AGE OF THE "MODELO" IN HASKELL CANYON, EASTERNMOST VENTURA BASIN, CALIFORNIA

by

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ILLUSTRATIONS

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ABSTRACT

An invertebrate fauna from the "Modelo" formation in Haskell Canyon, easternmost portion of the Ventura Basin, California, is listed and discussed. An Upper Miocene age, Neroly stage, is assigned to the fauna on the basis of Astrodapsis cf. tumidus, Astrodapsis cf. whitneyi, Pecten (Lyropecten) crassicardo, Turritella carrisaensis, Pecten (Aequipecten) discus, and Ostrea titan s.s. The Haskell Canyon fauna is correlated with the Santa Margarita s.s. and the Neroly formation of the San Pablo Group, and is shown to be older than the Jacalitos and the Elsmere Canyon faunas. A new species of Anadara is described.

INTRODUCTION

The "Modelo" formation, representing the marine Miocene in the easternmost portion of the Ventura Basin, has long been of interest to geologists. During the period from 1930 to 1939 there was considerable discussion regarding the age of these marine sediments as they appeared to be one key to the age of the underlying continental formation, The Mint Canyon.

To date, a rather scanty invertebrate assemblage has been used as a basis for assigning an upper Miocene age, correlative with the Neroly of the San Pablo Group of central California, to the "Modelo". It is the purpose of this paper to introduce an expanded invertebrate fauna in support of this age determination.

Invertebrate collections were made from an anticlinal exposure of the "Modelo" in Haskell Canyon, Los Angeles County, California, where approximately 670 feet of "Modelo" sandstones, siltstones and shales are exposed lying unconformably upon the terrestial Mint Canyon formation. Unconformably overlying the "Modelo" section at the top of the exposure is the Pliocene-Pleistocene Saugus formation. The collections were supplemented with specimens collected by W.P. Woodring, B.L. Clark, T.L. Clements, G.A. Cummings and J.H. Maxson from the same general area. These specimens were reviewed by the writer and have been included in the faunal list where appropriate and some of them are discussed in the succeeding pages.

Several days were spent in making the collections and the area between Haskell and Bouquet Canyons, portions of which are included on the accompanying map, (Plate 1, in pocket), was mapped by the writer in ten days during the spring and fall of 1946.

ACKNOWLEDGEMENTS

The writer is indebted to Dr. J. Wyatt Durham for his helpful guidance in the collection and determination of the fauna, for his critical review of the manuscript, and for making available the earlier collections of Woodring, Clark, Clements, Cummings and Maxson. Mr. E. C. Buffington and Mr. J.S. Martin measured the section exposed in the Haskell Canyon anticline, and Mr. Buffington drafted the columnar section appearing in this report. The writer is further indebted to Mr. Martin and to Dr. Richard H. Jahns who furnished map data to the west of Haskell Canyon and in the Bouquet Canyon area, respectively. Mr. Toshio Asaeda has kindly prepared the two excellent plates of the fossils.

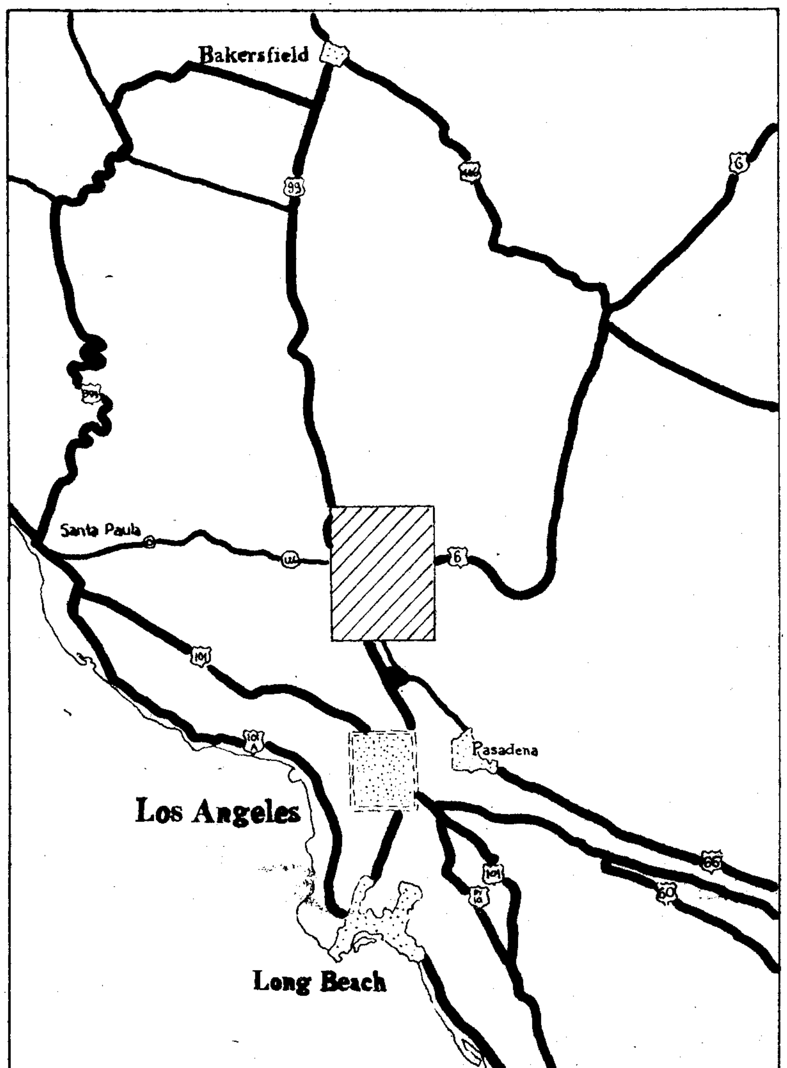


Fig. 1 Index map. Lined area shown in detail in Fig. 2

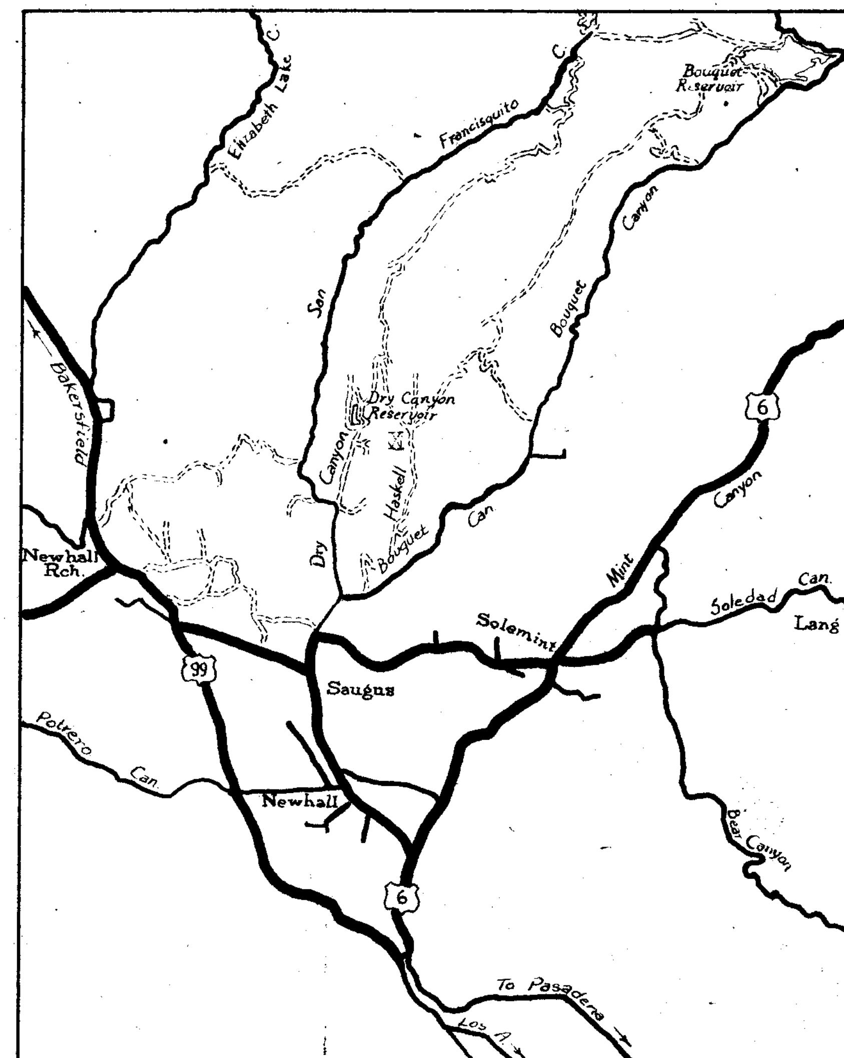


Fig. 2 Generalized map of Haskell Canyon Area. Anticlinal exposure is marked X

INDEX MAPS SHOWING LOCATION OF HASKELL CANYON EXPOSURE OF THE "MODELO"

HISTORICAL REVIEW

Kew, (1924, p. 68-69), recorded the following invertebrate fauna, determined by B.L. Clark, from the "Modelo" following reconnaissance mapping in 1919.

Amphissa, n.sp.
Ostrea titan Conrad
Pecten crassicardo Conrad
Pecten raymondi Clark

These specimens came from two localities, one west of the forks in Haskell Canyon in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 36, T.5 N., R.16 W.; the other directly east of the Los Angeles Aqueduct resevoir in Dry Canyon in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 26, T.5 N., R.16 W. Woodring, (1930, p. 155), added *Astrodapsis* cf. *tumidus* Remond to the fauna, and an Upper Miocene, (Neroly stage), age was assigned to the "Modelo" on the basis of the *Astrodapsis* and *Ostrea titan*.

Maxson, (1930, p. 85-86), referred the underlying Mint Canyon formation to the Upper Miocene on the basis of its vertebrate fauna. In a subsequent critical review of Maxson's paper, Stirton, (1933, p. 576), held the Mint Canyon to be Lower Pliocene in age, believing it equivalent to the Ricardo beds of the Mohave desert. Maxson's Mint Canyon vertebrate fauna, as ammended by Stirton, consists of the following forms:

Aelurodon sp.
Hypolagus cf. *apachensis* Gazin
Trilophodon sp.
Hipparion cf. *mohavense* Merriam
?*Nannippus* sp.
Pliohippus sp.
Rhinoceros fragments
?*Prosthenops* sp.
Alticamelus ? sp.
Merycodus near *necatus* Leidy
?*Merycodus* sp.

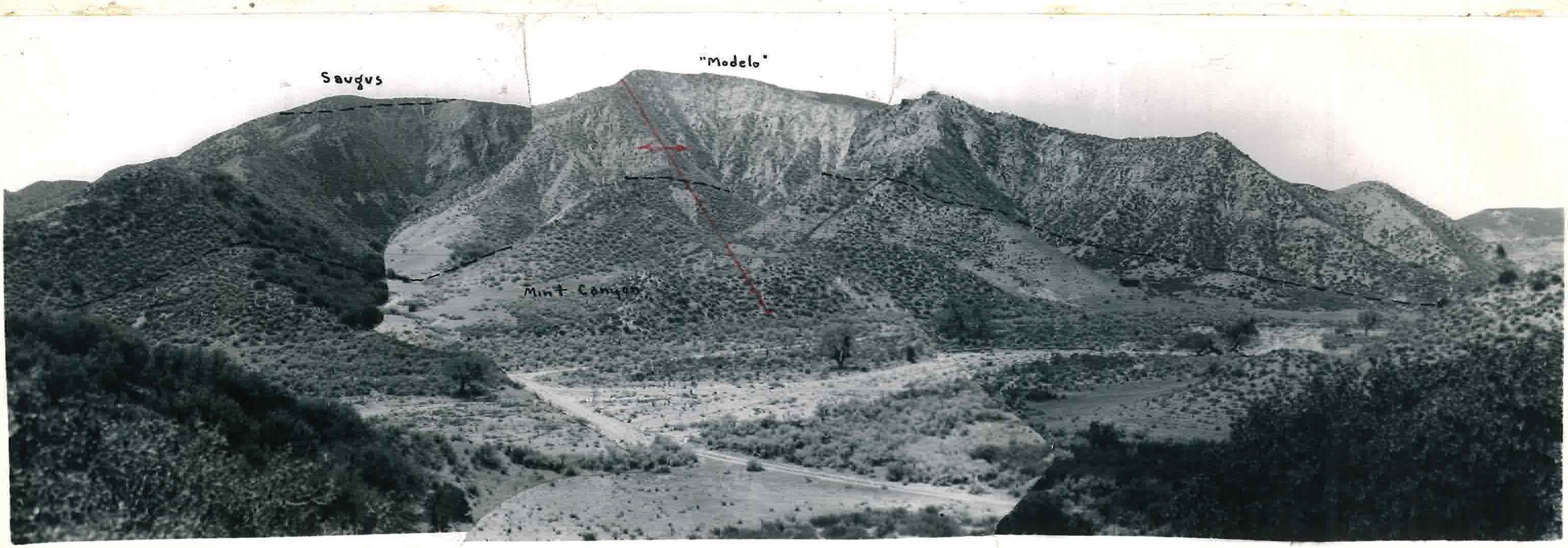
The appearance of the Equid genus *Hipparion* has been used by many vertebrate paleontologists as an index fossil of the Lower Pliocene, and accordingly the fauna has been feferred to the Clarendonian stage, (Wood, et. al., 1941, Pl. 1). The lack of an Upper Miocene or Lower Pliocene invertebrate tie-in with the European section and the controversial vertebrate correlation with the European section, based on the Equid genus *Hipparion*, leave us, in Haskell Canyon, with a conventional Pacific Coast Upper Miocene marine formation lying unconformably upon Lower Pliocene terrestial sediments. This problem was recognized by Reed and Hollister, (1936, pp. 1586-1588), when they wrote, "the Lower Pliocene of most vertebrate paleontologists is at least in part the equivalent of the Upper Miocene of the invertebrate paleontologists".

A similar situation is recorded from the Los Angeles Basin where an Equid tooth referred to *Hipparion mohavense* by Stock, (1928, pl 49-53), was discovered in the Puente formation. According to Wissler, (Woodring, 1938, p. 18), the diatomaceous shale from which the tooth was collected is of Miocene age in terms of the invertebrate time scale.

An invertebrate collection from the "Modelo" made by Maxson, (1938, pp. 1716-1717), identified by U.S. Grant, IV, and listed by Jahns, (1940, p. 167), substantiated the Upper Miocene age determination and the correlation with the Neroly stage of the San Pablo Group.

The forms identified by Grant are as follows:

Astrodapsis cf. *A. tumidus*
Terebratalia occidentalis
Terebratalia occidentalis obsoleta
Amphissa sp.
Anadara osmonti
Anadara obispoana
Pecten raymondi
Aequipecten discus
Lyropecten crassicardo
Lyropecten cf. *estrellanus*
Ostrea titan



Panoramic view of the Haskell Canyon Anticline, Looking west across Haskell Canyon

Astraea aff. *biangulata*
Polinices sp.
Tegula sp.

Hughes, (Kleinpell, 1938, p. 71), reported a meager foraminiferal assemblage from the "Modelo" in this area, including *Uvigerina hootsi*. Accordong to Kleinpell, (1938, pp. 114, 129, 150), this species is abundant in the lower Delmontian, (Uppermost Miocene), common in the upper Mohnian, and scarce in the lower Mohnian. He has not recorded it from strata younger than the lower Delmontian, but lists it as characteristic of the Modelo formation, where it is common from the basal beds to the upper shale member of Hoots.

STRATIGRAPHY

GENERAL STATEMENT

Since Cretaceous time, vast quantities of sediments have accumulated in the Ventura Basin, a great structural trough between the Santa Monica Mountains on the south and the Santa Ynez Mountains on the north. The stratigraphic relationship between the western portion of the basin and its eastern portion, which lies totthe north of the San Gabriel Mountains, is relatively obscure and difficult to establish. The nature of the sedimentation , in part marine and in part continental, necessitates a rather exact correlation between the vertebrate time scale and the invertebrate time scale of the Pacific Coast. Unfortunately vertebrate remains are exceedingly scarce in such important formations as thenSespe and the Mint Canyon, while large parts of the marine section, such as the Modelo, are almost entirely lacking in megafossils. Although correlation has been accompolished within the marine sediments through their microfauna, the foraminifera tend to disappear in the strandward facies of the marine formations.

As a result much of the early mapping in the basin was based on lithologic variations in the sediments, and lithologic characters were used in establishing and limiting the formations which were named. While valuable within its limitations, this proceedure shed little light upon the fundamental problem of the nature of the sedimentation of the basin.

The necessity for establishing proper time boundaries has long been recognized and much has been done toward this end by many workers. The difficulties to be overcome, however, are manifold. Not only is there a paucity of fossil evidence but the deposition of marine sediments during the Miocene is characterized by essentially conformable, progressive marine overlap. Older marine sediments and their terrestial equivalents are steadily encroached upon by younger marine sediments. The lithologic and faunal differences between basinward facies and shoreward facies of units of the same age, coupled with the lack of fossil evidence, accounts in large measure for the difficulties encountered in attempting to classify the sediments into time units.

In the easternmost portion of the Ventura Basin, with which we are primarily concerned, the oldest rocks present are the basement complex of pre-Cretaceous crystalline metamorphics. To the south, and partially covering the basement complex, is a thick section of Tertiary sedimentary rocks, largely nonmarine, with the exception of the "Modelo". The surface sediments decrease in age to the south and west and form a part of the northern flank of a large synclinorium, the axis of which runs generally east and west down the center of the Santa Clara Valley.

Fig. 1 View along the axis of the Haskell Canyon anticline, looking east into Haskell Canyon. Steeply dipping beds are Mint Canyon

Fig. 2 West view along anticlinal axis. The same hill is in the foreground of both pictures

BASEMENT COMPLEX

The basement complex consists of a series of metamorphic rocks and younger igneous intrusives. According to Jahns, (1940, p. 153), the fine grained, bluish-grey schist which appears to be most abundant is a part of the Pelona schist. Associated with it are minor amounts of hornblende rich schist, quartzite and phyllite. Later intrusions have introduced "spotted diorites", porphyroblastic gneisses, syenite and granodiorite. Assuming that the intrusions are related to the Sierran plutonics, a pre-Cretaceous age may be assigned to the basement complex.

VASQUEZ SERIES

The steeply dipping Vasquez series is exposed in a small area just to the west of Bouquet Canyon, faulted against the basement complex. It consists of earthy, red to light grey and buff, coarse sandstones and conglomerates. As yet, no fossils have been reported from the Vasquez. On a lithologic basis, Kew, (1924, pp. 38-39), correlated them with the non-marine Sespe formation in the western part of the Ventura Basin, and assigned them a doubtful Oligocene age, in which Jahns, (1940, p. 153), concurrs.

MINT CANYON FORMATION

The Mint Canyon formation lies unconformably upon the Vasquez series and, in Haskell Canyon, unconformably upon the basement complex. This latter contact appears to be depositional against the older Vasquez fault scarp. No attempt was made to separate the Mint Canyon into time or lithologic units, except in the case of the readily distinguishable tuff beds which were mapped seperately.

As exposed in Haskell Canyon, the Mint Canyon sediments consist of interbedded sandstones and conglomerates, with lesser amounts of siltstones, clays and volcanic tuffs. The sand content increases downward for 3000feet stratigraphically, which represents the total exposed section in this area. The uppermost beds are predominately grey, grading to brown and grey in the middle of the section. Coarse red sandstones and interbedded, greyish to reddish silts predominate in the lower third of the section.

The detailed section of the Mint Canyon measured by Jahns, (1940, pp. 155-162), exceeds that exposed in Haskell Canyon by over 1,000 feet. A lithologic comparison of the two sections has convinced the writer that the bottom one quarter of Jahns' section is missing in Haskell Canyon. Since the contact with the basement complex is a sedimentary one, exhibiting no indication of post-Mint Canyon faulting, the loss of the basal beds seems to indicate a gradually expanding basin of deposition during Mint Canyon time, with gradual terrestial overlap of the sediments as the basin expanded laterally by filling and erosion around its margins.

A wildcat oil well, the Roy Young Incorporated, Walker No. 1, drilled at the intersection of Haskell and Bouquet Canyons, indicates that the basal beds are present there at depth, at least in part. The first cores, taken at 1,300 feet, were of Mint Canyon sandstone. The depth to the base of the marine Miocene, ("Modelo"), was not established. The upper portion of the Mint Canyon, as described in the driller's log, resembles the outcrop section to the north. Beneath this several thousand feet of shales and siltstones, with occasional sandstone beds containing fresh water fossils, were penetrated.

Fig. 1 "Modelo" - Mint Canyon unconformity

Discordance of dip is over 10°

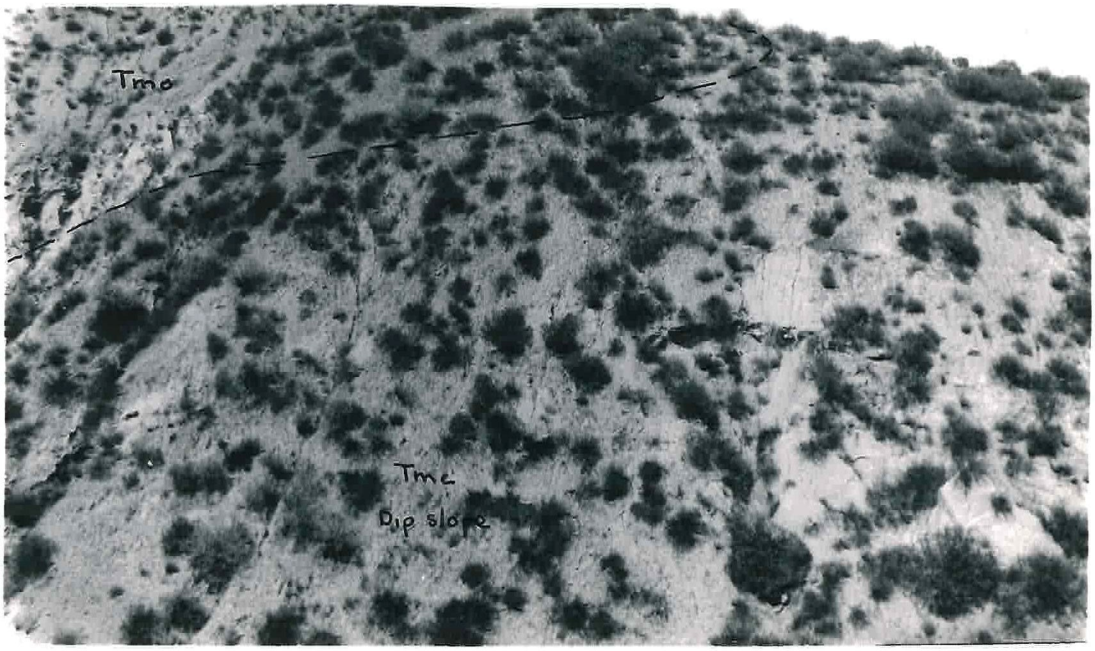


Fig. 2 View of unconformity showing side of hill just

to the right of Fig. 1

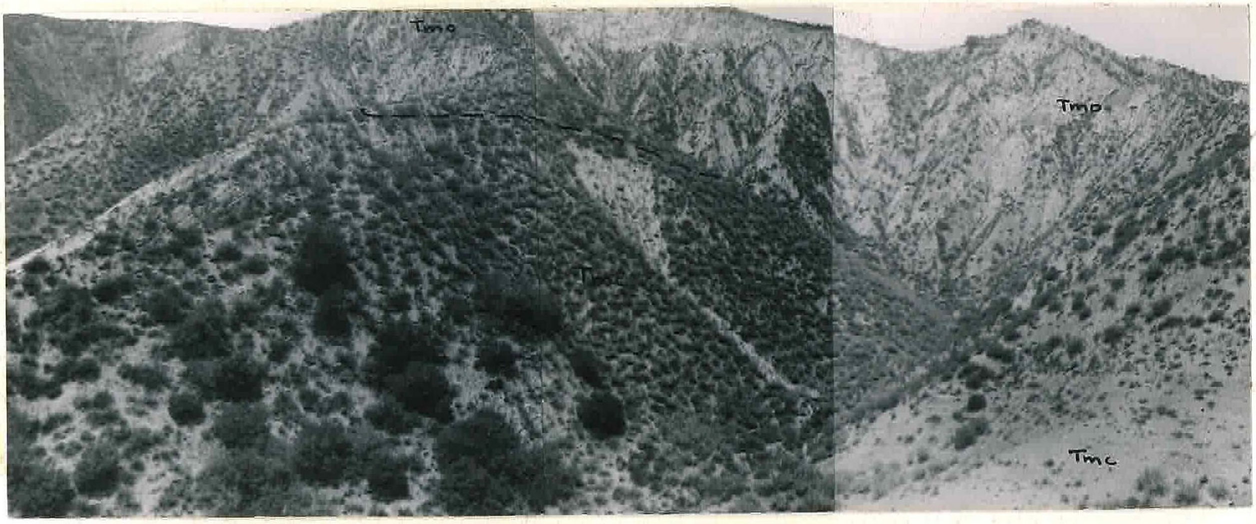


Fig. 1 Panoramic view of the crest of the Haskell Canyon anticline, looking west, showing "Modelo" shales lying unconformably on Mint Canyon arkose, (at left)

Fig. 2 Contact between the Mint Canyon and the "Modelo" in canyon shown in Figure 3.

Fig. 3 Southern, dip slope view of Mint Canyon beds seen at left in Fig. 1

How much of the upper Mint Canyon has been stripped off by erosion is not known, but a period of uplift and erosion preceding the deposition of "Modelo" sediments is clearly indicated by the marked unconformity between the two formations . In the anticlinal exposure on the west side of Haskell Canyon the discordance of the dips of the two formations, within ten feet of the contact, is approximately 10°. The basal member of the "Modelo" is a cobble conglomerate of fairly even thickness and is traceable at least several miles to the east. Jahns, (1940, p. 167), has shown that the "Modelo" and the Mint Canyon formations converge to the north and northeastward at a rate of about 200 feet in a half-mile.

"MODELO" FORMATION

The "Modelo" formation comprises a thin series of marine beds of especial interest in that they are locally quite fossiliferous. Unfortunately the state of preservation of the fossils is relatively poor, but a sufficiently diagnostic fauna has been collected to assign a definate age to the formation. A detailed section of the "Modelo" was measured in the anticlinal exposure just south of the road forks in Haskell Canyon, on the west side of the canyon, (See Plate No. 8), in order that the invertebrate fossil localities might be placed in their proper stratigraphic sequence.

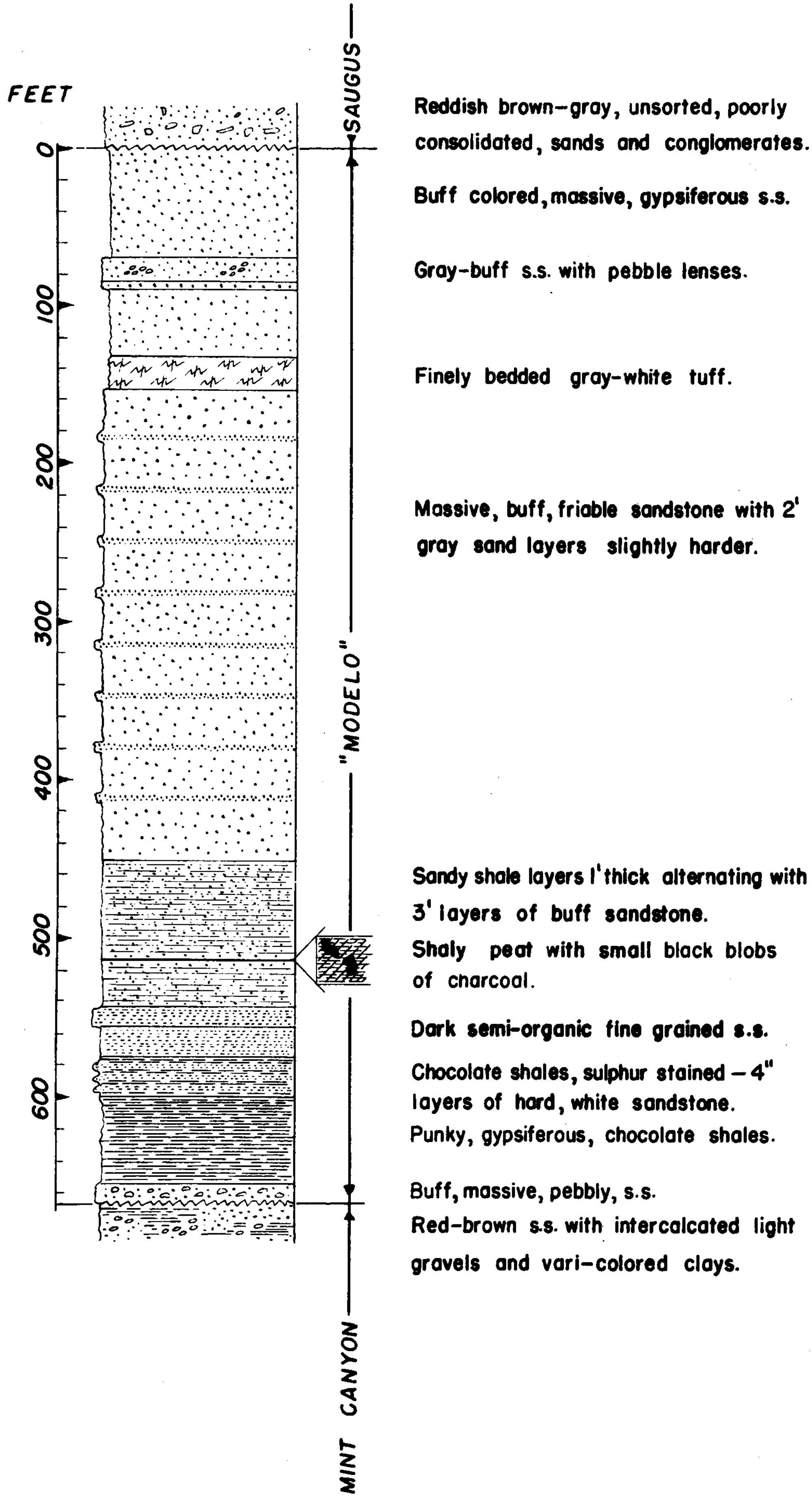
The Modelo formation was origionally proposed by Eldridge and Arnold, (1907, p.), for the Miocene sequence above the Vaqueros formation. The type section, in the vicinity of Modelo Canyon, Ventura County, consists of tow prominent sandstone and two diatomaceous shale members. These members are prominent in some places but are difficult to distinguish in others as they intergrade with one another over relatively short distances. Only three fossils were recorded from the type section: <u>Pecten pedroanus</u> Trask,

COLUMNAR SECTION

PLATE 8

MEASURED AT HASKELL CANYON

SCALE 1:1200



Pecten peckhami Gabb, and Tellina sp. Lithologically, the Modelo resembles the Monterey of central California in many points.

Kew, (1924, p. 67), applied the term Modelo(?) to the marine beds east of Saugus which he believed might be correlated with the upper part of the Modelo at the type section. Hudson and Craig, (1929, pp. 515-517), restricted the type Modelo and divided the group into three stages. They found the lower Modelo equivalent to the Topanga, which is of Temblor age. The upper portion was recognized as belonging to the Monterey stage and the Modelo s.s. was referred to the Briones and Cierbo substages of the Monterey. For the uppermost portion of the Modelo group, they proposed that the name Santa Margarita be used, since they believed it equivalent to the type Santa Margarita and the upper San Pablo of central California.

Clements, (1937, p. 215), suggested that the relationship between the "Modelo", (used here in the same sense as the Modelo(?) of Kew), and the Mint Canyon was one of interfingering and lateral, upward intergrading. Jahns, (1940, pp. 166-167), has shown conclusively that this was not the case and that their relationship was characteristic of a true unconformity.

SAUGUS FORMATION

The nonmarine, gravelly Saugus formation unconformably overlies the "Modelo" and overlaps it to the west in the vicinity of the Castaic Valley and the Ridge Basin. It appears to represent deposition on a broad, westward dipping flood plain or alluvial fan series, (Jahns, 1940, p. 167). The deposits consist of reddish to brown unsorted sands and gravels, and intercalcated grey clays. The beds in the area north and east of Saugus are generally non-fossiliferous but the fauna found in the marine equivalent in the western portion of the Ventura Basin indicate an upper Pliocene-lower Pleistocene age.

QUATERNARY DEPOSITS

Pleistocene terrace deposits are numerous in the Haskell Canyon area. Their flat-lying aspect makes them readily distinguishable as does their characteristic reddish-brown color. The deposits rarely exceed ten feet in thickness and the predominance of coarse gravel, made up of fragments of the basement complex, indicates their probable source. Deposition appears to have occurred under flood plain conditions.

Recent alluvium now fills the valley bottoms, particularly in the wider valleys. The present streams are now reworking the older material.

AGE OF THE "MODELO"

The occurrence in the "Modelo" fauna of *Astrodapsis* cf. *A. tumidus*, *Astrodapsis* cf. *A. whitneyi* and *Turritella carrisaensis* conclusively demonstrates a Neroly age for the members of the "Modelo" in Haskell Canyon. Of the two former species, J.E. Eaton has written[1]:

> "The genus *Astrodapsis* has numerous species and varieties, determinable if large collections of well preserved specimens are available. These fall into seven or eight more or less distinct clans into which the many different forms may be grouped. The small, thin, nearly whole specimen from Haskell Canyon that you showed me, though it differs from *A. tumidus* s.s. in having a thinner test, and petals which widen to the ambitus instead of becoming parallel-sided toward the latter, rather clearly belong to the clan of that name. The large, high-petalled, highly ventricose cast from a good mold exhibts a combination of dorsal attributes thus far known only in the *A. whitneyi* clan. Both of these clans, on the basis of existing collections, are confined to the Neroly, the late upper Miocene of California as commonly classified."

[1] Letter to J. Wyatt Durham, dated February 14, 1947.

Grant and Hertlein, (1938, p. 77), make the following comment regarding the age of A. tumidus: "In California this species marks the Astrodapsis tumidus zone, which is the middle Delmontian stage of the upper Miocene according to Dr. Kleinpell's classification."

The Astrodapsis cf. A. tumidus specimen viewed by Eaton was collected from C.I.T. Invert. Loc. no. 1678. The mold of A. cf. A. whitneyi was found in float in a stream bed on the east flank of the anticline. The boulder containing the mold appeared to be lithologically very similar to beds in the upper two thirds of the exposure and probably did not come from a point stratigraphically lower than 200 feet above the unconformity.

Turritella carrisaensis and Ostrea titan s.s. are not as yet known in stages outside the Neroly, and are generally held to be typical of that stage. (Eaton et. al., 1941, p. 248, Pl. 1, p. 247; Clark, 1915, pp. 426-427).

Miocene age is indicated by Pecten discus, which occurs in abundance near the base of the "Modelo". Of this species, Grant and Gale, (1931, p. 201), have written, "..Pecten discus has never been found in the Pliocene of California and can be used with confidence to distinguish the Miocene from the Pliocene."

The structural relationship between the "Modelo" and the Mint Canyon formation corroborates the above age determination. According to Eaton, Grant and Allen, (1941, p. 195), the transgression of the Miocene sea throughout California was essentially progressive, except for a moderate oscillation between the Cierbo and Neroly substages of the Monterey. A partial regression of the sea at this time, accompanied by diastrophism, resulted in strandward unconformity between the two stages. The succeeding transgression during Neroly time expanded the Miocene seas to their

FAUNAL LIST

	C.I.T. LOCALITIES														
	230	231	232	233	234	1623	1624	1626	1672	1674	1675	1676	1677	1678	Float
ECHINODERMATA															
Astrodapsis cf. tumidus Remond			X											X	
Astrodapsis cf. whitneyi Remond															X
BRACHIOPODA															
Terebratalia occidentalis Dall		X					?								
Terebratalia occidentalis obsoleta Dall		X													
PELECYPODA															
Anadara (Anadara) devincta subsp. montesanoana (Etherington)															X
Anadara (Anadara) haskellensis White, n.sp.			X					X				X	X		X
Apolymetis biangulata (Carpenter)															X
Cardium, sp. indet.															X
Chione diabloensis Clark													X		
Chione sp. indet.			X								X	X	X		
Dosinia, sp. indet.															X
Glycymeris grewingki Dall												X			
Glycymeris sp. A													X		X
Glycymeris sp. B															X
Lucina acutilineata Conrad							X								
Macoma, sp. indet.										X					
Ostrea titan Conrad	X	X	X		X		X				X				
Pecten (Lyropecten) crassicardo (Conrad)	X	X	X				X							X	X
Pecten (Aequipecten) discus Conrad			X	X		X	X		X		X				

	C.I.T. LOCALITIES														
	230	231	232	233	234	1623	1624	1626	1672	1674	1675	1676	1677	1678	Float
Pecten sp. indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Pinna cf. bicuneata Nomland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Protothaca staminea (Conrad)	.	.	.	.	.	.	.	.	.	.	X	.	.	.	X
Tellina sp. indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
GASTROPODA	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astraea cf. biangulata Gabb	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Cancellaria tritonidea Gabb	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Cancellaria sp. indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Conus juanensis Wiedy	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Crepidula cf. adunca Sowerby	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
Cypraea sp. indet. (young)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Ficus (Trophoscyon) sp. indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Kelletia sp. indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Lunatia cf. draconis (Dall)	.	.	.	.	.	.	.	.	.	.	X	X	.	.	X
Oliva sp. indet.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Olivella cf. baetica Carpenter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Olivella pedroana (Conrad)	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
Olivella sp. indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Polinices (Neverita) reclusianus (Deshayes)	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.
Searlesia seccensis Buffington, n.sp.	.	X	X	.	.	.	X	.	.	.	X	X	X	.	X
Tegula varistriata Nomland	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Turritella carrisaensis Anderson & Martin	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.

maximum extent. In Haskell Canyon the "Modelo" lies with distinct unconformity upon the Mint Canyon. This is best exhibited in the anticlinal exposure from which the invertebrate collection were made.

If a tentative orogenic correlation is made between the Cierbo-Neroly unconformity and the "Modelo"-Mint Canyon unconformity, it would appear that the Mint Canyon could be no younger than the Cierbo substage. A correlation of this type is hazardous in an isolated area, particularly where different basins of deposition are concerned and the lateral distances are so great.

COMPARISON WITH THE SANTA MARGARITA FORMATION

The "Modelo" fauna bears a close relationship to the fauna from the type section of the Santa Margarita formation, as collected by R.E. Dickerson and R.E. Gordon, (Nomland, 1917, p. 303), along Santa Margarita Creek and Trout Creek near the town of Santa Margarita, San Luis quadrangle. Both of the Astrodapsis species are represented here, as is the diagnostic Ostrea titan. Further comparison with the fauna at the type section is difficult in that many of the forms are very poorly preserved and not specifically identifiable. In addition to the three species listed above, three other species are common to the two faunas.

Clark, (1915, pp. 417-423), Nomland, (1917, pp. 300-301), and Anderson and Martin, (1914, p. 70), present a more complete list of forms from the Santa Margarita and its correlatives, principally from the region north of Coalinga. Of the species listed, (See page 16), only 11 are common to the Haskell Canyon fauna, but these include the critical Astrodapsis species, Pecten crassicardo, Pecten discus, and Turritella carrisaensis. On this evidence it would appear that the "Modelo" is contemporaneous with at least

COMPARATIVE FAUNAL LISTS

Haskell Canyon	Living	Jacalitos	Elsmere Canyon	Upper San Pablo	Santa Margarita	Santa Margarita correl.
Astrodapsis cf. A. tumidus Remond	...	...	...	X	X	X
Astrodapsis cf. A. whitneyi Remond	...	...	...	X	X	X
Terebratalia occidentalis Dall	X	...	...	...	...	...
Terebratalia occidentalis obsoleta Dall	X	...	...	...	...	...
Anadara (Anadara) devincta subsp. montesanoana (Etherington)	...	...	...	X	...	...
Anadara (Anadara) haskellensis White, n.sp.	...	...	...	...	...	...
Apolymetis biangulata (Carpenter)	X	X	X	X	X	X
Chione diabloensis Clark	...	...	...	X	...	...
Glycymeris grewingki Dall	X	...	...	...	...	...
Lucina acutilineata Conrad	X	...	...	...	...	...
Ostrea titan Conrad	...	...	...	X	X	X
Pecten (Lyropecten) crassicardo Conrad	...	...	...	X	X	X
Pecten (Aequipecten) discus Conrad	...	...	...	...	...	X
Pinna cf. bicuneata Nomland	...	...	...	X	...	X
Protothaca staminea (Conrad)	X	X	...	X	...	X
Astraea cf. biangulata Gabb	...	...	...	X	...	...
Cancellaria tritonidea Gabb	X	X	X	...	...	...
Conus juanensis Wiedy	...	...	...	...	...	...
Crepidula cf. adunca Sowerby	X	X	...	X	X	...
Lunatia cf. draconis (Dall)	X	...	...	...	...	...
Olivella cf. baetica Carpenter	X	...	...	...	...	...
Olivella pedroana (Conrad)	X	X	X	X	...	...
Polinices (Neverita) recluziana (Deshayes)	X	X	X	X	...	X
Tegula varistriata Nomland	...	...	...	...	X	...
Turritella carrisaensis Anderson & Martin	...	...	...	...	...	X

a part of the Santa Margarita as exposed at the type locality and elswhere.

COMPARISON WITH THE SAN PABLO FORMATION

The Santa Margarita formation, s.s., is generally recognized in California as being equivalent to the Neroly substage of the San Pablo group, (Clark, 1915, p. 435; 1930, p. 764). In addition to the forms listed from the Santa Margarita, with the exception of the *Turritella*, the following species from the "Modelo" have been reported from the upper San Pablo: *Chione diabloensis*, *Astraea* cf. *bicuneata*, *Crepidula* cf. *adunca*, *Olivella pedroana* and *Arca devincta* subsp. *montesanoana*. In total, fifty percent of the Haskell Canyon fauna is represented specifically in the upper San Pablo, (Neroly). On the basis of the echinoids, the "Modelo" is correlative with the lower Neroly.

COMPARISON WITH THE JACALITOS FORMATION

The Jacalitos is definately younger than the "Modelo". The six species common to the faunas from the two formations are living species. In a comparison of the San Pablo with the Jacalitos, Clark, (1914, pp. 435-436), found that only the beds above the *Astrodapsis whitneyi* zone showed affinity to the lower Pliocene. In the writer's opinion, strata younger than the *A. whitneyi* zone of Clark are not exposed in Haskell Canyon. Faunally, the Jacalitos is definately younger than the "Modelo" exposure under discussion.

COMPARISON TO THE ELSMERE CANYON FAUNA

Four species from the "Modelo" are found in the Elsmere Canyon fauna, all of which are living forms. Thus it would appear that the Elsmere Canyon is definately younger than the Haskell Canyon fauna. At the present time Mr. Lauren Wright of the California Institute of Technology is studying a fauna from the "Modelo" west of Sand Canyon, about seven miles to the southeast of Haskell Canyon on the south side of the Santa Clara Valley. This fauna has definite affinities for the Elsmere Canyon fauna. The writer has viewed several specimens of _Anadara haskellensis_ n.sp. from the Sand Canyon locality, which, according to a verbal description from Mr. Wright, occur several feet above the main fossiliferous zone. Maxzon's specimens from C.I.T. loc. 1626 are stratigraphically above Wright's fauna, and include several specimens identified by Grant as _Anadara obispoana_. These specimens are referred to _A. haskellensis_ n.sp. by the writer, (See page 23). If, as it would appear from the literature, (Reinhart, 1943, pp. 16-17), the species of _Anadara_ have short time ranges and do not carry over from the Miocene into the Pliocene, further study might yield valid reasons for shifting the Miocene-Pliocene boundary upwards to include the Elsmere Canyon, or portions of it, in the Miocene. A downward shift of the boundary is also possible but less probable in view of the present invertebrate time scale as generally accepted on the Pacific Coast. Only more extensive and detailed mapping and collecting will resolve this problem.

CONCLUSIONS

On the basis of the available paleontological data, a lower Neroly age has been assigned to the "Modelo" in Haskell Canyon. The meaning of this age assignment is not altogether clear, however. It is recognized that long range correlations with the well known sections in the San Francisco

Bay area are not altogether safe, particularly since the invertebrate collections from the intervening areas are few and far between. It is recognized that the Miocene seas were getting progressively colder toward the end of the epoch, and a gradual faunal shift to the south is not at all improbable. Thus the problem arises as to whether two similar faunas from widely separated points are of equivalent age. It is conceivable that under such conditions the relative ages may vary a substage, a stage, or even more.

Such a faunal shift would raise the age of the "Modelo" in the standard Pacific Coast invertebrate time scale. The extremely short vertical range of the Astrodapsis species, coupled with their widespread occurrence throughout California in similar relationship to the epeirogenic boundaries, seems to indicate that the Echinoids are more cold tolerant than the associated megafauna and microfauna. This has not been definately proved but it is generally recognized that echinoids are better time indicators in the late Tertiary than molluscs.

DESCRIPTION OF SPECIES

ECHINOIDEA

Astrodapsis cf. *A. tumidus* Remond

Pl. 9, Figs. 2,3

Astrodapsis tumidus Remond, 1863, Proc. Calif. Acad. Sci., 3:52-53.

Astrodapsis cf. *tumidus*, Woodring, 1930, Geol. Soc. Amer., 41:155.

Occurrence: Locs. 232, 1678.

Astrodapsis cf. *A. whitneyi* Remond

Pl. 9, Fig. 4

Astordapsis whitneyi Remond, 1863, Proc. Calif. Acad. Sci., 3:52; -1920, Kew, Univ. Calif. Publ. Bull. Dept. Geol. Sci., 12:111, 112, pl. 16, figs. 1a, 1b; pl. 17, fig. 2.

Occurrence: Float

BRACHIOPODA

Terebratalia occidentalis Dall

Pl. 10, Fig. 10

Terebratella occidentalis Dall, 1871, Proc. Calif./Acad. Sci., 4:182, Pl. 1 fig. 7.

Terebratalia occidentalis Dall, -1944, Hertlein-Grant, Publ. Univ. Calif. Los Angeles Math. Phys. Sci., 3:127-131, pl. 10, fig. 3; pl. 17, figs. 2, 5, 8, 11, 12; text fig. 27.

Occurrence: Locs. 231, 1624 (?)

Terebratalia occidentalis obsoleta Dall

Terebratella occidentalis var. *obsoleta* Dall, 1891, Proc. U.S. Natl. Mus., 14:186.

Terebratalia occidentalis obsoleta Dall, -1944, Hertlein-Grant, Publ. Univ. Calif. Los Angeles Math. anf Phys. Sci., 3:131-133, pl. 12, figs. 5, 9-11; text fig. 28.

Occurrence: Loc. 231

PELECYPODA

FAMILY ARCIDAE
SUBFAMILY ANADARINAE
GENUS ANADARA GRAY, 1847
SUBGENUS ANADARA S.S.

Genotype: *Arca antiquata* Linnaeus, 1758, (orig. desig.)

Anadara (*Anadara*) *devincta* subsp. *montesanoana* (Etherington)

Pl. 10, Fig. 3

Arca devincta montesanoana Etherington, 1931, Univ. Calif. Pub. Bull. Dept. Geol., 20:44, 69-70, pl. 3, figs. 1-5, 7, 8

Anadara (*Anadara*) *devincta* subsp. *montesanoana* (Etherington), Reinhart, 1943, Geol. Soc. Amer. Sp. Paper 47, pp. 45-46, pl. 11, figs. 13, 14.

Occurrence: Loc. 1624; float.

Anadara (*Anadara*) *haskellensis* White, n.sp.

Pl. 10, Figs. 1, 2, 4, 5a, 5b, 6a, 6b, 6c

Holotype: California Institute of Technology Invertebrate Paleontology collection, no. , loc. no. 1677.

Description: Large, compressed, inequilateral, elongate; dorsal margin straight, interrupted by umbo; anterior margin evenly rounded merging into broadly rounded ventral margin; posterior margin more sharply rounded than ventral margin and meets hinge line at a low angle; umbo located one quarter of distance from anterior end; gentle ridge extends from umbo to posterior ventral margin, above which shell is slightly concave; no byssal gape. 34 radial ribs, separated by narrow interspaces at posterior end; interspaces slightly narrower than ribs on posterior half; ribs wider toward posterior than toward anterior part of shell; interspaces and ribs nearly flat; medial, longitudinal groove faintly vivible in each rib. Concentric growth lines most noticeable toward margins. Ligamental area, hinge, and interior of holotype concealed by matrix.

Dimensions: (in millimeters), length, 70; height, 56; convexity, 16 (left valve), No. of ribs, 34.

Comparisons: *A. haskellensis* n.sp. closely resembles *A. montereyana* but differs in that it is more elongate and compressed, the umbo is located closer to the anterior end, the size is larger, and it has 34-35 ribs, wheras *A. montereyana* has 29-31.

A. haskellensis n.sp. resembles *A. obispoana* and *A. osmonti*, but the much greater number of ribs in *A. haskellensis* is a diagnostic difference. The large number of ribs in *A. haskellensis* is a very distinctive character and the species can readily be separated from all other Miocene and Pliocene *Anadaras* on this character alone.

Number of specimens: About 15 specimens were collected, along with numerous casts and molds.

Preservation and matrix: Preservation is fair but rarely complete. External molds usually retain portions of the shell, making it difficulat to obtain good specimens. Shell generally dry and flaky. Matrix varies from fine, pebble conglomerate to coarse, brown sandstone and may be hard or soft.

Type locality: "Modelo" formation, Los Angeles County, Calif. In fine, pebble conglomerate lenses in brown sandstone 1300 feet east and 2150 feet south of the northwest corner, section 36, T. 5 N., R. 16 W., Saugus quadrangle.

Collector: Robert C. White.

Associated faunule: Occurs with *Turritella carrisaensis*, *Lunatia* cf. *draconis*, *Chione* sp. and *Searlesia seccoensis*.

Geologic age: Lower Neroly. Characteristic of zone 300 to 500 feet stratigraphically above the "Modelo"-Mint Canyon unconformity at the type locality.

Repository of type material: California Institute of Technology Invertebrate Paleontology Collection.

Remarks: The *Anadara obispoana* specimens collected by Maxson, (1938, pp. 1716-1717), from the "Modelo" near Sand Canyon, and reported in his fauna, (Jahns, 1940, p. 167), were examined by the author. Dr. Maxson has indicated to J. Wyatt Durham that the specimens examined by the writer are those that he collected from C.I.T. Invert. Paleo. loc. 1626, at the head of Sand Canyon, which is approximately 7 miles southeast of Haskell Canyon. These specimens, (Pl. 10, Figs. 2, 4), exhibit the characteristics of *A. haskellensis*, in that they have 34 ribs or more. Accordingly, they are referred to *A. haskellensis*.

Glycymeris grewingki Dall

Pl. 9, Fig. 8

Glycymeris grewingki Dall, 1909, U.S. Geol. Surv. Prof. P. 59, p. 107, pl. 2, fig. 13. --Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:135, 136.

Occurrence: Loc. 1676

Glycymeris sp. *A*

Pl. 9, Fig. 9

Occurrence: Loc. 1677; float

Glycymeris sp. B

Pl. 9, Fig. 10

Occurrence: Float

Pinna cf. *bicuneata* Nomland

Pinna cf. *bicuneata* Nomland, 1917, Univ. Calif. Publ. Div. Geol. Sci., 10: 301, 308, pl. 15, figs. 1a, 1b.

Pinna (*Atrina*) *bicuneata* Nomland, Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:146-147.

Occurrence: Float

Ostrea titan Conrad

Pl. 9, figs. 1a, 1b

Ostrea titan Conrad, 1853, Proc. Acad. Nat. Sci. Phila., 6:199. --Clark, 1915, Univ. Calif. Publ. Dept. Geol. Sci., 8:pl. 44, fig. 1. --Eaton, Grant and Allen, 1941, Bull. Amer. Assoc. Petrol. Geol., 25:247-248, pl. 4, fig. 3.

Occurrence: Locs. 230, 231, 232, 234, 1624, 1675

Pecten (*Lyropecten*) *crassicardo* (Conrad)

Pl. 9, Fig. 7

Pallium crassicardo Conrad, 1857, Proc. Acad. Nat. Sci. Phila., 8:313.

Pecten (*Lyropecten*) *crassicardo* (Conrad), Arnold, 1906, U.S. Geol. Surv. Prof. P. 47, p. 71, pl. 16, figs. 1, 1a; pl. 17, figs. 1, 1a, 1b.

Occurrence: Locs. 230, 231, 232, 1624, 1678, float.

Pecten (*Aequipecten*) *discus* Conrad

Pl. 9, figs. 5a, 5b, 6

Pecten discus Conrad, 1857, Pac. R.R. Repts., 7:190, pl. 3, fig. 1.

Pecten (*Aequipecten*) *discus* Conrad, Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:200, pl. 4, fig. 7.

Occurrence: Locs. 232, 233, 1623, 1624, 1672, 1675.

Pecten sp. indet.

Occurrence: Loc. 1672, float.

Lucina acutilineata Conrad

Lucina acutilineata T.A. Conrad, 1849, U.S. Expl. Exped. (Wilkes), 10:725. —Arnold, 1903, Mem. Calif. Acad. Sci., 3:131.

Lucina (*Myrtea*) *acutilineata* Conrad, Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:286-287, pl. 14, figs. 22a, 22b.

Occurrence: Loc. 1624

Cardium sp. indet.

Occurrence: Float

Chione diabloensis Clark

Pl. 9, Fig. 11

Chione diabloensis Clark, 1915, Univ. Calif. Publ. Dept. Geol. Sci., 8:468, 469, pl. 58, fig. 4.

Occurrence: Loc. 1677

Chione sp. indet.

Occurrence: Float.

Protothaca staminea (Conrad)

Venus staminea Conrad, 1837, Jour. Acad. Nat. Sci. Phila., 7:250, pl. 19, fig. 15.

Venerupis (*Protothaca*) *staminea* (Conrad), Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:329-331, pl. 18, figs. 1a, 1b, 2a, 2b.

Occurrence: Loc.,1675, float.

Dosinia sp. indet.

Occurrence: Float.

Tellina sp. indet.

Occurrence: Float.

Apolymetis biangulata (Carpenter)

Pl. 9, Fig. 12

Tellina alta Conrad, 1837, Jour. Acad. Nat. Sci. Phila., 7:258.

Sorobicularia biangulata Carpenter, 1855, Proc. Zool. Soc. London, pt. 23, pp. 213, 230.

Apolymetis biangulata (Carpenter), Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:363-364, pl. 20, fig. 16.

Occurrence: Float

Macoma sp. indet.

Occurrence: Loc. 1674

GASTROPODA

Conus juanensis Wiedy

Conus juanensis Wiedy, 1928, Tr. San Diego Soc. Nat. Hist., 5:123, pl. 9, fig. 3.

Occurrence: Loc. 1624

Cancellaria tritonidea Gabb

Cancellaria (Euclia) tritonidea Gabb, 1866, Geol. Surv. Calif. Paleo., 2:11, pl. 2, fig. 18; p. 79, 1868-69.

Cancellaria tritonidea Gabb, Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:616-617, pl. 27, fig. 8.

Occurrence: Float

Cancellaria sp. indet.

Occurrence: Float.

Oliva sp. indet.

Occurrence: Loc. 230

Olivella pedroana (Conrad)

Strephona pedroana Conrad, 1855, U.S. House of Rep., House Doc. 129:17; —1856, U.S. Pac. R.R. Rpts., 5:327, pl. 6, fig. 51.

Olivella pedroana (Conrad), Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:626-627, pl. 24, fig. 10.

Occurrence: Loc. 1675

Olivella cf. baetica Carpenter

Olivella baetica Carpenter, 1864, Brit. Assoc. Adv. Sci. Rpt. for 1863, p. 661. —Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:627.

Occurrence: Float

Olivella sp. indet.

Occurrence: Float

Kelletia sp. indet.

Occurrence: Float.

Searlesia secoensis Buffington, n. sp.

Searlesia secoensis Buffington, n.sp., 1947, Unpubl. manuscript, Cal. Inst. Tech., pp. 29-30, pl. 1, fig. 6a, 6b, 6c.

Occurrence: Locs. 231, 232, 1624, 1675, 1676, float, 1677

Ficus (Trophosycon) sp. indet.

Occurrence: Float

Cypraea sp. indet. (young)

Occurrence: Float

Turritella carrisaensis Anderson and Martin

Pl. 10, Fig. 11, 12

Turritella carrisaensis Anderson and Martin, 1914, Pr. Calif. Acad. Sci. (4), 4:70, pl. 4, fig. 4. —Merriam, 1941, Univ. Calif. Publ. Dept. Geol. Sci., 26:120, pl. 34, figs. 1-3, 5-6.

Turritella carissaensis Anderson and Martin, Eaton Grant and Allen, 1941, Bull. Amer. Assoc. Petrol. Geol., 25:pl. 1, figs. 10, 10a.

Occurrence: Loc. 1675, 1677

Crepidula cf. *adunca* Sowerby

Crepidula adunca Sowerby, 1825, Cat. Tankerville, Appen. p. 7. --Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:791.

Occurrence: Loc. 1675

Polinices (*Neverita*) *recluzianus* (Deshayes)

Pl. 10, Fig. 7

Natica reclusiana Deshayes, 1839, Rev. Zool. Soc. Cuv., p. 361.

Polinices (*Neverita*) *reclusianus* (Deshayes), Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., 1:800-801, text fig. 13a, 13b, 13c.

Occurrence: Loc. 1624, 1677.

Lunatia cf. *draconis* (Dall)

Pl. 10, Figs. 8a, 8b, 9

Polinices draconis Dall, 1903; Proc. Biol. Soc. Wash., 16:174. --U.S. Natl. Mus., Bull. 112, pl. 14, figs. 4, 6. --Oldroyd, 1927, Stanford Univ. Publ. Geol. Sci., 2:pt. 3:128-129, pl. 99, figs. 3,6.

Occurrence: Locs. 1675, 1676, float.

Astraea cf. *biangulata* Gabb

? *Pachypoma biangulata* Gabb, 1866, Paleon. Calif., 2:15, pl. 3, fig. 26.

Astraea (*Pachypoma*) *biangulata* (Gabb), Stewart, 1927, Proc. Acad. Nat. Sci. Phila., 78:318, pl. 32, fig. 6.

Occurrence: Loc. 1624

Tegula varistriata Nomland

Tegula varistriata Nomland, 1917, Univ. Calif. Publ. Bull. Dept. Geol. Sci., 10:311, pl. 20, figs. 4a, 4b.

Occurrence: Loc. 1624

DESCRIPTION OF FAUNAL LOCALITIES

All localities are California Institute of Technology. (C.I.T.). invertebrate localities, located in the upper Santa Clara Valley, sec. 36, T. 5 N., R. 16 W., San Bernardino Base and Meridian, Los Angeles County, California, unless otherwise noted.

230 - NW ¼ sec. 36, 800 feet W of Haskell Canyon, on N limb of anticline near crest; conglomerate about at base of "Modelo". W.P. Woodring and B.L. Clark, coll.

231 - NW ¼ sec. 36, 950 feet W of Haskell Canyon and 1500 feet S of N sec. line; south slope of steep ridge, near crest; about 70 feet above base of "Modelo" and 25 feet above white, sileceous shale. W.P. Woodring and B.L. Clark, coll.

232 - NW ¼ sec. 36, same as loc. 231 but from top of ridge and 15 feet higher stratigraphically. W.P. Woodring and B.L. Clark, coll.

233 - NW ¼ sec. 36, 1500 feet W of Haskell Canyon and 900 feet S of N sec. line; N slope of dip slope ridge near head of canyon; few feet stratigraphically above loc. 232. W.P. Woodring and B.L. Clark, coll.

234 - SE ¼ sec. 36, 2,000 feet E of Haskell Canyon; from sandstone near base of "Modelo" forming sharp-crested ridge. W.P. Woodring, T.L. Clements, G.A. Cummings, coll.

1623 - Humphrey quadrangle; "Modelo" shales, approx. 50 feet above Mint Canyon formation unconformity, in road cut, E side of Bouquet Canyon, N of highway. J.H. Maxson, coll.

1624 - 100 yards SE of loc. 232; top, central portion of central ridge in amphitheater, W side of Haskell Canyon, on anticlinal axis; 75 feet above unconformity. J.H. Maxson, coll.

1626 - Sylmar quad. 100 yards N of road in divide between Placerita and Reynier Canyons; ridge slope, 50 feet below plateau. J.H. Maxson, coll.

1672 - 1700 feet E and 1850 feet S from NW cor. sec. 36. 14 feet above "Modelo"-Mint Canyon unconformity, near bottom of gully in brown, sandy shales. R.C. White, J.W. Durham, E.C. Buffington, S. Martin.

1674 - 1650 feet E and 2200 feet S from NW cor. sec. 36. Brown sandstone and conglomerate near bottom of stream valley. White et. al., coll.

1675 - 1050 feet E and 1950 feet S from NW cor. sec. 36. Conglomerate lenses near center of steep E slope, N limb of anticline, 50 feet below white shale bed. White et. al., coll.

1676 - 1500 feet E and 2200 feet S from N.W. cor. sec. 36; brown sandstone with conglomeratic lenses , just E of separation of valleys. White, coll.

1677 - 1300 feet E and 2150 feet S from NW cor. sec. 36; buff, friable conglomerate near stream bed, W of separation of streams. White, coll.

1678 - 1500 feet E and 1300 feet S from NW cor. sec. 36; very friable, pebble conglomerate, 30 feet below massive sandstone member at crest of ridge, N limb of anticline. White et. al., coll.

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EXPLANATION OF PLATE 9

Fig. 1a — *Ostrea titan* Conrad, C.I.T. Invert. Paleo. Loc. 1675; side view of left valve, showing flat laminae or shell layers. x 2/3

Fig. 1b — *Ostrea titan* Conrad, same specimen as Fig. 1a, interior view of left valve, showing convex ligamental callous of typical *O. titan* character. x 2/3

Fig. 2 — *Astrodapsis* cf. *tumidus* Remond, C.I.T. Invert. Paleo. Loc. 231 Dorsal view x 2

Fig. 3 — *Astrodapsis* cf. *tumidus* Remond, C.I.T. Invert. Paleo. Loc. 1678. Petals widen toward the ambitus instead of becoming parallel sided as in *A. tumidus* ss. x 1 1/2

Fig. 4 — *Astrodapsis* cf. *whitneyi* Remond, C.I.T. Invert. Paleo. Loc. float. Latex rubber cast from a good mold. x 1

Fig. 5a, 5b — *Pecten* (*Aequipecten*) *discus* Conrad, C.I.T. Invert. Paleo. Loc. 1623, left and right valves of a gypsiferous, internal mold. x 1

Fig. 6 — *Pecten* (*Aequipecten*) *discus* Conrad, C.I.T. Invert. Paleo. Loc. 1623. Interior gypsum cast of an external mold. x 1

Fig. 7 — *Pecten* (*Lyropecten*) *crassicardo* (Conrad), C.I.T. Invert. Paleo. Loc. 1678. Fragment showing striations in interspaces. x 1

Fig. 8 — *Glycymeris grewingki* Dall, C.I.T. Invert. Paleo. Loc. 1676. x 2

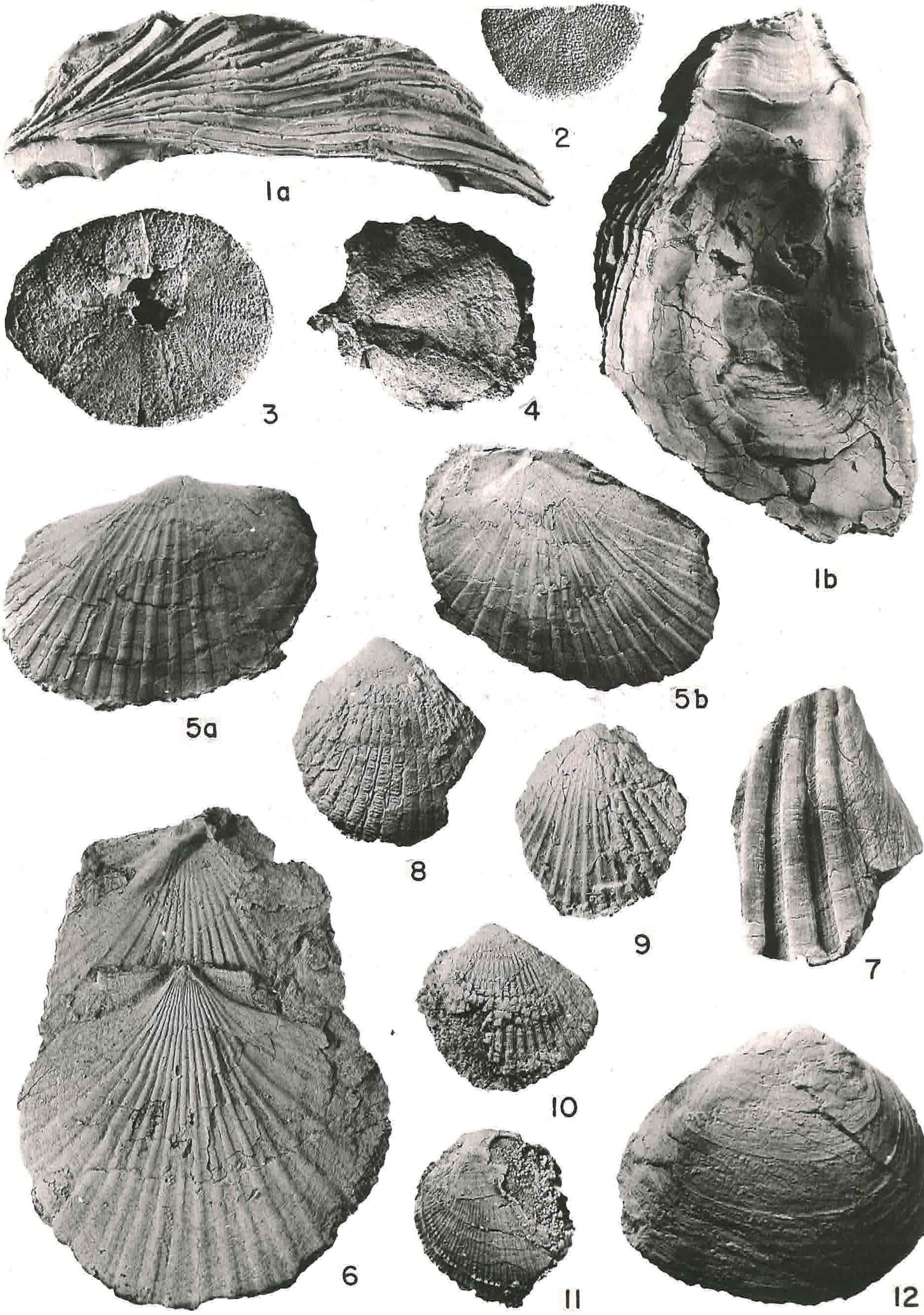
Fig. 9 — *Glycymeris* sp. *A.*, C.I.T. Invert. Paleo. Loc. 1677. x 2

Fig. 10 — *Glycymeris* sp. *B.*, Float. x 2

Fig. 11 — *Chione diabloensis* Clark, C.I.T. Invert. Paleo. Loc. 1677. x 2

Fig. 12 — *Apolymetis biangulata* (Carpenter), Float. x 1

PLATE 9



EXPLANATION OF PLATE 10

Fig. 1 — Anadara (Anadara) haskellensis White, n.sp., C.I.T. Invert. Paleo. Loc. 1677, Holotype no. . Left valve. x 1

Figs. 2, 4 — Anadara (Anadara) haskellensis White, n.sp., C.I.T. Invert. Paleo. Loc. 1626. Latex rubber casts from external molds. Fig. 4 crushed. Specimens collected by Maxson from Sand Canyon area, 7 miles southeast of Haskell Canyon, in "Modelo" formation. Referred by Maxson to A. obispoana, but both specimens have approximately 34 ribs, a characteristic of A. haskellensis, n.sp. x 1

Fig. 3 — Anadara (Anadara) osmonti ? (Dall), C.I.T. Invertebrate Paleo. Loc. 1624. Maxson's specimen from Sand Canyon. Determination doubtful. x 2

Figs. 5a, 5b — Anadara (Anadara) haskellensis White, n.sp., C.I.T. Invert. Paleo. Loc. 1671. Fig. 5a is a natural cast of an external mold. Upper portions of the right valve have been removed to expose dentition and hinge line on left valve. Fig. 5b is a latex rubber cast from the external mold in which specimen in Fig. 5a was found. 35 ribs. x 1

Figs. 6a, 6b, 6c — Anadara (Anadara) haskellensis White, n.sp., C.I.T. Invert. Paleo. Loc. 1671, in Dry Canyon. Specimens, including those in Figs. 5a, and 5b, occurr stratigraphically above those in the Haskell Canyon exposure. 6a, right valve of small specimen; 6b, left valve; 6c, dorsal view. x 2

Fig. 7 — Polinices (Neverita) reclusianus (Deshayes), C.I.T. Invert. Paleo. 1676. x 2

Fig. 8a, 8b, 9 — Lunatia cf. draconis (Dall), C.I.T. Invert. Paleo. Loc. 1675. Fig. 8a, umbilical view; 8b, apertural view, 9, apertural view.
8a, 8b x 1
9 x 2

Fig. 10 — Terebratalia occidentalis Dall, C.I.T. Invert. Paleo. Loc. 231. x 2

Fig. 11, 12 — Turritella carrisaensis Anderson and Martin, C.I.T. Invert. Paleo. Loc. 1675.
Fig. 11 x 2
Fig. 12 x 1 1/2

PLATE 10