate fossils		•		•	•									•																	•												•							

TEXT-FIG. *2*—Check list of fossils from the Castaic Formation.

(Carpenter), *Corbula* (*Lentidium*) *luteola* Carpenter, *Crepidula princeps* Conrad, *Neverita reclusiana* (Deshayes), and *Olivella* (*Olivella*) *pedroana* (Conrad).

Many of these species occur in Pliocene strata of both southern and central California and, in particular, in the lower Pliocene strata of the Towsley Formation in Elsmere Canyon, adjacent to the outcrop area of the Castaic Formation but west of the San Gabriel fault. Durham (1948) has pointed out the close similarity of the Castaic and Elsmere Canyon faunas. The age of the Towsley Formation is Mohnian (upper Miocene) to lower Pliocene, but the exact stratigraphic relationship of the Elsmere Canyon strata to the rest of the Towsley Formation is not known (Winterer & Durham, 1962, p. 320–321). Where the Towsley and Castaic Formations occur together, they are separated by an angular unconformity. Winterer & Durham (1962) present the arguments for early Pliocene age of the Elsmere Canyon strata and indicate it so on their pl. 45, section A-A′. In summary, the Castaic Formation is at least in part older than the Towsley Formation; the Castaic fauna resembles the Elsmere Canyon fauna but seems to be slightly older; in this paper, the Elsmere Canyon fauna is considered early Pliocene.

The following taxa have been reported from Pliocene or younger strata of the Pacific Coast of North America but have not previously been reported from upper Miocene strata:

Glycymeris cf. *G. gigantea* (Reeve), *Chlamys parmeleei* (Dall), *Pododesmus* sp., *Spondylus* sp., *Eucrassatella* (*Hybolophus*) *subgibbosa* (Hanna), *Pseudochama* sp., *Chione fernandoensis* English, *Chione elsmerensis* English, *Calliostoma coalingense* Arnold, *Liotia carinata* Carpenter, *Nerita* sp., *Tegula gallina* (Forbes), *Polinices uber* (Valenciennes), *Lunatia lewisii* (Gould), *Jaton eldridgei* (Arnold), *Pyrene* sp., *Kelletia vladimiri* Kanakoff, *Calicantharus fortis* (Carpenter) *angulatus* (Arnold), *Cancellaria rapa* Nomland, *Oliva spicata* (Röding), *Marginella* cf. *M. albuminosa* Dall, *Conus californicus* Hinds, *Conus* sp.—large form, *Lora oldroydi* (Arnold), *Clavus* (*Clathrodrillia*) *elsmerensis* (English), and *Astrodapsis fernandoensis* Pack.

Of these taxa, the following have been reported from the Imperial Formation, which is generally considered to be lower Pliocene (Durham, 1954b) but may be wholly or in part upper Miocene (Dibblee, 1954):

Glycymeris gigantea (Reeve), *Spondylus* sp., *Eucrassatella* (*Hybolophus*) *subgibbosa* (Hanna), *Nerita* sp., *Polinices uber* (Valenciennes), *Oliva spicata* (Röding), and large conids allied to the *Conus* sp. of the Castaic Formation.

Recent shallow marine molluscan provinces are shown in text-figure 1. The Panamanian province contains a tropical fauna and extends as far south as northern Peru; the Californian and Oregonian provinces contain temperate faunas. Each province is characterized by distinct faunas. The fauna changes relatively slowly within provinces and rapidly at province boundaries. Newell (1948) and Valentine (1961) discuss the provinces in more detail and present a sound basis for the subdivision into provinces.

The following taxa present in the Castaic Formation have not previously been reported from upper Miocene strata of the California Coast

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Explanation of Plate 5

Figs. *1*—*Anadara* aff. *A.* (*Anadara*) *montereyana* (Osmont), ×0.5, CIT locality 1671; latex cast of whole specimen, valves offset; exterior of right valve, hinge of left.

2,3—*Glycymeris* cf. *G. gigantea* (Reeve), ×0.5, CIT locality 2075; *2*, whole specimen, valves offset; exterior of left valve, part of right hinge; *3*, hinge of a right valve.

4,5—*Chlamys hodgei* (Hertlein), ×1, CIT locality 1663; *4*, right valve; *5*, left valve.

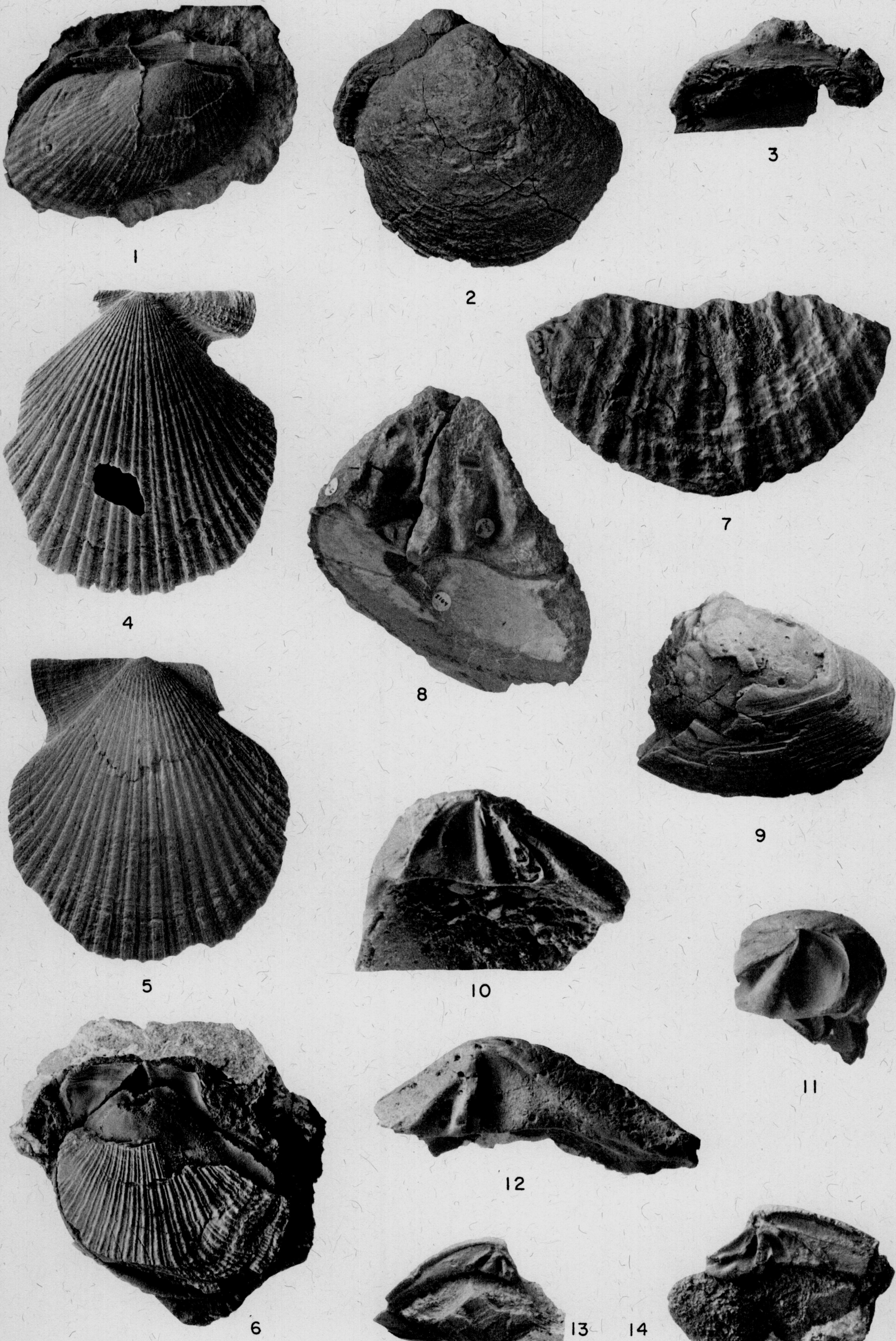
6—*Hinnites multirugosus* var. *crassiplicatus* (Gale), ×1, CIT locality 2069; incomplete articulated specimen, exterior of left valve, hinge of right.

7—*Pododesmus* cf. *P. macroschisma* (Deshayes), ×1, CIT locality 1670.

8—*Spondylus* sp., ×0.5, CIT locality 2104; specimen has been sectioned obliquely showing outer dark shell layer, inner light layers.

9–12—*Eucrassatella subgibbosa* (Hanna), CIT locality 1663; *9*, ×1, exterior of left valve; *10*, ×2, left hinge; *11, 12*, ×2, right hinges.

13,14—*Dosinia* sp., ×1.5, CIT locality 2093; *13*, incomplete left hinge; *14*, incomplete right hinge, posterior cardinal broken.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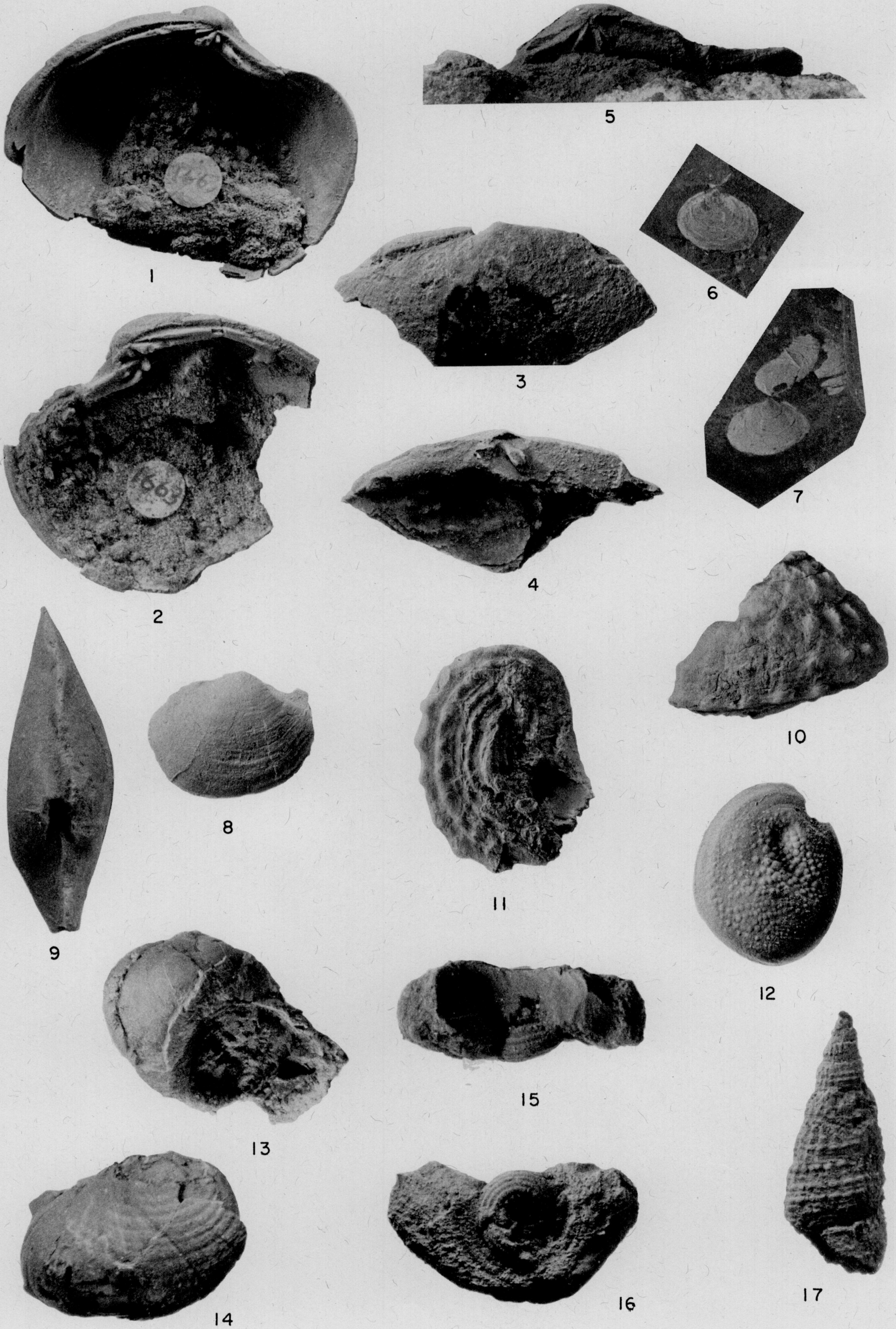
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Ranges and are conspecific with or closely related to taxa restricted at present to the Panamanian province:

Glycymeris cf. *G. gigantea* (Reeve), *Spondylus* sp., *Eucrassatella* (*Hybolophus*) *subgibbosa* (Hanna), *Liotia carinata* Carpenter, *Nerita* sp., *Trochita* cf. *T. trochiformis* (Born), *Polinices uber* (Valenciennes), *Pyrene* sp., *Oliva spicata* (Röding), *Marginella* cf. *M. albuminosa* Dall, and *Conus* sp.

The presence of these taxa in the Castaic Formation and their absence in correlative strata of similar facies further north indicates that the site of deposition of the Castaic Formation was very near the northern limit of the late Miocene equivalent of the Panamanian province.

The northern boundary of the Panamanian province is gradational. The same was probably true in the late Miocene, for the following taxa, characteristic of the Panamanian province, occur in the Castaic Formation but have also been reported from various locations further north in southern and central California:

Anadara sp., *Miltha xantusi* (Dall), *Dosinia* sp., *Turritella* sp., *Trochita* sp., *Ficus* sp., and *Oliva* sp.

In addition, Addicott & Vedder (1963) and Hall (1964) have listed several Panamanian taxa from the San Joaquin Valley and from the San Luis Obispo region.

In the transitional boundary between the Recent Panamanian and Californian provinces, Panamanian fauna is largely confined to embayments and other protected localities (Valentine, 1955). The equal abundance of tropical taxa in both embayment and open-coast settings during deposition of the Castaic Formation indicates that the site of deposition of the Castaic Formation was south of such a transition that may have existed in the late Miocene.

The relative abundance of Panamanian taxa in the Castaic Formation compared to correlative strata to the north suggests that, by analogy to present faunal provinces, the site of deposition of the Castaic Formation would be equivalent to a present site along the southwest coast of Baja California, and the average minimum (February) surface temperature must have been about 19° or 20°C. Durham (1950, fig. 3) assigned a February temperature of about 18°C. to the latitude of the Castaic Formation. Hall (1960, p. 288, and map 2) suggested that the winter temperature at the site of deposition of the Castaic Formation was the same or slightly warmer than in the San Luis Obispo region, where the winter surface temperature was about 18°C.

The similarities between the faunas of the Castaic and Imperial formations reflect their common location within the tropical molluscan province. Even though the Imperial Formation may be Pliocene, it would have contained a tropical fauna in spite of the progressive cooling trend documented by Durham (1950) because of its protected position at the head of the Gulf of California. On the other hand, the lack of tropical forms in the Elsmere Canyon fauna may be the result of the cooling trend and thus confirm that the Elsmere Canyon fauna is younger than the fauna of the Castaic Formation. However, the degree of sheltering from the open ocean of the Castaic and Elsmere Canyon depositional sites must be considered in detail in testing this

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Explanation of Plate 6

Figs. *1,2*—*Pitar* (*Lamelliconcha*) sp., ×1.5, CIT locality 1663; *1*, left valve; *2*, right valve, hinge fractured so that anterior part is pushed back and under posterior part.

3,4—*Sanguinolaria* cf. *S. nuttallii* Conrad, ×2, CIT locality 2093; *3*, exterior of right valve; *4*, interior of same specimen, anterior cardinal broken.

5—*Psammotreta* (*Florimetis*) *biangulata* (Carpenter), ×1.5, CIT locality 2093; incomplete right hinge.

6,7—*Macoma*? sp., ×1, CIT locality 277; *6*, exterior of single valve; *7*, interior view of articulated but opened valves.

8,9—*Periploma* cf. *P. discus* Stearns, CIT locality 1671; *8*, ×1, left view of interior mold; *9*, ×2, dorsal view of same specimen.

10–12—*Astraea* cf. *A.* (*Pomaulax*) *gradata* Grant & Gale; *10,11*, ×1, CIT locality 2077, lateral and ventral views of same specimen; *12*, ×2, CIT locality 2069, exterior of operculum.

13,14—*Nerita* sp., ×1.5, CIT locality 2072; lateral and oblique views of same specimen.

15,16—*Liotia carinata* Carpenter, ×3, CIT locality 1663; lateral and ventral views of same specimen.

17—*Bittium arnoldi* Bartsch, ×3, CIT locality 279.

hypothesis. The analysis of paleoclimate must take into account the importance of paleogeography, as Addicott & Vedder (1963) have most recently pointed out.

In the descriptions that follow, only limited references are given. Original references are listed if they are used; the most recent reference is given that treats the species in detail or that contains an exhaustive synonymy. All localities are California Institute of Technology localities.

Previously published references to the megafauna of the Castaic Formation consist of short faunal lists by the following authors: Dehlinger (1952), Durham (1948), Jahns (1940), Kew (1924), Oakeshott (1958), White & Buffington (1948), and Wright (1948).

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TAXONOMIC NOTES AND DESCRIPTIONS

PELECYPODA

ANADARA aff. A. (ANADARA) MONTEREYANA (Osmont)
Pl. 5, fig. 1

Arca montereyana OSMONT, 1905, p. 96, pl. 9, fig. 5.
Anadara (Anadara) montereyana (Osmont), REINHART, 1943, p. 47, pl. 10, figs. 1,3,4,9.

Most of the specimens are articulated. Sculpture consists of 30 to 34 radial ribs, interspaces flat, narrower than ribs, ribs flat-topped or slightly rounded, with shallow median groove on largest specimen. Dimensions, in mm, of specimens complete enough to measure are:

Locality	1671					1626				
Length	80	30	30	30	17	42	34	40	30	47
Height	50	18	20	20	12	34	22	30	22	34
Diameter (single valves)	15	4	7	6	4					5

The specimens differ from *A. montereyana* in having a slightly greater number of ribs. The number of ribs is 30 to 34 whereas that of *A. montereyana* is 29 to 32. The specimens from locs. 1624 and 1626 had been previously referred to *A. osmonti* and *A. obispoana* by Jahns (1940, p. 167).

GLYCYMERIS cf. G. GIGANTEA (Reeve)
Pl. 5, figs. 2,3

Glycymeris (Glycymeris) gigantea (Reeve), OLSSON, 1961, p. 106, pl. 11, fig. 1.

Most shells are articulated. Sculpture is not preserved except for concentric growth lines; internal margins of valves are crenulate; chevron grooves are poorly preserved; the teeth are restricted to the ends of the hinge by overlap of the cardinal area upon the central teeth. Teeth are boomerang shaped, lying nearly horizontally within the hinge. Dimensions, in mm, of two representative specimens are:

Length	70	95
Height	75	95
Diameter	25—(single valve)	60
Shell thickness, approximate, in center of shell	5	7

The specimens closely resemble *G. gigantea* in form, dentition, and size. However, except for being somewhat larger, they also closely resemble *G. branneri*. The specimens cannot be identified specifically because the sculpture is poorly preserved. *G. branneri* occurs in Oligocene and lower Miocene sediments of central California. *G. gigantea*, a Recent Panamanian species, occurs in Pliocene and Pleistocene sediments of Baja California and the Gulf of California. *G. branneri* and *G. gigantea* differ only in size and prominence of secondary ribbing. These two species and the Castaic form are representatives of a group of warm water glycymeridids that occurred as far north as central California in the Oligocene and early Miocene and southern California in the late Miocene but is now restricted to the Panamanian province. The specimens from the Castaic Formation are the first representatives of this group to be reported from upper Miocene or younger sediments of coastal California.

CRASSOSTREA TITAN (Conrad)

Ostrea titan CONRAD, 1857a, p. 72, pl. 4, fig. 17; pl. 5, fig. 17a.

The species varies considerably in abundance and morphology from north to south within the Castaic Formation. In the northern part of the formation, the species is more abundant and individuals are much larger than in the southern part. The average dimensions of specimens from north of San Francisquito Canyon are: length 30 cm., width 10 cm., and valve thickness 3 cm. The average dimensions of specimens from the southern part of the formation are: length 15 cm., width 8 cm., valve thickness 2 cm. Some valves from the southern part bear three to five irregular, round-crested ribs which may be discontinuous between laminae. Ribbing is more prevalent on left valves and particularly on those that are deeply cupped. Right valves are generally flat without ribbing.

The valves of most specimens have been bored. Clionid? borings about one mm. in diameter are more common in the northern than southern part of the outcrop area. Larger borings, about one cm. in diameter and commonly containing an unidentified boring pelecypod, are abundant only in the northern part of the outcrop area.

C. titan has been reported from middle and upper Miocene strata of central and southern California. Eaton, Grant, & Allen (1941) describe from Miocene strata of the Caliente Range a number of new species and a new subspecies of *C. titan* from material that would have been grouped previously under *C. titan*. In addition, three other varieties or subspecies of *C. titan* have been described. In the Castaic Formation, in strata that are contemporaneous, morphologic variability is so great that, according to the illustrations and descriptions of type specimens, several of the previously described species and subspecies could be identified among the Castaic specimens. Most shells found in the northern part of the formation correspond to typical *C. titan;* some thick specimens could be classified as the species *C. ligminuta*. The largest specimens from the southern part of the outcrop area of the Castaic Formation are eight to ten inches long and thus would correspond to *C. titan* var. *prior*, which differs from *C. titan* only in being about half the size, and in being presumably ancestral to it. Ribbed specimens differ from the species *C. bourgeoisii*, as described and illustrated by Clark (1915, p. 447, pl. 43) and by Eaton, Grant, & Allen (1941, pl. 3, fig. 1) in lacking the elongate narrow ligamental pit. They differ from the species *C. cierboensis* in having ribs that are narrow rather than broad and rounded. Ribbing, along with decrease in size and abundance, presumably reflects an environment to the southeast less hospitable for the species than to the northwest. The morphologic changes coincide with the change in environment from embayment in the north to open coast in the southeast.

CHLAMYS DISCUS (Conrad)

Pecten discus CONRAD, 1857b, p. 190, pl. 3, fig. 1; GRANT & GALE, 1931, p. 200, pl. 4, fig. 7.

Clark (*in* Kew 1924, p. 68) identified *Chlamys raymondi* from the Castaic Formation in the general area of locs. 232 and 1670. Shells referable to *C. raymondi* have been found in this study but appear to be part of a gradational series encompassing both *C. raymondi* and *C. discus* and grouped most closely around the typical *C. discus*.

CHLAMYS HODGEI (Hertlein)
Pl. 5, figs. 4,5

Pecten (Chlamys) hodgei HERTLEIN, 1925, p. 42, pl. 4, figs. 1,2.

Two articulated specimens and a single right valve, all unworn, have been found in pebbly sandstone. The specimens agree with the original description of the species. The right valves are ornamented with about 20 bifid ribs; interspaces contain a median riblet, and, in a few instances, one or two tertiary riblets. The left valves bear about 22 flatly rounded ribs; interspaces contain a median riblet one-third to one-fourth as wide as the primary rib and in some interspaces tertiary ribs lie along the sides of the primary ribs. The sculpture of the right valve is variable. On one specimen all the ribs are bifid; on another, only a few are bifid; and on the third, most ribs are bifid but the two parts of the ribs are not equally wide. Dimensions, in mm., of the three specimens are

Height	52	49	44
Length	49	43	40
Diameter	19	18	8 (single right valve)

CHLAMYS PARMELEEI (Dall)

Pecten (Chlamys) parmeleei DALL, 1898, p. 708, pl. 37, figs. 14,14a; ARNOLD, 1906, p. 119, pl. 41, fig. 5.

The specimens closely resemble the specimen from the Pliocene sediments of Crescent City figured by Arnold (1906, pl. 41, fig. 5). They differ from the holotype of *C. parmeleei*, which has relatively narrower and less prominently ribbed primary ribs.

Chlamys parmeleei previously has been considered diagnostic of the Pliocene in southern California (Vedder, 1960, p. B327). These specimens represent a slightly earlier occurrence.

HINNITES MULTIRUGOSUS var. CRASSIPLICATUS (Gale)
Pl. 5, fig. 6

Pecten (Chlamys) multirugosus var. *crassiplicatus* GALE, 1928, p. 93.

Sculpture consists of more than 17 primary ribs with well-developed secondary ribs occurring singly or in pairs between the primary ribs. In a few interspaces one or two tertiary ribs are also present.

The specimens resemble *H. crassiplicatus* more than they resemble the Recent specimens of *H. multirugosus*, which bear as many as five secondary ribs between pairs of primary ribs. Until it is demonstrated that the Miocene to Recent *Hinnites* of the Pacific Coast may be part of a single variable group, it is useful to point out the sculptural differences of Miocene specimens by use of the varietal name.

SPONDYLUS sp.
Pl. 5, fig. 8

All specimens are fragmental; only one is articulated.

Shell large, approximately circular, thick, inequivalve. Sculpture has been obscured by boring organisms. Nature of ears indeterminable. The best preserved specimen, a right valve, had the following dimensions: height 150 mm.; length 150 mm.; valve thickness at center of valve, 25 mm.; Hinge dimensions: resilial pit depth 10 mm.; resilial pit width 11 mm.; distance between centers of teeth 17 mm.; hinge line width 65 mm.; distance from hinge line to beak 60 mm.

Shell microstructure can be recognized although the shell is recrystallized to coarse calcite. The inner shell layer is composed of prisms oriented normal to the shell surface; the middle layer is crossed lamellar and is the most poorly preserved of the three; the outer layer has an irregular foliated structure. The foliae extend obliquely out from the base of the layer into flat spines, forming a rough squamose exterior. The outer shell layer is riddled by borings about one-half to one mm. in diameter. Inner layers are also bored but to a lesser extent.

Because the sculpture is poorly preserved, the specimens cannot be identified specifically. *Spondylus* has been reported from strata of Eocene to Pliocene age in California. The genus occurred as far north as central California during the Eocene epoch. It has not been reported from Oligocene strata. It has been reported from the lower Miocene Vaqueros Formation in the Transverse Ranges and Channel Islands of southern California, and as far north as Monterey County. Ogle (1953, p. 28) reported a *Spondylus* from the basal strata of the upper Miocene and lower Pliocene Wildcat Group in northern California. The specimen identified as *Spondylus* was examined and is, however, probably *Chlamys parmeleei*. *Spondylus* is common in the lower Pliocene Imperial Formation of the Colorado Desert of California. It also occurs in Pleistocene and lower Pliocene strata of the Gulf of California. Along the west coast of Baja California, the northernmost Pliocene occurrence of the genus is on Cedros Island. The Recent northern limit of distribution of the genus on the Pacific Coast is the Gulf of California. The *Spondylus* in the Castaic Formation is the only post-early Miocene occurrence of the genus in the coastal strata of California and fits into a continuous southward movement of the known northern limit of distribution of the genus from central California in the Eocene and early Miocene to within the Gulf of California at present.

PODODESMUS cf. P. MACROSCHISMA
(Deshayes)
Pl. 5, fig. 7

Pododesmus macroschisma (Deshayes), GRANT & GALE, 1931, p. 241, pl. 12, figs. 3,4a,4b.

Shell large, thin, flat. No hinge features preserved. Sculpture of coarse uneven radiating ribs and prominent growth lines. Every third or fourth rib several times the size of the smaller intervening ribs. Interspace width not constant, about as wide as the adjacent ribs. The sculpture differs from that of *P. macroschisma* in being coarser with ribs larger, more widely spaced, and of two sizes. The sculpture is similar to that of *P. newcombei* from the upper Oligocene of Vancouver Island. However, specimens of *P. newcombei* are smaller, and the ribs, although of comparable size and spacing, judging from illustrations, are of uniform size.

The reported range of *P. macroschisma* is Pliocene to Recent; the Pliocene distribution is central and southern California.

EUCRASSATELLA (HYBOLOPHUS)
SUBGIBBOSA (Hanna)
Pl. 5, figs. 9–12

Crassatellites subgibbosa HANNA, 1926, p. 463, pl. 28, figs. 1–4.

Shell opisthogyrate; posterior end truncated; dorsal posterior margin straight to slightly concave; inner shell margin smooth. Sculpture of rounded concentric ribs; lunule ovate, depressed but not deeply set; escutcheon broad, long, depressed. Sides of cardinal teeth grooved on well preserved specimens. Left valve: two cardinals, a posterior and an anterior lateral; anterior cardinal sloping forward, high; posterior cardinal much smaller; a low narrow ridge is on posterior edge of the resilifer; a posterior lateral lies well back along the narrow extension of the hinge plate; a small reduced anterior lateral is situated on the ventral edge of the anterior end of the hinge plate. Right valve: three cardinals, an anterior lateral; the anterior cardinal lies along the edge of the lunule; it is long, narrow, and low; the middle cardinal is much heavier and higher; the right posterior cardinal is represented by a short spur branching from the middle cardinal about midway from beak to hinge plate edge and extending down and back to the edge of the hinge plate. The right anterior lateral is a small reduced bump at the anterior end of the hinge plate. Dimensions, in mm., of two representative specimens are

Length	60	55
Height	38	35
Diameter	28	23
Shell thickness	5	4

Several problems arise in determining the unique characteristics of *E. subgibbosa* and in determining the relationship of *E. subgibbosa* and other described late Cenozoic species. When Hanna described *E. subgibbosa*, he lacked good comparative material. Therefore, he differentiated *E. subgibbosa* from *E. gibbosa* on the basis of illustrations of *E. gibbosa* by Reeve (1843, pl. 1, fig. 1) and by Nelson (1870, pl. 7, fig. 9). However, Spieker (1922, p. 129) refers Nelson's illustration of *E. gibbosa* to *E. nelsoni;* consequently, *E. subgibbosa* and *E. gibbosa* were originally separated only on the basis of the figures by Reeve of the exteriors of two left valves of *E. gibbosa*. From a study of specimens of *E. gibbosa*, of Reeve's illustrations of *E. gibbosa*, and of the holotype, paratype, and other specimens of *E. subgibbosa*, it is evident that the two species are distinctly different.

The diagnostic characteristics of *E. subgibbosa* are difficult to determine, however, for when Hanna described the species, he illustrated two specimens that differ markedly in shape. The holotype, his plate 28, figures 3,4, has a concave posterior dorsal margin; the paratype, his plate 28, figures 1,2, has a straight posterior dorsal margin. Furthermore, the hinge of the holotype is not exposed, so that the described hinge characteristics are based on the paratype.

From a study of the late Cenozoic and Recent species of *Eucrassatella* from western North America, three characteristics appear to be of use in distinguishing the different species. These characteristics are: lunule shape, shell shape, and position of the right posterior cardinal tooth. *E. subgibbosa* is distinguished from *E. gibbosa, E. digueti*, and *E. laronus* by having an ovate rather than elongate lunule. *E. gibbosa* is distinguished from *E. subgibbosa, E. digueti*, and *E. laronus* by its rostrate shape and very concave posterior dorsal margin. *E. digueti* is less rostrate than *E. gibbosa* but its shape is variable, including forms, like the holotype of *E. laronus*, which are nonrostrate with straight dorsal posterior margin. Assuming that the holotype and paratype of *E. subgibbosa* are conspecific on the basis of the distinctive lunule, the shape of the posterior margin in *E. subgibbosa* is variable, as indicated by the holotype and paratype. All the specimens from the Castaic Formation, however, resemble the paratype in shape.

The right posterior cardinal tooth in *E. gibbosa* is joined to the middle cardinal close to the beak and lies alongside the middle cardinal. In contrast, the right posterior cardinal in *E. subgibbosa* projects as a spur from the middle of the middle cardinal. The position of the right posterior cardinal in *E. digueti* ranges from alongside the middle cardinal as in *E. gibbosa* to being joined to the middle cardinal dorsally and then branching off as a spur similar to the spur in *E. subgibbosa*. Probably the spur-like tooth in *E. subgibbosa* developed through an intermediate stage like that in *E. digueti*.

Differences in the extent of grooving on the sides of the cardinal teeth are present among specimens of each species. These differences are the result of both individual variability from specimen to specimen and of obliteration of the grooving in less well preserved specimens. Well preserved specimens from the Castaic Formation are grooved; specimens less well preserved (and the paratype of *E. subgibbosa*) lack the grooves. Thus, grooving does not appear to be a diagnostic character.

In summary, on the basis of shell shape, lunule shape, and dentition, the species *E. gibbosa, E. digueti*, and *E. subgibbosa* can be distinguished. *E. gibbosa* is distinctively different in shape; *E. subgibbosa*, in lunule shape and in dentition. *E. digueti* has an intermediate shape and dentition; both characters are less fixed than in the other species, and the range of variability includes the holotype of *E. laronus*, which species has been put into synonymy with *E. digueti*. The specimen of *E. laronus* illustrated by Durham (1950a, pl. 16, figs. 8,14) from the Pleistocene of Baja California resembles *E. subgibbosa* more closely than it does *E. digueti* or the holotype of *E. laronus*. *E. nelsoni*, on the basis of the illustrations by Nelson and by Spieker (1922, pl. 7, fig. 8), differs from *E. subgibbosa* in shape and in dentition. It is similar to *E. digueti*.

PSEUDOCHAMA sp.

A right valve is attached to the right valve of an articulated *Crassostrea titan*. The valve is eight mm. in diameter, circular, bored and weathered so that internal features are not preserved.

This is the earliest reported occurrence of the genus from western North America. *P. exogyra, P. saavedrai* and *P. granti* are the only species of *Pseudochama* described as fossils from the west coast of North America. *P. exogyra* has been reported from Pleistocene and upper Pliocene strata of Ventura County and of the southern Gulf of California; *P. saavedrai* from the Pleistocene of the Gulf of California; and *P. granti* from the Pleistocene of the Los Angeles Basin. The poor preservation of the Castaic Formation specimen prevents comparison with any of these species.

TRACHYCARDIUM cf. T. QUADRAGENARIUM (Conrad)

Cardium quadragenarium CONRAD, 1837, p. 230, pl 17, fig. 5.
Laevicardium (*Trachycardium*) *quadragenarium* (Conrad), GRANT & GALE, 1931, p. 306, pl. 19, fig. 15.

Ribs about 35, prominent, wider than interspaces; no sculpture seen on ribs; all specimens badly weathered. Approximate dimensions, in mm., of specimens complete enough to measure are:

Length	25	23	25	35	75
Height	25	22	25	35	?
Diameter (of single valve)	7	8	6	9	23

The specimens are too fragmentary and poorly preserved to be identified specifically. They resemble *T. quadragenarium* var. *fernandoense* Arnold (1907, p. 535, pl. 48, figs. 2,2a,3) in that they are smaller and have fewer ribs than *T. quadragenarium*.

The previously reported late Miocene occurrences of *T. quadragenarium* have been in central California. *T. quadragenarium* var. *fernandoense* has been reported only from Pliocene sediments of the Newhall and Los Angeles areas. Wright (1948) reported the variety from the Castaic Formation on the basis of some of the same material used in this study.

PITAR (LAMELLICONCHA) sp.
Pl. 6, figs. 1,2

A single articulated specimen is in pebbly sandstone. A hole has been bored through the umbo of the left valve. A *Crepidula adunca* is attached to the left valve. Shell medium size, elongate-ovate; beak prosogyrous, slightly anterior of center; margins rounded, smooth internally. Sculpture of coarse, irregular, rounded, concentric ridges. Left valve: three cardinal teeth; posterior cardinal long, thin, parallel to narrow nymph plate; middle cardinal short, heavy; anterior cardinal short, thinner than middle one. Anterior lateral elongate, close to cardinals. Right valve: a prominent elongate posterior cardinal; middle and anterior cardinals close together under beak, small; deep anterior socket with small laterals above and below. Lunule incised, slightly depressed; escutcheon not defined. Dimensions, in mm., of articulated individual are length 42, height 31, diameter 23.

No comparable forms have been described from the Cenozoic of western North America.

AMIANTIS STALDERI (Clark)

Pitaria stalderi CLARK, 1915, p. 468, pl. 53, figs. 5,6.
Amiantis callosa (Conrad) variety *stalderi* (Clark), GRANT & GALE, 1931, p. 349, pl. 17, figs. 8a,8b.

Amiantis stalderi has been distinguished from *A. callosa* primarily on shape differences; however, the dentition differs slightly too. The nymph plate of *A. stalderi* is narrower, and the left anterior lateral is lower on the hinge plate so that a line projected back from along the lateral tooth would intersect the base of the cardinals rather than the middle of them as in *A. callosa*. The specimens from the Castaic Formation correspond to *A. stalderi* in these hinge characteristics. They also closely resemble *A. stalderi* in shape, but the distinction between *A. callosa* and *A. stalderi* based on shape is not clear. The anterior dorsal margin in specimens of *A. stalderi* descends more abruptly so that the beaks appear to be higher and more central than in specimens of *A. callosa*. However, in growth series of Recent specimens of *A. callosa*, shape changes with size. As the shell becomes larger it becomes less elongate and more circular, the posterior dorsal margin becomes more curved, and the anterior dorsal margin descends more abruptly. The specimens from the Castaic Formation and *A. stalderi* fit within this morphological range. In shape, the specimen of *A. callosa* illustrated by Arnold (1907, p. 544, pl. 49, fig. 2) is even further from the typical *A. callosa* than is the typical *A. stalderi*. Thus, if Arnold's specimen is an *A. callosa*, as Grant & Gale (1931, p. 348) and Keen & Bentson (1944, p. 31) consider it to be, then *A. stalderi* fits well within the morphologic variability of *A. callosa*, and the distinction between the two species on the basis of shape is not valid. If further study reveals that hinge differences are not significant, *A. stalderi* should be placed in synonymy under *A. callosa*.

DOSINIA sp.
Pl. 5, figs. 13,14

Specimens are so fragmentary that the shape is indeterminate. The hinges differ from those of the described species of western North America and are characterized by the teeth being widely spread: the left anterior cardinal is nearly parallel with the shell edge; the left posterior cardinal is straight rather than curving down to the edge of the hinge plate; the right anterior lateral is set far out on the hinge.

PSAMMOTRETA (FLORIMETIS) BIANGULATA (Carpenter)
Pl. 6, fig. 5

Tellina alta CONRAD, 1837, p. 258.
Apolymetis biangulata (Carpenter), PALMER, 1958, p. 107, pl. 14, fig. 5.

Psammotreta (*Florimetis*) *biangulata* (Carpenter), KEEN, 1962, p. 178.

The specimens differ from Recent specimens of *P. biangulata* in that the hinge plate is considerably broader and heavier.

MACOMA (?) sp.
Pl. 6, fig. 6,7

This species occurs widely throughout the Castaic Formation, restricted to the mudstone facies. Only molds are found in weathered outcrops. Shell small, thin, equivalve, slightly inequilateral, compressed, elongate-oval; margins smoothly rounded. Sculpture of faint growth lines. Lateral teeth absent or poorly developed, two small cardinal teeth. Hinge line short. Average dimensions in mm. are length 15, height 10, diameter 3.

Dentition and general shape are suggestive of *Macoma;* however, hinge features are poorly preserved so the identification is tentative.

SANGUINOLARIA cf. S. NUTTALLII Conrad
Pl. 6, figs. 3, 4

Sanguinolaria nuttallii CONRAD, 1837, p. 230, pl. 17, fig. 6; GRANT & GALE, 1931, p. 383, pl. 20, figs. 15a,b.

The anterior hinge plate in the specimens from the Castaic Formation is much broader than in *S. nuttallii. Sanguinolaria alata* Gabb, as described and figured by Clark (1915, p. 476, pl. 61, fig. 14; pl. 62, fig. 5), differs from the specimens in having more pronounced sculpture, a more prominent beak, and a larger nymph plate with a longitudinal groove on it.

The range of *S. nuttallii* is late Miocene to Recent. The species has been reported previously from upper Miocene sediments only in the San Francisco Bay area.

PERIPLOMA cf. P. DISCUS Stearns
Pl. 6, figs. 8,9

Periploma discus STEARNS, 1890, p. 222, pl. 16, fig. 1,2; KEEN, 1958, p. 228, fig. 583.

Except for a small fragment of one valve, all specimens are molds, most are articulated.

The specimens closely resemble *P. discus,* which occurs presently from Monterey, California, to El Salvador and which has been reported from Pliocene sediments in Los Angeles. The shape of the dorsal margin of the Castaic Formation specimens is the same as that of *P. discus* and different from that of any other described species of *Periploma* from the west coast of North America. The specimens also are similar to *P. discus* in having only a short buttress beneath and behind the chondrophore, in having the beak position more central, and in being less inequivalve than other Pacific Coast *Periploma.* The specimens differ from *P. discus* only in being oval rather than nearly circular.

BORING PELECYPODS

Boring pelecypods are found in oyster shells at many localities throughout the Castaic Formation, particularly in the northern part of the outcrop area. They are found most commonly in shells that are broken and worn but also in thick articulated shells.

Shell elongate, inflated, equivalve, thin, poorly preserved, imbedded in shells in very well cemented pebbly sandstone; length about 20 mm., height and diameter about 8 mm. The borings are about 10 mm. in diameter. Most are lined with a variable number of carbonate layers. The lining generally is not of uniform thickness around a boring.

At loc. 2069, a rounded tuff pebble is pitted by several shallow borings about three mm. in diameter. The borings resemble those made by Recent pholads.

GASTROPODA

ASTRAEA cf. A. (POMAULAX) GRADATA Grant & Gale
Pl. 6, figs. 10–12

Astraea (*Pomaulax*) *gradata* GRANT & GALE, 1931, p. 818–819, pl. 31, figs. 1a,1b,3a,3b,5,8,9.

Shell medium to large, conical, about six convex whorls; apical angle 75–80 degrees. Periphery of body whorl is a noded undulating carina; sculpture above the carina consists of two rows of nodes which are similar in size to those of the carina; the nodes on the upper row are elongate, less numerous, and slightly larger than those on the lower row; the number of nodes on the upper and lower rows of the body whorl are in the proportion 14:19. Sculpture on the base of the body whorl consists of a prominent noded spiral rib next to the carina and about three finer unnoded ribs crossed by thread-like growth lines. There is an arcuate depression on the planar outer surface of the columella comparable to that in *A. undosa.* Aperture ovate; opercula, found associated with the specimens but not in place, are ovate, nucleus submarginal near the left side of the thinner, more pointed end (viewing the interior of the operculum with broad end down); the exterior of the operculum is granulose, with two broad low ridges and a small crescentic depression. Granulose texture is most concentrated in the slight depression. Dimensions, in mm., of all the shells collected from several localities are:

Locality	2077			2069	1849			
Height	12	20	25	18	35	30	23	20
Diameter	15	22	31	22	39	35	23	22

The specimens closely resemble *A. gradata*. They differ from it, however, in the following respects: smaller, larger apical angle, more strongly nodose carina and outer basal rib, less angular whorl profile, and less strongly ribbed operculum. Although the opercula from the Castaic Formation were not in place within the shell apertures, there is no other species found to which they can be referred (this is the same situation as for the operculum of *A. gradata* that Grant & Gale described). The operculum of the Castaic Formation species is like that of *A. gradata* in shape and position of the nuclear whorl. It differs markedly, however, in having fewer ridges which are low and broad rather than high and sharply defined.

A. gradata has been reported only from Pliocene sediments of southern California.

LIOTIA CARINATA Carpenter
Pl. 6, figs. 15,16

Liotia carinata Carpenter, STRONG, 1934, p. 440, pl. 28, figs. 1,2,3; pl. 31, figs. 1,2,3.

Shell small, depressed, turbinate, umbilicate; whorls approximately circular in cross-section. Sculpture of beaded spiral ribs and fine axial threads. The ten ribs on the penultimate whorl are all of about equal width except that the ribs at the base and top of the whorl are slightly larger. Two ribs lie along the side of the umbilicus on the inner side of the basal rib. An angular umbilical cord as in *Architectonica* is not present. The periphery of the whorl is not carinate. Interspaces between ribs are slightly wider on the dorsal side of the whorl. The suture between body whorl and penultimate whorl is about one-third of the whorl height above the base of the penultimate whorl. The body whorl is missing—only a mold of part of the dorsal exterior of it is present. Height 4 mm., diameter 6 mm., diameter of last whorl 2 mm. The approximate height and diameter of the specimen, with body whorl present, were 5.5. mm. and 8 mm., respectively. Only one specimen has been found.

This species, restricted in the Recent to the Panamanian province, has not previously been reported as a foss'l.

NERITA sp.
Pl. 6, figs. 13,14

Shell medium size, globose; spire very low, slightly crushed. Shell low, thick, body whorl rapidly expanding; aperture semicircular, broad callus deposit on inner lip extends as shelf out into body whorl, callus thickest at posterior corner of aperture, no detail preserved on callus. Margin of outer lip broken, so no details preserved. Sculpture of 15 to 20 coarse flatly rounded spiral ribs, narrow interspaces, coarse growth lines. Dimensions in mm: height 25, diameter 28.

No post-Eocene occurrence of *Nerita* has been reported from the west coast of the United States. Judging from its low spire, the specimen is probably in the subgenus *Theoliostyla*. It is larger and has fewer spiral ribs than the Pleistocene specimen of *N. bernhardi* from the Gulf of California illustrated by Durham (1950a, pl. 35, figs. 6,9). The specimen has about the same number of ribs as the middle Pliocene *Nerita* sp. from the Gulf of California illustrated by Durham (1950, pl. 35, fig. 5); however, the rib interspaces are less deeply incised in the Castaic specimen. The single specimen found probably represents a new species but is not well enough preserved to be described.

This occurrence of *Nerita* is the only one reported from west North American sediments younger than Eocene and older than middle Pliocene.

TURRITELLA COOPERI Carpenter
Pl. 7, figs. 1–5

Turritella cooperi Carpenter, MERRIAM, 1941, p. 117, pl. 33, figs. 1–4. pl. 34, figs. 9,12–16; pl. 35, figs. 14,15; PALMER, 1958, p. 168, pl. 20, fig. 7.

The species is present throughout the outcrop area but is numerous only at locs. 1625 and 1849, in well-sorted, fine-grained sandstone. The specimens possess a sutural secondary rib at the base of the whorl which is similar to that of *T. margaritana*. They differ from *T. margaritana* in having, in most specimens, only one secondary rib between the two primary ribs.

TURRITELLA aff. T. FREYA Nomland
Pl. 7, figs. 6,7

Turritella freya NOMLAND, 1917, p. 312, pl. 19, fig. 2; MERRIAM, 1941, p. 124, pl. 37, figs. 14,15.

Most specimens are fragmentary, consisting of only several whorls. Sculpture is variable, possessing elements of both *T. freya* and *T. vanvlecki*. On the basis of the median primary rib, the specimens belong in the *T. broderipiana* stock as described by Merriam (1941, p. 50). They are closely related to *T. freya* on the basis of the general pattern of sculpture. They differ from *T. freya*, however, and resemble *T. vanvlecki* in that the basal rib is not so well developed as in the *T. freya*, and a posterior quarter-line secondary is present on some of the specimens. The specimens are close to *T. freya* but are probably transitional to *T. vanvlecki*.

T. freya has been reported from upper Miocene strata of central and southern California. *T. vanvlecki* has been reported from Pliocene strata of central and southern California and Baja California. A form compared to *T. vanvlecki* has been reported from upper Miocene strata of the San Joaquin Valley.

VERMETIDAE

Two forms of irregularly coiled gastropods are present in the Castaic Formation. Irregularly coiled tubules with outside diameter of 1.5 mm., inside diameter of 1.2 mm., nucleus and juvenile whorls not exposed or preserved: locs. 279, 2093, 2085, 2105, 2099, 2081, 2088, all in the northern part of the outcrop area, in pebbly sandstone. Masses of larger, relatively straight tubes. Outside diameter 4.7 mm., inside diameter 3.5 mm. Exterior tube surface smooth, unsculptured: locs. 1663, 1670, in the southern part of the outcrop area, in pebbly sandstone.

?BITTIUM ARNOLDI Bartsch
Pl. 6, fig. 17

Bittium arnoldi BARTSCH, 1911, p. 411, pl. 56, fig. 1.

Shell small, turreted, high-spired, whorl profile flatly convex, suture appressed, whorls five, nucleus $1\frac{1}{2}$ whorls. Aperture oval, margins not preserved. Sculpture consists of four strong spiral cords. One is just below the suture, two are close together on the center of the whorl, and the fourth is low on the whorl. On the larger whorls, secondary cords lie between the primaries and below the lowest primary. About 20 axial ribs are present on the penultimate whorl. The intersection of the axial and spiral ridges forms spirally elongate nodes. Height 15 mm., diameter 5.5 mm.

The size and sculpture of this individual are very close to those of *B. arnoldi*. The specimen cannot be positively identified because the aperture is poorly preserved.

TROCHITA cf. T. TROCHIFORMIS (Born)
Pl. 7, fig. 8

Trochita trochiformis (Born), WOODRING, 1957, p. 81, pl. 19, figs. 11–14.

Shell large, low-spired. Apical whorls have been infilled with shell deposit so that the living chamber consisted of $1\frac{1}{3}$ whorls. Surface of shell bored so that the sculpture of coarse axial ribs is largely destroyed. Shell margin crenulate. Diameter about 90 mm., height about 35 mm. A single specimen was found.

No *Trochita* of similar size has been reported from the Cenozoic or Recent of the west North American coast. The late Miocene forms described from California are much smaller. The diameter of *T. diabloensis* is 55 mm., that of *T. martini* is 43 mm. The Recent species occurring in the northern part of the Panamanian province, *T. spicata*, has a diameter of about 60 mm.

Grant & Gale (1931) and Woodring (1957) place the Tertiary species from California into *T. trochiformis*. This specimen is compared to *T. trochiformis* but is much larger than any previously described individual of the species.

NEVERITA RECLUSIANA (Deshayes)

Polinices (Neverita) reclusianus (Deshayes), GRANT & GALE, 1931, p. 800–803, text figures 13a,b,c.

In terms of the groupings of varieties by Grant & Gale, most of the individuals from the Castaic Formation are the variety *N. andersoni* Clark; the rest, the variety *N. reclusiana* s.s.

FICUS (TROPHOSYCON) OCOYANA (Conrad)
Pl. 7, figs. 9, 10

Trophosycon nodiferum (Gabb), ENGLISH, 1914b, p. 247, pl. 25, figs. 2,4.

The range of morphologic variability is wide among the specimens collected. The spiral sculpture on most of the specimens from the Castaic Formation is not differentiated as strongly as in the variety *F. ruginodosa* Grant & Gale, nor are the nodes triple-pronged. The specimens do not fit readily into the varieties described by Grant & Gale (1931, p. 743–749) but resemble more closely the specimens from Elsmere Canyon illustrated by English (1914). They differ from the variety *F. contignata* Grant & Gale in having weaker and double, rather than triple, nodes. The specimens from localities 231 and 1670 have very low, almost flat, spires, relatively low rounded nodes on the whorl shoulder, and very reduced nodes lower on the whorl. They represent yet another morphologic variant, but their exact shape cannot be determined for they have been deformed by burial.

ANOMALOSIPHO sp.
Pl. 7, figs. 11,12

Most of the fossils are incomplete molds. Shell elongate, thin, of six whorls, spire high, apical angle 30 degrees. Sutures appressed, whorl profile smoothly rounded. Sculpture of sharp narrow spiral ridges separated by broad shallow interspaces several times as wide as the ridges. About 20–25 ridges on body whorl. No axial sculpture. Growth lines inconspicuous except on the body whorl. Sculpture reflected slightly on interior of shell. Aperture elongate, oval, canal short, columella straight, smooth, with thin callus covering; outer lip simple. Dimensions, in mm., of five specimens are:

Height	40	32	43	43	52
Diameter	15	12	15	16	18

This species differs from the described west North American species of *Anomalosipho* in having a higher spire. *Colus riversi* reported from Pliocene sediments of the Ventura basin, is larger and broader with a relatively lower spire. The specimens from the Castaic Formation are very similar in shape to *A. altus* (Wood), as illustrated by Harmer (1914, p. 150, pl. 15, fig. 6) from the Pliocene of England. MacNeil (1957, pl. 12, figs. 2,3) has reported a similar form from Pliocene sediments of northern Alaska.

CANCELLARIA TRITONIDEA Gabb

Cancellaria (Euclia) tritonidea GABB, 1866, p. 11, pl. 2, fig. 18.
Cancellaria tritonidea Gabb, ARNOLD, 1910, p. 31, pl. 26, fig. 10.
Cancellaria tritonidea Gabb, ENGLISH, 1914a, p. 218, pl. 23, fig. 2.

The specimens of *C. tritonidea* in the Castaic Formation can be subdivided into two morphologic groups. All differ somewhat from the holotype of *C. tritonidea*, from the Pleistocene of San Pedro. The specimens of one group are like the specimen from the Pleistocene of San Pedro illustrated by Arnold (1910, pl. 26, fig. 10). They are lower spired than the holotype of *C. tritonidea* as illustrated by Gabb (1866, pl. 2, fig. 18) or the individual illustrated by Woodring et al. (1946, pl. 35, fig. 21) from the Pleistocene of San Pedro. They are similar in shape to *C. perrini* Carson but have more prominent shoulders on the spire whorls. The specimens of the other group are like the specimen from the Pliocene strata of Elsmere Canyon illustrated by English (1914a, pl. 23, fig. 2). They differ considerably from the holotype of *C. tritonidea*, from the other form of *C. tritonidea* from the Castaic Formation, or from the specimens illustrated by Woodring et al. (1946, pl. 35, fig. 21) and by Arnold (1910, pl. 26, fig. 10). They have a higher, more slender spire and more strongly shouldered, angulated whorls. They represent the extreme in whorl profile angularity of the whole group of forms closely related to *C. tritonidea*. The only previously reported occurrence of this latter form is in the Pliocene strata of Elsmere Canyon.

The low-spired forms have been found only at loc. 1849. The higher spired forms have been found at locs. 1849, 2069, 2090.

OLIVA SPICATA (Röding)
Pl. 7, fig. 13

Oliva spicata (Bolten), DURHAM, 1950, p. 103, pl. 29, fig. 1.

A single well-preserved specimen has been found. It differs from *O. simondsi*, found in the Briones Formation of the San Francisco Bay region, in being more slender with less prominent shoulders and in having many more columellar folds, all of about equal strength. It differs from both *O. californica* and *O. futheyana*, found in lower and middle Miocene strata of central and southern California, in being more slender and straight-sided and in having a higher spire and more numerous, uniform plications. *Oliva spicata* and *O. incrassata* are similar, and shells of immature individuals of the two species are difficult to distinguish. Individuals of both species attain a size somewhat larger than the Castaic Formation specimen. This specimen is referred to *O. spicata* because it lacks the much more angular shoulder relatively low on the body whorl characteristic of *O. incrassata*. It is indistinguishable from specimens of *O. spicata* from the Imperial Formation (Hanna, 1926, p. 452, pl. 21, figs. 4,5).

The published range of *O. spicata* is Pliocene to Recent. The Pliocene distribution of the species was the Colorado Desert of California, and the Gulf of California.

MARGINELLA cf. M. ALBUMINOSA Dall
Pl. 7, figs. 14,15

Marginella albuminosa Dall, KEEN, 1958, p. 433, fig. 668.

Shell medium size, subcylindrical, ovoid, thick, smooth; spire very low. Apex of shell barely extends above broadly rounded shoulder of body whorl. Outer lip not preserved, inner lip incomplete, three heavy horizontal plications just below the middle of the inner lip, more may have been present. Aperture narrow, open anteriorly, extending posteriorly over shoulder to suture. Height 25 mm., diameter 19 mm. A single, poorly preserved specimen has been found.

The specimen closely resembles *M. albuminosa* in size and shape and in position and size of the columellar folds. The spire is probably lower than in *M. albuminosa*, but this cannot be determined definitely because the specimen is crushed. It is larger and has a much lower spire than *M. sapotilla*.

Marginella albuminosa has been reported only from the Recent of the west coast of Mexico. This specimen greatly enlarges the known Cenozoic distribution of marginellids in western North America, for previously reported occurrences are limited to the Eocene of California, Oligocene of Washington, Pliocene of Panama, and Pleistocene of Panama, Mexico, and California.

CONUS sp.

A single specimen has been found. Features of spire, shoulder, suture, and ornamentation are not preserved. Height 100 mm., diameter 45 mm. This specimen is noteworthy because large conids, restricted in the Recent along the west North American coast to the Panamanian Molluscan province, are rare in the Tertiary strata of the California Coast Ranges. *C. hayesi* has been reported from middle Miocene strata of southern California and the San Joaquin Valley; *C. beali*, from Pliocene strata of southern California. This specimen is too poorly preserved to be compared with them except in size—it is much larger than either. The two Recent species of comparable size, *C. regularis* and *C. fergusoni* are also found in Pleistocene and Pliocene sediments along the Pacific Coast of Mexico and in the Gulf of California embayment.

Antiplanes sp.
Pl. 7, fig. 16

A single incomplete specimen has been found. It is large, dextral, fusiform, with very high spire; whorls are only slightly convex. Shell smooth except for faint spiral sculpture and growth lines on body whorl. Spiral sculpture of fine impressed widely-spaced lines is poorly preserved. Anal fasciole narrow, rounded, very close to suture. Suture oppressed. Outer lip not preserved; inner lip smooth, straight; columella straight. Aperture narrow, elongate, extending into a long straight canal. Incomplete height 47 mm., complete height probably not less than 65 mm.; diameter 15 mm.

No species from the Recent or Tertiary of western North America has been described which closely resembles this specimen. *Antiplanes litus* resembles it closely in shape but is much smaller. *A. major* is similar in shape and size but is sinistral rather than dextral.

The specimen differs from these and other described species in three distinctive ways: The inner lip is long and straight; the canal is relatively long and straight; the outline of the anterior part of the body whorl is only very slightly concave.

Surculites (Megasurcula) remondii (Gabb)

?*Metula remondii* Gabb, 1866, p. 3, pl. 1, fig. 5.
Megasurcula remondii (Gabb), Weaver, 1942, p. 528, pl. 98, fig. 6.

The angularity of the shoulder and the prominence of the sculpture is variable in this species. The specimens from the Castaic Formation are like the specimens figured by Grant & Gale (1931, pl. 25, figs. 5,6) from the lower Pliocene strata of the Fernando Pass area, Los Angeles County. The lectotype figured by Stewart (1926, pl. 31, fig. 5) has more subdued, rounded shoulders.

Clavus cf. C. (Cymatosyrinx) hemphilli (Stearns)

Pleurotoma (*Drillia*) *hemphilli* Stearns, 1873, p. 80, pl. 1, fig. 3.
Clavus (*Cymatosyrinx*) *hemphilli* (Stearns), Grant & Gale, 1931, p. 577, pl. 26, fig. 8.

The single specimen found differs from *C. hemphilli* in lacking spiral sculpture and in being larger. The height of the incomplete shell is 18 mm.; about 3 mm. of spire is missing. The diameter is 7 mm. The specimen is similar to *C. johnsoni* Arnold (1903, p. 206, pl. 8, fig. 17) but is smaller and has a less sculptured sutural band.

The range of *C. hemphilli* is Pleistocene and Recent of southern California and Baja California.

Acteon cf. A. boulderana Etherington
Pl. 7, fig. 17

Acteon boulderana Etherington, 1931, p. 113, pl. 14, fig. 9; Keen, 1943, p. 42, pl. 4, fig. 22.

The specimen differs from *A. boulderana* as illustrated by Keen (1943, pl. 4, fig. 22) in having a more strongly developed columellar fold and a slightly lower spire.

SCAPHOPODA

Dentalium sp.
Pl. 7, fig. 21

Shell medium size, slightly curved, shell extremities not preserved; sculpture of 12 rounded ribs, interspaces wider than ribs, no finer ribs are intercalated towards the anterior end of the shell, the 12 ribs are strongly developed from one end of the shell to the other. Length of shell about 30 mm.; anterior diameter 3 mm., posterior diameter about 1.5 mm., wall thickness about 0.3 mm.

The sculpture of this species is different than that of any species previously described from the Cenozoic of western North America. All those species described that have about 12 ribs have a variable number from one end of the shell to the other, adding new ribs between the old as the shell becomes longer.

BRACHIOPODA

Terebratalia occidentalis Dall

Terebratalia occidentalis Dall, 1871, p. 183, pl. 1, fig. 7; Hertlein & Grant, 1944, p. 127.

Most of the specimens are articulated. All occur in coarse-grained to pebbly sandstone. The specimens from localities 1663 and 1670 are more strongly ribbed; those from localities 231 and 233 are smoother and less broad. The range of variability includes forms that could be identified as *T. occidentalis*, *T. obsoleta*, *T. arnoldi*, and *Miogryphus willetti*. However, Mattox (1955) has shown that similar variability is present within a single population of living *T. occidentalis*.

ECHINODERMATA

ASTRODAPSIS FERNANDOENSIS Pack
Pl. 7, fig. 22

Astrodapsis fernandoensis PACK, 1909, p. 279, pl. 24, figs. 3,4; GRANT & HERTLEIN, 1938, p. 72, pl. 25, figs. 4,5; Hall, 1962, p. 76, pl. 33, figs. 8,10.

Astrodapsis occurs throughout the northern and central part of the Castaic Formation, but specimens are, in general, poorly preserved. Only molds have been found at locality 1671, but surface details are well preserved on these. Fragments and whole tests from localities 232, 2084, 2087, 2092, 2100, and 2070 indicate the shape and size of the species, but surface features are poorly preserved. In addition to these occurrences of tests, at some of which spines have also been found, spines alone have been found at localities 2074, 2075, 2102, 2073, 2085, 2093, 2103, 2083, 2086, 1670, 2095, 2091, 2099, and 2105.

Astrodapsis specimens collected by geologists in the past from the Castaic Formation in the Haskell Canyon-San Francisquito Canyon area have been compared with *A. tumidus*, *A. whitneyi*, and *A. fernandoensis* (Woodring, 1930; Durham, 1948; White & Buffington, 1948). In this study, however, all the specimens sufficiently well preserved to be identified are referred to *A. fernandoensis* on the basis of the large tubercles, the slightly pointed posterior margin, and the relatively flat, uninflated test. *A. fernandoensis* has been reported only from the lower Pliocene strata of Elsmere Canyon.

Cidarid spines
Pl. 7, figs. 18–20

Two types of echinoid spines have been found in the Castaic Formation. Those from locality 2069 are characterized by few large nodes in annular clusters. The spines from locs. 1670, 2094, and 2105 have many smaller spinose nodes arranged in longitudinal rows. The arrangement of nodes is different on opposite sides of the spines. Both types of spines are cylindrical, 3 to 4 mm. in diameter. All are incomplete; the length of the longest is 27 mm.

BRYOZOA

Encrusting bryozoa have been found at two localities. At locality 1663, they line part of the interior of the body whorl of a large gastropod, probably *Ficus* (*Trophosycon*). At locality 2075 they cover the inside of a large *Lyropecten crassicardo* valve and several gastropod shells within the *Lyropecten*.

ARTHROPODA

BALANUS sp.

Whole specimens attached to shells or loose in the sediment and single compartments, but no opercular plates have been found. Individuals were up to 20 mm. in height and diameter. The fossils are identified as *Balanus* on the basis of wall microstructure.

VERTEBRATA

The following vertebrate fossils have been found in the Castaic Formation:

Two shark teeth, both nonserrate; elongate, triangular. The one from locality 2093 is 24 mm. high including the base, 23 mm. wide at the base. That from locality 1663 has corresponding measurements of 21 and 17 mm.

Fish vertebra, 20 mm. long, 23 mm. in diameter, from locality 2069.

Bone fragments from localities 1663, 1670, 2069, and 2089.

Fish skeleton, incomplete, poorly preserved, locality 1626, length at least 40 mm.

Fish scales are common throughout the formation in the mudstone facies.

CLIONID? BORINGS

Borings are common in pelecypod shells throughout the formation but are most abundant in the northern part of the outcrop area. They are 0.5 to 1 mm. in diameter. The organism causing them is unknown, although they are like the borings formed by clionid sponges. The borings are most abundant in large valves of *Crassostrea titan* but also occur in large *Lyropecten* valves. The boring organism was active on the shells of living pelecypods. Whether it was also on empty shells is not clear.

LOCALITIES

All fossil localities cited are California Institute of Technology localities. Descriptions of locations are based on the following U.S.G.S. topographic quadrangle maps: Newhall, 1952; Sylmar, 1935, reprinted 1944; Humphreys, 1932, reprinted 1946; Violin Canyon, 1937, reprinted 1951; Red Mountain, 1936, reprinted 1943; Redrock Mountain, 1936, reprinted 1942.

Locality

230—NW¼, sec. 36, T 5N, R 16W. 800 ft W of Haskell Canyon. North Limb of anticline near crest. Conglomerate about at base of formation.

231—NW¼, sec. 36, T 5N, R 16W. 750 ft W of Haskell Canyon, 150 ft S of N sec. line. S slope of steep ridge near crest. About 70 ft above base of formation.

232—NW¼, sec. 36, T 5N, R 16W. Same location as 231 but 15 ft stratigraphically higher, at top of ridge.

233—NW¼, sec. 36, T 5N, R 16W. 1500 ft W of Haskell Canyon, 900 ft S of N sec. line. North slope of dip slope ridge near head of canyon. A few feet stratigraphically above 232.

234—E½, sec. 32, T 5N, R 16W. 75 ft W of E section line NW of 1900-ft hill on E section line; coarse-grained sandstone bed.

277—W¼, SW¼, NW¼, sec. 18, T 5N, R 16W. W bank at junction of Castaic and Elizabeth Lake Canyons. Mudstone.

279—NW¼, sec. 7, T 5N, R 16W. W side of northerly trending tributary to Elizabeth Lake Canyon.

1623—E½, sec. 6, T 4N, R 15W. Roadcut north side of Bouquet Canyon Road, SW side of low hill W of 1429.

1624—NW¼, sec. 36, T 5N, R 16W. Top central portion of central ridge in ampitheatre on anticline axis. 75 ft above base of formation; 100 yrds SE of 232. Coarse-grained sandstone.

1626—NW¼, NW ¼, sec. 2, T 3N, R 15W. 150 ft S of N section line on S end of hill 2323. Diatomaceous mudstone.

1627—NE¼, sec. 27, T 4N, R 15W. On NW trending ridge, S 34° W from NE section corner. Pebbly sandstone.

1663—W¼, NW¼, SW¼, sec. 27, T 4N, R 15W. S side of W trending ridge, 150 ft E of W section line, 75 ft N of S edge of Humphreys Quad. sheet.

1670—Center of SW¼, SE¼, SE¼, sec. 26, T 5N, R 16W. N side of small W trending valley E of Dry Canyon Dam. Pebbly sandstone bed in mudstone.

1671—E edge of SE¼, NE¼, SE¼, sec. 26, T 5N, R 16W. Bottom of small canyon tributary to Haskell Canyon. 1500 ft N of SE section corner. Fine-grained sandstone.

1849—SW¼, SE¼, sec. 35, T 4N, R 15W. On ridge W of junction of Reynier and Sand Canyons. S 24° W of NW section corner.

2069—W¼, NW¼, SW¼, sec. 27, T 4N, R 15W. S edge of Humphreys Quad. sheet, 150 ft E of W section line. Down slope from 1663. Basal pebble conglomerate.

2070—E bank of S trending tributary to Castaic Creek. 3100 ft N 9.5° E from SW corner sec. 25, T 6N, R17W. Basal pebble conglomerate.

2071—E bank near mouth of same canyon as 2070. 2400 ft N 11° E from SW corner sec. 25, T 6N, R 17W. Fossiliferous sandstone and conglomerate unit interbedded in mudstone.

2072—NE bank of Castaic Canyon just outside mouth of tributary canyon containing 2070, 2071. 2300 ft N 12° E from SW corner sec. 25, T 6N, R 17W. Sandstone bed in mudstone; 15 ft stratigraphically above 2071.

2074—WSW of shelter house in upper Castaic Canyon, Redrock Mtn. Quad. on ridge top SW of hill 2734 where 118°40′ line crosses ridge. Basal pebble conglomerate.

2075—W¼, NE¼, NW¼, sec. 31, T 6N, R 16W. N side of W flowing tributary to Elderberry Canyon. Massive pebble conglomerate bed overlying basal cobble conglomerate.

2077—NW¼, SE¼, NW¼, sec. 31 T 6N, R 16W. Crest of ridge SE of Elderberry Canyon. S 41° E from NW section corner. Pebbly sandstone.

2081—SE¼, NE¼, NW¼, sec. 31, T 6N, R 16W. Sandstone bed capping ridge summit.

2082—E¼, NE¼, NW¼, sec. 31, T 6N, R 16W. 2650 ft S74° E from NW section corner. Basal pebble conglomerate.

2083 to 2089—These localities and 2102 and 2103 are on a broad flat ridge NW of Castaic Creek, at the N edge of sec. 26, T 6N, R 17W and just under the ON in National on the Violin Canyon Quadrangle map. All localities are in the basal sandstone to conglomerate member of the formation.

All distances and directions measured from NW corner sec. 26, T 6N, R 17W.

2083—2190 ft N 86° E. Lowest unit exposed in stream-cut bank at W end of ridge. Cobble conglomerate.

2084—2200 ft N 85 ° E. 10 ft N of 2084, face of small cliff. Pebbly sandstone overlying 2083.

2085—2220 ft N 88° E. SE end of small cross ridge. Pebbly conglomerate overlying 2084.

2086—2210 ft N 86° E. Top of small cross ridge, top of cliff above 2083. Fine to pebbly sandstone overlying bed containing 2085.

2087—2400 ft S 88° E. Dip slope of sandstone underlying conglomerate of 2083.

2088—2900 ft N 78.5° E. Cliff on N side of ridge. Pebbly sandstone tongue in cobble conglomerate. Correlative with beds containing localities 2084–2086.

2089—3250 ft N 78.5° E. E side of ridge top below saddle. Pebbly coarse-grained sandstone.

2090—NW¼, sec. 31, T 6N, R 16W. Ridge top at 2100 ft elev., 3150 ft S 63° E from NW section corner. Pebbly sandstone bed.

2091—NE¼, SW¼, sec. 31, T 6N, R 16W. Rim of small canyon SW of hill 1986. 1800 ft elev. N 45° E from SW section corner. Pebbly sandstone.

2092—NW¼, NE¼, sec. 26, T 6N, R 17W. E side Castaic Canyon, S 71° W from NE section corner at 1700 ft elev. Dip slope of upper surface, basal conglomerate.

2093—NE side of Castaic Canyon, at 1860 ft elev., 2550 ft N 8° E from BM 1458, sec. 25, T 6N, R 17W. Basal conglomerate.

2094—SE bank of main tributary entering Castaic Creek N of Cordova Ranch, sec. 36, T 6N, R 17W. 1500 ft N 31° E from Ranch. Mudstone.

2095—E side Castaic Canyon, 2010 ft elev. 3000 ft S 82° E from intersection of 118°40′ and N edge, Violin Canyon Quad. map. N side of ridge top. Pebbly basal sandstone.

2096—NE¼, NE¼, sec. 36, T 6N, R 17W. 1710 ft elev. 1600 ft N 83° E from Cordova Ranch. Pebbly sandstone bed in mudstone. Correlative with 2077, 2081, 2107.

2097—SW¼, SE¼, sec. 1, T 5N, R 17W. N bank of narrow canyon, 2350 ft N 60.5° E from Daries Ranch. Sandstone.

2098—NE¼, sec. 12, T 5N, R 17W. E bank of Castaic Creek under low stream terrace. 3500 ft S 58.5° E from Daries Ranch. Friable coarse-grained sandstone.

2099—3750 ft N 72.5° E from Cordova Ranch, sec. 36, T 6N, R 17W. 2025 ft elev. Sandstone bed with abundant *Crassostrea titan*. Within the basal sandstone-conglomerate member.

2100—100 ft E of 2099, on ridge summit. Pebble conglomerate. Overlying the basal cobble conglomerate.

2101—W side of Castaic Creek, Redrock Mtn. Quad.

2100 ft elev. 4250 ft N 30° W from 1668 BM at Castaic Creek-Fish Creek junction. Dip slope of upper surface of basal member of formation. Medium-grained sandstone.

2102—NW¼, NE¼, sec. 26, T 6N, R 17W. 2830 ft S 82.5° E from NW section corner. S end of ridge containing locs. 2083–2089 and 2103. Ridge top S of small gulley cut into ridge.

2103—2850 ft N 81° E from NW corner sec. 26, T6 N, R 17W. Cliff on N side of ridge. 100 ft S of 2088 in same pebbly sandstone bed.

2104—E of junction of Castaic and Fish Creeks. 1750 ft elev. 350 ft S 55° E from 1668 BM. Pebble conglomerate 4 ft above basal contact.

2105—E of junction of Castaic and Fish Creeks. 1825 ft elev. 600 ft S 42° E from 1668 BM. Dip slope upper surface of basal conglomerate.

2106—75 ft NE of loc. 2099. Ridge crest north of Elderberry Canyon. Sandstone bed stratigraphically midway between 2099 and 2100.

2107—SW¼, NW¼, sec. 31, T 6N, R 16W. 2100 ft S 21.5° E from NW section corner. Pebbly sandstone bed containing also 2077, 2081, 2096.

2108—NE¼, sec. 26, T 6N, R 17W. 1650 ft elev. S 75° W from NE section corner. 225 feet NW from 2092. Basal pebbly sandstone.

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(*Explanation of Plate 7 is on following page*)

EXPLANATION OF PLATE 7

FIGS. *1–5*—*Turritella cooperi* Carpenter, ×2, CIT locality 1849, showing variability in sculpture.

6,7—*Turritella* aff. *T. freya* Nomland, ×2, CIT locality 1849.

8—*Trochita* cf. *T. trochiformis* (Born), ×0.5, CIT locality 1663; body whorl preserved as internal mold with only a small amount of shell preserved; infilled and bored apex visible above.

9,10—*Fiscus (Trophosycon) ocoyana* (Conrad); *9*, ×1, CIT locality 279, typical form; *10*, ×1, CIT locality 2069, specimen approaching variety *contignata* in sculpture.

11,12—*Anomalosipho* sp., CIT locality 1671; *11*, ×2, *12*, ×1.

13—*Oliva spicata* (Röding), ×1, CIT locality 230.

14,15—*Marginella* cf. *M. albuminosa* Dall, ×1.5, CIT locality 2069; lateral and apical views of same specimen.

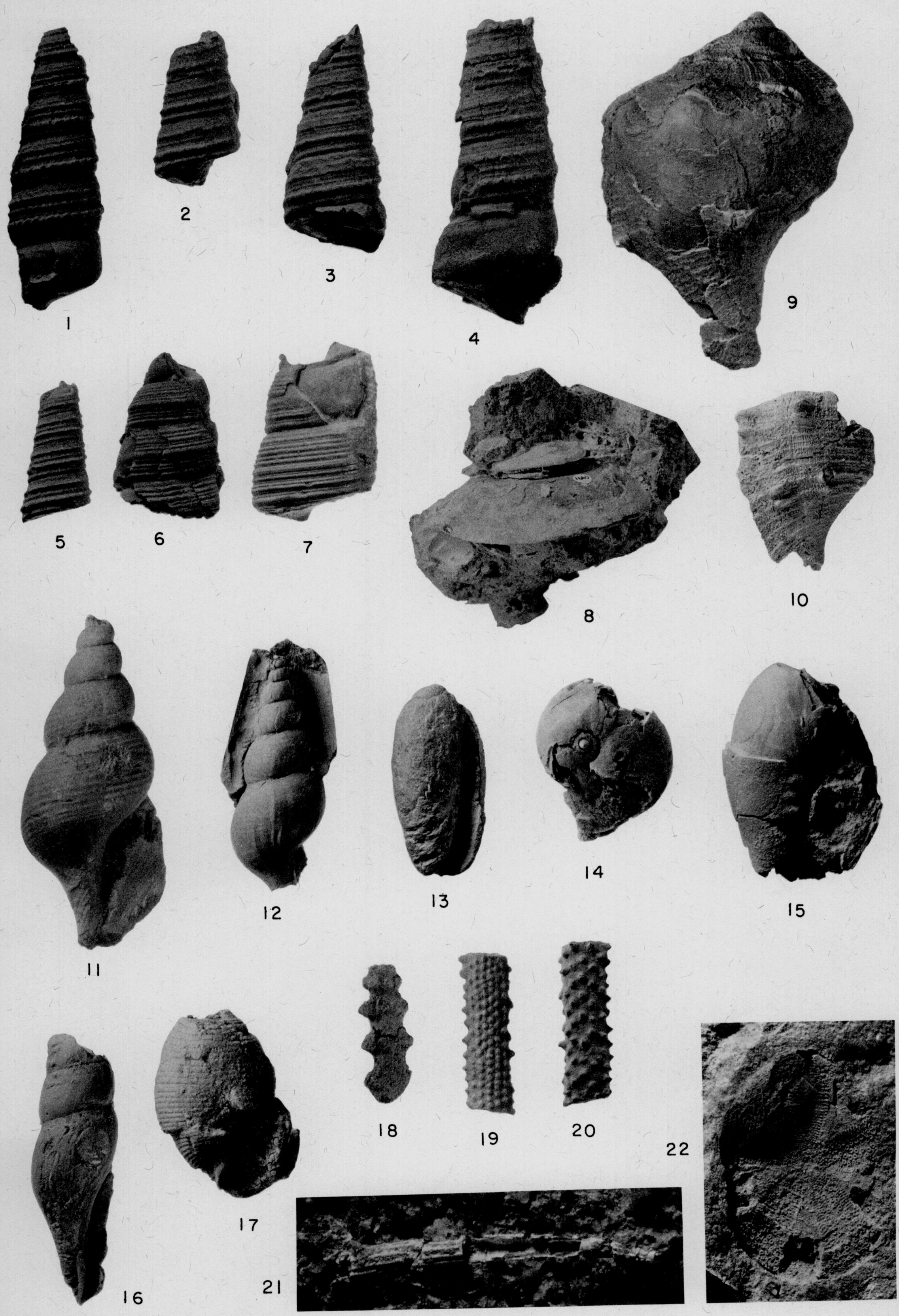
16—*Antiplanes* sp., ×0.5, CIT locality 1849.

17—*Acteon* cf. *A. boulderana* Etherington, ×2, CIT locality 2093.

18–20—Cidarid spines; *18*, ×2, CIT locality 2069, spine with annular nodes; *19*, *20*, ×2, CIT locality 2094, opposite sides of single specimen.

21—*Dentalium* sp., ×2, CIT locality 1670.

22—*Astrodapsis fernandoensis* Pack, ×1, CIT locality 1671, mold of dorsal surface.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