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CONTRASTING MEGAFAUNAL AND SEDIMENTARY RECORDS FROM OPPOSITE ENDS OF THE GULF OF CALIFORNIA: IMPLICATIONS FOR INTERPRETING ITS TERTIARY HISTORY

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Introduction

Distribution patterns of marine mollusks supported by radiometric and sedimentological data indicate important differences between Tertiary records in the northern and southern parts of the Gulf of California. Published geophysical reconstructions have focused on the mouth of the Gulf and assumed seawater entered the Gulf at 4 - 6 Ma (Larson, 1972; Johnson and others, 1983; Curray and Moore, 1984; Hagstrum and others, 1987), about the age of marine microfossils at the Tres Marias Islands. A record of a more ancient gulf extending through the Cabo Trough correlates in part with thicker sections in the northern Gulf, including the northern and southern Salton Trough.

Results of megafaunal studies indicate that by 13 Ma seawater extended as far as the northern Salton Trough (Figure 1). Time represented at the mouth of the Gulf by unconformities and 1.5 km of deposits is recorded in up to 5 km of sediments in the north. There has been 8 million years more time than is generally assumed for the evolution of the Gulf of California. In places, fault movement dated on the basis of displaced marine sediments incorrectly regarded as Pliocene may actually have occurred as early as late middle Miocene.

Sedimentary records and structural details are complex and different at opposite ends of the Gulf. At the north end, in the central Salton Trough, Tertiary sediments are about 5 km thick, but along the trough's southwestern margin they are only 0-l km thick. Basement consists of metamorphic and volcanic rocks and even old alluvial deposits (Kidwell, 1988). At the south end, in the Cabo Trough, Tertiary marine sediments measure 1 - 1.3 km, overlying nonmarine Coyote Redbeds and granitic basement (McCloy, 1984). In the Tres Marias Islands Tertiary marine rocks on Maria Madre Island have a combined thickness of 1,145 m, ranging in age from late Miocene to late Pliocene (Carreño, 1985; McCloy and others, 1988). Unconformable on Cretacous granite and Tertiary (?) volcanic basement rocks, the Maria Madre deposits are older than those penetrated at Deep Sea Drilling Project sites in the area.

Tectonic events in the evolution of the present gulf are considerably younger than the entrance of seawater in the area. Arc volcanism in central and southern Baja California ended about the time of the first marine incursion, ca. 12.5 Ma (Sawlan and Smith, 1984), but reorganization of

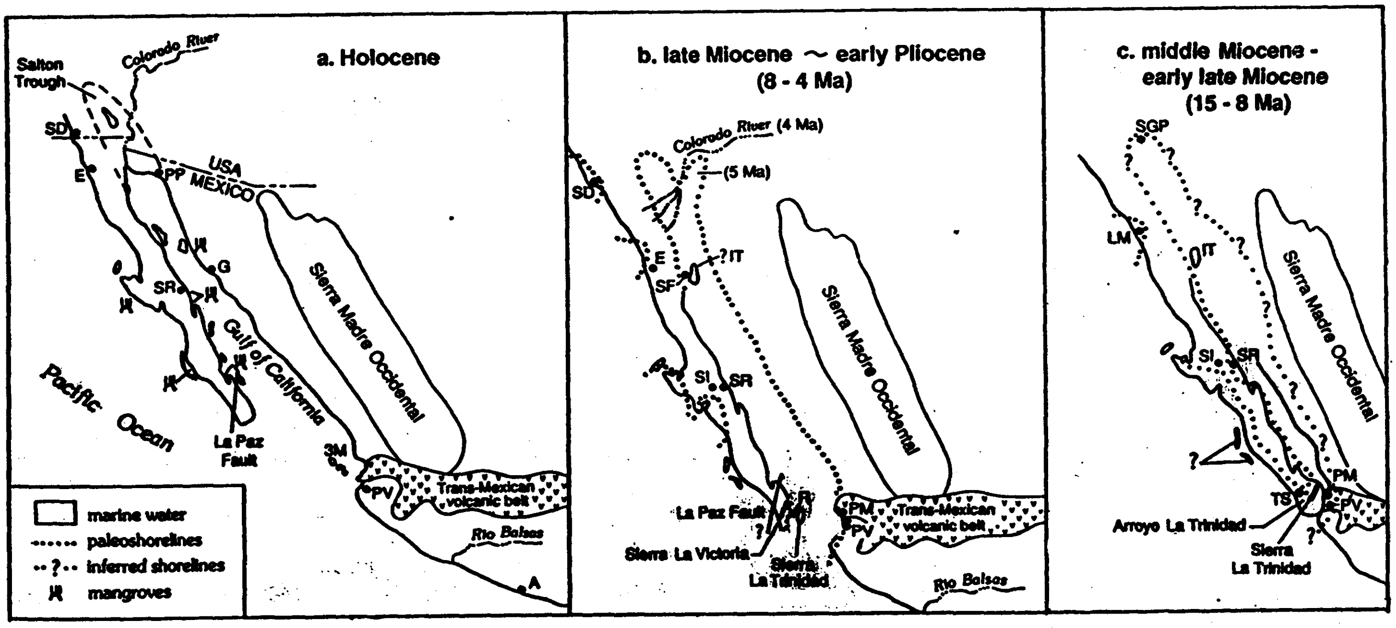


Figure 1 Paleogeography of the Gulf of California according to marine molluscan distributions, 15 MA to the present. A, Acapulco; E, Ensenada; G, Guaymas; 3M, Tres Marias Islands; IT, Tiburon Island; LM, La Mision; PM, Punta Mita; PP, Puerto Peñasco; PV, Puerto Vallarta; R, Rancho el Refugio; SD, San Diego; SF, San Felipe; SGP, San Gorgonio Pass, CA; SI, San Ignacio; SR, Santa Rosalia; TS, Todos Santos.

spreading events at 6.5-3.5 (Mammerickx and Klitgord, 1982) and much of the faulting in the Salton Trough were younger. Data constraining the timing of these events include radiometric ages of volcanic rocks associated with marine sediments as well as evolutionary sequences of index fossils (see for example the *Spondylus* lineage on Plate 4). Combined faunal and radiometric data offer possibilities of greater resolution in dating events in the evolution of the Gulf and correlating distant reference sections, especially those of different biofacies. They show that the history of the Gulf cannot be told from records near its mouth alone, as critical as that area is, and that previously published reconstruction models need to be reconsidered in light of a longer time frame.

Previous work

Previous work on the Gulf of California including the Salton Trough is summarized in a number of papers, including McCloy and others (1988), Kidwell (1988), Powell (1986, 1988), Winker (1987), Smith (1988 and 1989, in press), and papers in review volumes edited by Frizzell (1984), Rigsby (1984), and Dauphin and Simoneit (1989, in press). Fossil mollusks from the Gulf are illustrated in Jordan and Hertlein (1926), Hanna and Hertlein (1927), Hertlein (1966), Durham (1950), Hertlein and Emerson (1959), and Smith (1989).

Middle and Late Pliocene marine mollusks from the southern Gulf at the time of the "mid Pliocene spreading event" (ca. 4.5 Ma).

Ages are difficult to verify for marine mollusks living in shallow embayments in the southern Gulf. Few datable volcanic rocks are associated with late Neogene fossiliferous sediments, except in the area north of Loreto (McLean, 1987, 1988). Elsewhere in the southern gulf ages are construed by interpolation from microfossil zonation in the Tres Marias Islands (McCloy and others, 1988) or correlation using megafossils whose ranges are in turn constrained by radiometric data in the central and northern gulf (Smith, 1989). A suite of shallow water mollusks representing ca. 3.5- 2.5 Ma is here referred to informally as the "mid-Pliocene spreading event assemblage;" it consists of species common in the Gulf at the time the Baja California peninsula began to separate from mainland Mexico. Index species, several of which are figured on Plate 1, include the pelecypods*Argopecten abietis, Argopecten revellei, "Aequipecten" dallasi, Leopecten bakeri, Nodipecten arthriticus,* and large *Clypeaster* echinoids. Endemic or Pacific-Panamic in faunal affinity, the Argopectens are gregarious scallops found in large concentrations similar to *Argopecten circularis* beds at 15 - 20 m today. All except *Nodipecten arthriticus* became extinct before the Pleistocene.

The assemblage is found in unnamed sediments on the Tres Marias Islands (Madre and Cleofas), on many of the southern gulf islands (Emerson and Hertlein, 1964), the Loreto embayment, and the Infierno Formation of Wilson (1948, p. 1783) near Santa Rosalía. Since extensive deposits of marine sediments are known from the northern Gulf but not yet sampled for mollusks, northern ranges for the "mid-Pliocene spreading event assemblage" are not yet verified.

Middle to late Pliocene molluscan species at Maria Madre Island represent a bank top faunule that occupied a seamount well removed from a source of continental sediments (McCloy and others, 1988). They are found in 150 to 200 m thick massive beds that overlie the Arroyo Hondo diatomite that, according to diatom and radiolarian correlations, was deposited in the Tres Marias Basin ca. 8.2 Ma (McCloy and others, 1988). The basin subsided from early late Miocene through middle Pliocene; uplift of the submarine bank offered a suitable habitat for shallow neritic mollusks until the late Pleistocene when the island rose above sealevel.

Elsewhere in the southern Gulf the same species are found on the east side of Maria Cleofas Island (Hertlein and Emerson, 1959, American Museum of Natural History collections) and on southwestern Cerralvo Island (Hanna and Hertlein, 1927; Hertlein, 1957; Emerson and Hertlein, 1964; Hertlein, 1966; Durham, 1965 field notes, and Smith field reconnaissance for this paper). The Cerralvo locality, mislocated in the literature, is between the "Farallones blancos" of Hertlein (1966, fig. 1) and an arroyo on the north side of the Ruffo's Ranch site, 10 km south of El Mostrador. Rocks include white algal limestone, coquina, sandstone, and cobble to boulder conglomerate exposed in seacliffs for about 1.5 km along the beach. *Argopecten abietis* is especially abundant in the lower outcrops. Ash-flow tuff on the north end of this mainly pre-Tertiary basement island are not closely associated with the sediments (Smith and Sawlan, 1983, oral communication), and what seem to be beds of white volcanic tuff are ledge-forming sandstone containing concentrations of *Leopecten bakeri.*

Late Pliocene Records in the Loreto area

Larger, more diverse assemblages of Gulf mollusks are found on Carmen Island and north of Loreto in rocks referred to the Carmen-Marquer Formation, undifferentiated (Durham, 1950; McLean, 1988). Additional localities include southern Coronado Island in the low terrace 20 feet above low tide, southwestern Monserrate Island, and most

Plate 1 "Mid-Pliocene spreading event assemblage," southern and central Gulf of California.

Figure 1 *Turritella marcosensis* Durham, 1950. Latex mold, hypotype USNM 418217, ht 5.2 cm. USGS loc. M9048, Carmen-Marquer Formation, undifferentiated, north of Loreto, B.C.S.; also occurs at Cerralvo and San Marcos Islands.

Figure 2 *Turritella* sp. Hypotype USNM 418215, ht 4.4 cm. USGS loc. M9057 = Smith loc. 86JS14e, Carmen-Marquer Formation, undifferentiated, north of Loreto, B.C.S. Also at Cerralvo Island.

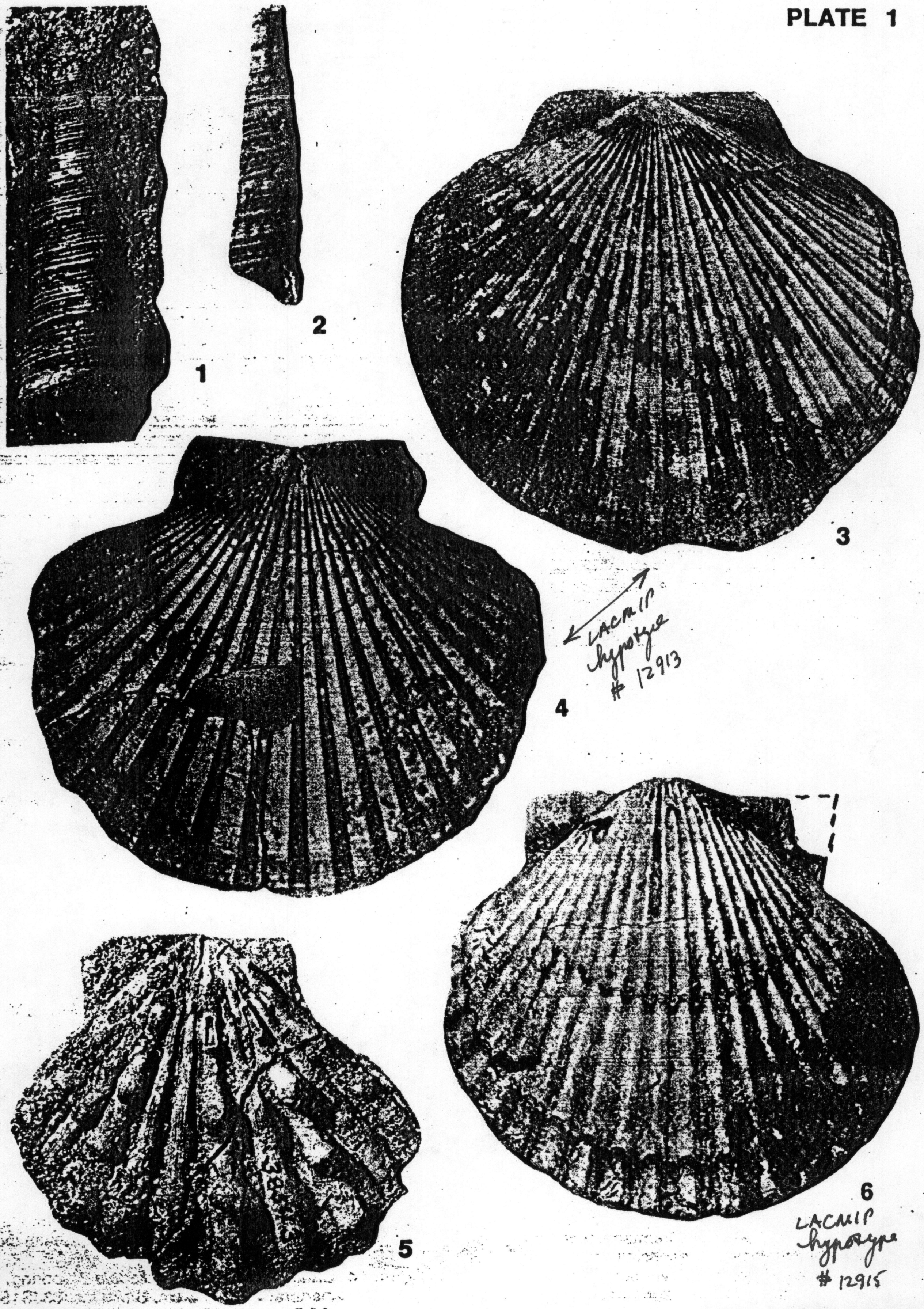
Figures 3, 4 *Leopecten bakeri* (Hanna and Hertlein, 1927) LV, RV, ht. 11.9 cm, lth 13.3 cm, Smith field loc. 83JS7, "*Leopecten* ledge" [= CAS loc. 38543].

Figure 5 *Nodipecten arthriticus* (Reeve, 1853). LV, voucher specimen CAS 60985, ht 7cm, lth 7.6 cm. CAS loc. 38543, unnamed sediments, Cerralvo Island.

Figure 6 *Argopecten abietis* (Jordan and Hertlein, 1926). LV, ht. 10 cm, lth 10.8 cm. USGS loc. M9045 = Smith loc. 84JS22, Carmen-Marquer Formation, undifferentiated, Arroyo de Arce, north of Loreto, B.C.S. Also at Cerralvo and Maria Madre Islands.

Plate explanations: RV, right valve; LV, left valve; locality data on file at Cenozoic register, Menlo Park, California or from author.

PLATE 1



of other islands between Monserrate Island and the Très Marias Islands (Emerson and Hertlein, 1964; Durham, 1950). Northwest of Loreto several tuffs are interbedded with about 1,200 m of marine and nonmarine clastic deposits shown on the reconnaissance map of McLean (1988). The "mid-Pliocene spreading event assemblage" of mollusks is here confined to the lower and middle parts of the section. Tuffs dated at 3.3 - 2.1 Ma (McLean, 1988) also occur in this same part of the section.

Tertiary marine record in the Cabo Trough

It is significant that none of the "mid-Pliocene spreading event assemblage" megafossils is found in the Trinidad Formation or the overlying unnamed sandstone ("Salada" of authors) in the Cabo Trough between the present-day Sierra la Victoria and Sierra la Trinidad, B.C.S. Molluscan data there suggest that the basal Trinidad Formation of Pantoja and Carrillo (1966) may be as old as late middle to early late Miocene, an age not yet verified by microfossil determinations.

Megafossils from the basal Trinidad Formation, Member A of McCloy (1984), are Tertiary Caribbean species that are also found in Panama and the Dominican Republic. Representative index fossils include *Anadara patricia* (Sowerby, 1850), the main component of the *Larkinia* beds in the Cercado Formation, Dominican Republic (Saunders and others, 1986), *Cerithium avus* (Pilsbry and Brown, 1917), and other Tertiary Caribbean taxa illustrated in Plate 2. The basal part of the Trinidad Formation, Member A represents an "estero" or near-mangrove environment with abundant infaunal clams (*Tagelus* sp), cerithiid gastropods, and the tiny multicolored neritinid snail *Theodoxus luteofasciatus*. Miller, 1879. The upper part of the Trinidad Formation, Member A, is neritic and contains *Turritella abrupta fredeai* Hodson, 1926 and other Tertiary Caribbean taxa. Shark teeth measuring 12-15 cm high from *Carcharadon megalodon* Agassiz, 1843 are also present.

Megafossils are rare in the overlying members B - D of the Trinidad Formation, member C being a deep water diatomite. Mollusks from the overlying clastic deposits near Rancho el Refugio have affinities with late middle to early late Miocene taxa from Santa Rosalía to the Salton Trough. A thesis by Rodriguez (1988), mapping by McCloy (in preparation) and microfossil studies in progress (McCloy, Carreño) will contribute new data on the age and relations of these highly fossiliferous units. Several important fossils from the basal Trinidad Formation and correlative deposits from northeast of Santa Anita (83JS10 = USGS locality M9113) and Rancho Algodones (Espinosa A., 1979) have recently been recognized: the basal Imperial Formation index species *Conus spurius* Gmelin, *Codakia* sp. cf. *C. orbicularis* Linnaeus, and *Strombus obliteratus* Hanna, among others.

Tertiary records in the southwestern Salton Trough, California

Tertiary sediments in the southern Salton Trough vary from 0 - 5 km thick and represent a variety of facies from bathyal to neritic to evaporite to nonmarine clastic rocks. In the southern Coyote Mountains the part of the Imperial Formation described by Hanna (1926) and refined by Woodring (1932) represents the lower part of the section, the Latrania Sand Member. It is distinguished from younger facies in the Fish Creek/Vallecitos Mountains that have been subdivided by lithology and especially by the presence or absence of Colorado River sediments by Winker (1987). Megafossils whose ages have been interpolated from their occurrence elsewhere with associated radiometrically dated volcanic rocks support the age constraints suggested by lithofacies.

The basal Imperial Formation, Latrania Sand Member overlies the Alverson Andesite of authors, which was dated as 16.1 ± 1.0 Ma by Eberley and Stanley (1978). Latrania Member fossils include many index species with strong Caribbean affinities also found on Tiburon Island in a 1.5 km thick conglomerate sequence. The Tiburon Island section contains an interbedded volcanic breccia dated at 12.9 ± 0.4 Ma (Smith and others, 1985; Smith, 1989) and is overlain unconformably by an ash flow cap of 11.2 ± 1.3 Ma (Gastil and Krummenacher, 1977). None of these index mollusks is known from younger Miocene deposits in Baja California. The earliest Colorado River sediments in the Salton Trough are younger than 5.4 ± 0.2 Ma, the age of the basal Bouse Formation (Damon and others, 1978); Colorado River sediments are found in the Fish Creek/Vallecitos area by 4.3 Ma (Winker and Kidwell, 1986). Magnetostratigraphy indicates the age of the youngest deltaic members of the Imperial Formation, the Jackson Fork and Camels Head Members of Winker and Kidwell (1986), as 4 Ma. Taken together these figures imply an age span of ca. 14 - 4 Ma for rocks mapped as the Imperial Formation. Different facies deposited over basement varying from metamorphic to volcanic rocks to old alluvium (Kidwell, 1988) complicate correlation throughout this sequence of rocks, and more accurate age determinations are needed to unravel the complex history of the area.

Plate 2 Late middle or early late Miocene mollusks from the Cabo Trough, B.C.S., Trinidad Formation, Arroyo la Trinidad, unless noted.

Figure 1 *Tagelus* sp. LV, ht. 1.5 cm, lth. 3.7 cm. Smith loc. 83JS12 = USGS loc M9041.

Figure 2 *Theodoxus luteofasciatus* Miller, 1879. Ht 3 mm. Smith field loc. 83JS12 = USGS loc M9041.

Figures 3, 4 *Turritella abrupta fredeai* Hodson, 1926. Fig. 3, CAS loc. 58337, ht. 7 cm. Well preserved comparative specimen, Gatun Formation, Panama, collected by William and Lois Pitt. Fig. 4, USNM hypotype 418199, ht 7.7 cm, USGS loc. M9042 = Smith field loc. 83JS13. Miocene, typical preservation for Trinidad Formation, upper basal Member A.

Figure 5 *Turritella* sp. cf. *T. planigyrata* Guppy, 1867. Ht. 5 cm. Smith field loc. 83JS12 = USGS loc. M9041.

Figures 6, 7 *Anadara patricia* (Sowerby, 1850). LV, hypotype USNM 418201, ht 9 cm, lth 9.5 cm. USGS loc. M9112 = Smith loc. 83JS11.

Figures 8, 9 *Turbo crenulatoides* Maury, 1917. Fig. 8, ht. 1.8 cm. Fig. 9, ht. 1.3 cm, Smith loc. 83JS12 = USGS loc. M9041.

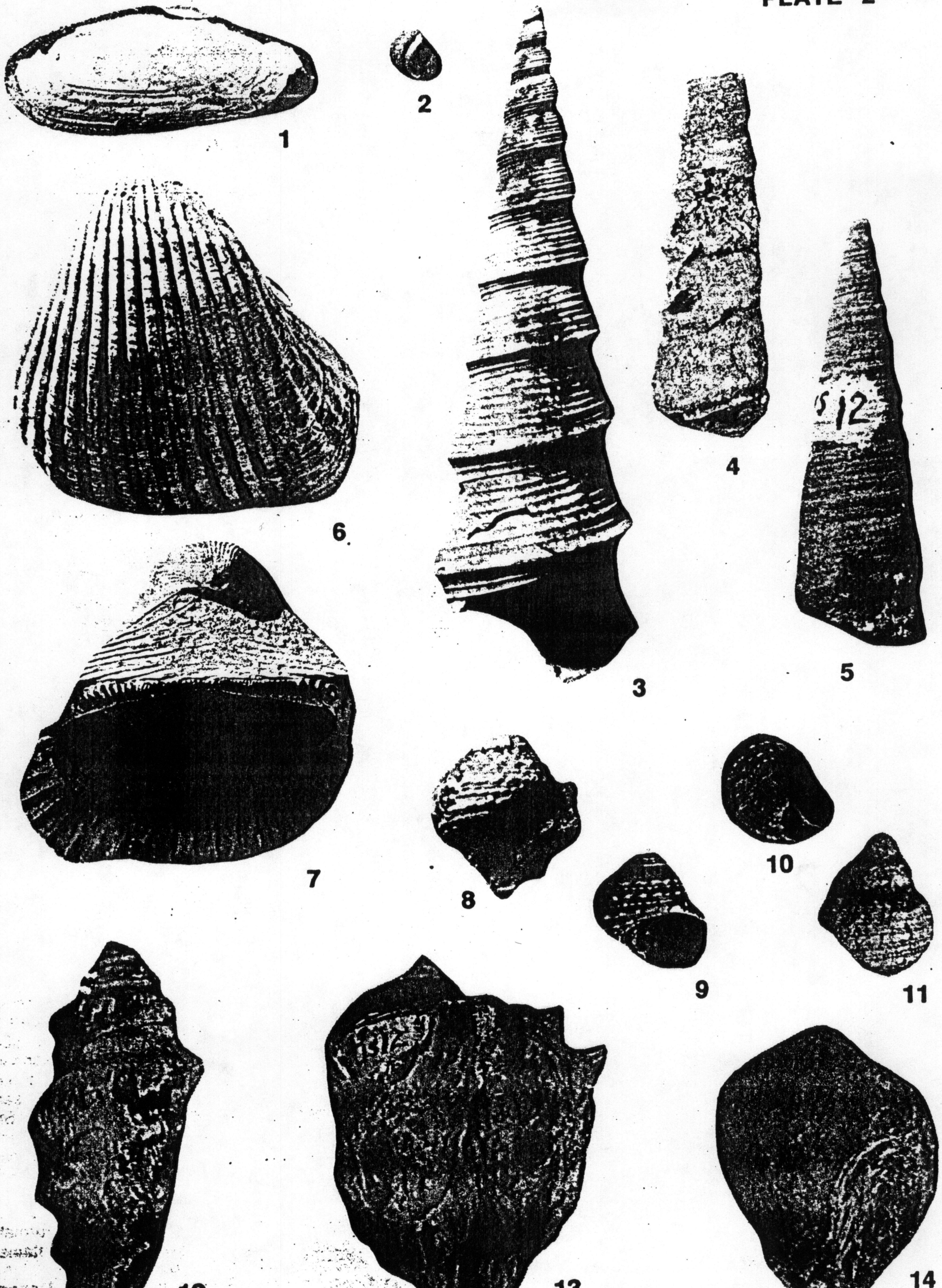
Figures 10, 11 *Turbo antiguensis* Cooke 1919. Basal, abapertural views, ht. 1.4 cm, diameter 1.2 cm, loc. 83JS12 = USGS loc. M9041.

Figure 12 *Strombus obliteratus* Hanna, 1926. Side view, ht. 4.3 cm. Smith loc. 83JS13= USGS loc M9042.

Figure 13 *Melongena melongena consors* (Sowerby, 1850). Apertural view, ht. 6.4 cm. Smith loc. 83JS12 = USGS loc. M9041.

Figure 14 *Cancellaria (Pyruclia) diadela* Woodring, 1970. Apertural view, ht 3 cm. Smith loc. 83JS15 = USGS loc M9042.

PLATE 2



Late middle or early late Miocene molluscan index fossils from the basal Imperial Formation in the southern and southeastern Coyote Mountains are illustrated by Hanna (1926). They include *"Aequipecten" muscosus* (Wood), *Spondylus* sp. aff. *S. ursipes* Berry [= *A. bostrychites* Guppy of Hanna, 1927], and *Lyropecten* n. sp. Tertiary Caribbean taxa from the Latrania Member that are also recognized in the Cabo Trough basal Trinidad Formation, Member A, and unnamed sandstone northeast of Santa Anita and at Rancho Algodones are figured on Plate 3. They include *Conus spurius* Gmelin, *Vasum haitense* (Sowerby) [described as *V. pufferi* Emerson, 1964], *Strombus obliteratus* Hanna, *Anadara thauma* Maury, 1925, and *Codakia* sp. aff. *C. orbicularis* (Linnaeus). The *Conus spurius* with its well preserved color pattern is especially interesting, as it is a Miocene fossil in Panama (Woodring, 1970) and Holocene in Florida and the West Indies.

Discussion of the molluscan and sedimentary records near San Gorgonio Pass and the Whitewater River area of the northern Salton Trough is beyond the scope of this paper, but a few comments can be made. Rocks mapped as the Imperial Formation have a variety of facies; both mollusks and microfossils (Kristin McDougall, 1988, personal communication), suggest neritic to outer shelf deposition from late middle or early late Miocene to early or middle Pliocene. Fossils from the Imperial Formation in the Super Creek area underlie a basalt flow in the lower Painted Hill Formation dated at 6.04± 0.18 Ma to 5.94 ± 0.18 Ma (Matti and others, 1985). In the Indio Hills Imperial Formation fossils are regarded as Pliocene by Powell (1986, 1988), who reported 255 molluscan taxa from four areas in the northern Salton Trough: Lion Canyon, Super Creek, Garnet Hill, and Willis Palm, Riverside County.

Paleontologists have long noted that Imperial Formation faunas have a "strong Caribbean aspect," an especially problematic affinity when the taxa were believed to be Pliocene in age and known only from the head of the ancient Gulf of California. Although the geologic setting is complex, the area seemed not to be a "suspect terrain," an interpretation borne out by new faunal distribution data and radiometric age constraints. The present study found both field and museum collection evidence that a number of diagnostic basal Imperial formation taxa are also found in the Cabo Trough of Baja California in the basal Trinidad Formation and correlative deposits near Santa Anita and Rancho Algodones. The "strongly Caribbean affinity" is further documented by the presence of *Conus spurius* Gmelin with its unmistakably Caribbean color pattern in the Coyote Mountains, Arroyo la Trinidad (private collection of the Fiol family at Rancho la Trinidád), and in the Gatun Formation of Panama.

Paleontological notes

Locally sections whose ages are unconstrained by associated dated volcanic rocks can be dated by the presence of index fossils belonging to a documented evolutionary series. Although the systematic nomenclature is complicated, the relationships are clear, as shown for a lineage of *Spondylus* in Plate 4. A late middle or early late Miocene form from the Coyote Mountains, Tiburon Island, and the Boleo Formation near Santa Rosalía is ancestral to a late Miocene or early Pliocene form from San Felipe. The Holocene descendant (*Spondylus ursipes* Berry, plate 4, fig. 4) lives in the northern Gulf from Adair Bay, Puerto Peñasco, to Angel de la Guarda Island.

Two other taxa are commonly listed as index fossils in the Imperial Formation and at Tiburon Island: *Turritella imperialis* Hanna and *Euvola keepi* (Arnold) [= *E. refugioensis* (Hertlein) from the Cabo Trough]. Both species need careful study to determine whether they have long chronostratigraphic ranges or whether subspecies of different ages can be recognized when shell preservation is sufficiently good.

Applications of megafaunal data

The history of the Gulf of California involves the San Andreas Fault system in the north, the East Pacific Rise in the south, and a complex series of tectonic events related to changes in plate boundaries, tectonic styles, and volcanic products. Fossil distributions in conjunction with radiometric and sedimentologic data provide a time context for dating events and correlating discontinuous parts of an extensive sedimentary record exceeding 5 km in thickness in the Salton Trough. Many published geophysical models assume seawater entered the Gulf when the Baja California peninsula began to separate from mainland Mexico, ca. 4.5 Ma. A number of studies now show that the ancient gulf is at least as old as 13 Ma and that unconformities in the southern sections represent 5-8 million years of the record preserved in sediments and volcanic rocks in the northern and central gulf. Better ages are available for key sections, many of which contain dissimilar facies, to constrain times of spreading reorganization, episodes of faulting and rotation, and local tectonic events. Paleogeographic reconstructions need to incorporate data from extensive, largely unstudied sections from the Salton Trough to Santa Rosalía.

Plate 3 Late middle or late Miocene molluscan species common to the basal Imperial Formation, Coyote Mountains, California, and the basal Trinidad Formation and correlatives, Cabo Trough

Figure 1 *"Aequipecten" muscosus* (Wood, 1828). RV, hypotype USNM 422805, ht 4.8 cm, lth 4.9 cm. Miocene, unnamed conglomerate, southwestern Tiburon Island, USGS loc M9117. Also occurs in Latrania Sand Member, Imperial Formation, and at 83JS10.

X Figure 2 *Conus spurius* Gmelin, 1791. Apertural view, ht. 6 cm. Remarkable specimen showing brown rectangular color pattern. LACM locality no. 9802.,Coyote Mountains, Imperial Formation. Also from Miocene of Panama, Dominican Republic; Holocene in Florida, West Indies.

Figure 3 *Turritella imperialis* Hanna, 1926 [= *Turritella* sp. cf. *T. altilira* Conrad, 1857 of Smith (1989)]. Hypotype USNM 418200, ht. 7.8 cm. White sandstone facies, hills northeast of Santa Anita, B.C.S., loc. USGS M9113 = Smith loc. 83JS10.

Figures 4, 5, 6 *Codakia* sp. cf. *C. orbicularis* (Linnaeus, 1758). Figs. 4, 6, LV, end view of specimen 6 cm in ht, 7.5 cm in lth from unnamed white sandstone facies, northeast of Santa Anita, B.C.S., Smith loc. 83JS10. Fig. 5, RV, ht 5.3 cm, lth. 6 cm, Imperial Formation, Latrania Sand Member, Coyote Mountains, CA. Univeristy of California Riverside loc. 7267.

X Figure 7 *Anadara thauma* Maury, 1925. LV, ht. 5.5 cm, lth. 8.5 cm. LACM loc. 9855 , Imperial Formation, Latrania Sand Member, Coyote Mountains, CA. Also found at 83JS10.

X Figure 8 *Strombus* sp. Side view, ht. 5.6 cm. Unnamed white sandstone facies, northeast of Santa Anita, B.C.S., Smith loc. 83JS10 = USGS loc. M9113.
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PLATE 3

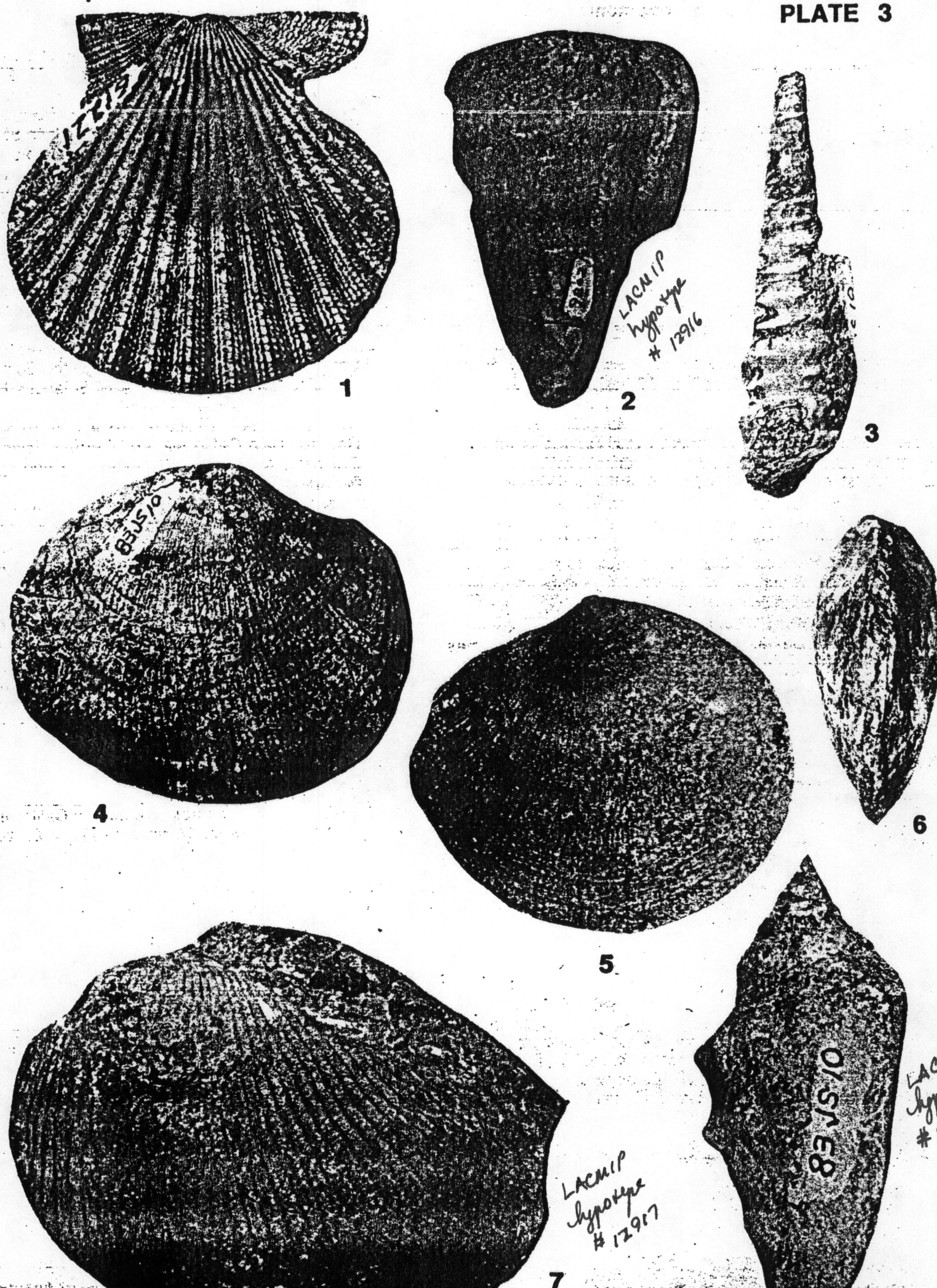
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Plate 4 Index species from the Gulf of California

Figure 1 *Euvola keepi* (Arnold, 1906) [= *E. refugioensis* (Hertlein, 1925)]. Holotype LSJU/CAS 5, ht. 7.5 cm, lth. 7.4 cm. Imperial Formation, Latrania Sand Member, Coyote Mountains, CA.

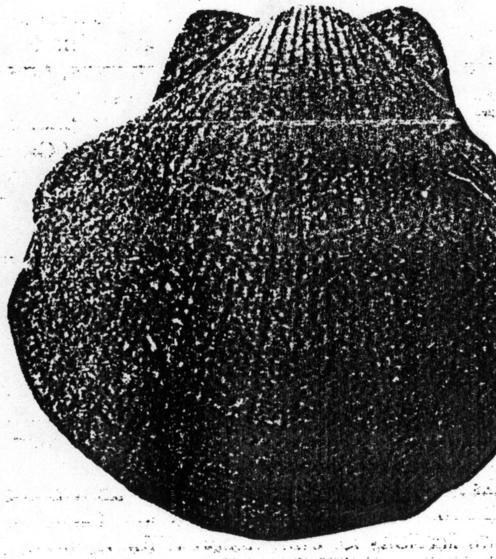
Figures 2, 3 *Turritella imperialis* Hanna, 1926. Fig. 2, hypotype USNM 418206, ht. 3.8 cm. Late Miocene or early Pliocene, west of San Felipe, Baja California, USGS loc. M9040 = CAS 40666. Fig. 3, hypotype USNM 418205, ht. 5 cm. Miocene, Imperial Formation, Latrania Sand Member, Univ. California Berkeley loc. 738.

Figure 4 *Spondylus ursipes* Berry, 1959. RV, ht. cm, lth cm. Holocene, Bahia de Adair, Sonora, Mexico. Santa Barbara Museum of Natural History specimen.

Figure 5 *Spondylus* sp. cf. *S. ursipes* Berry, 1959 [= *S. victoriae* of Durham, 1950]. CAS voucher specimen 61210, ht. 15 cm, lth. 12.3 cm. Late Miocene or early Pliocene, west side of Sierra San Felipe, Baja Califomia, R.L. Anderson thesis area, San Diego State University locality B6G-29.

Figure 6 *Spondylus* sp. aff. *S. ursipes* Berry, 1959 [= *S. bostrychites* Guppy of Hanna, 1926]. Ht. 11 cm, lth. 8 cm. Miocene, Imperial Formation, southeastern Coyote Mountains, CA., Smith loc. 88JS9 = Kidwell loc. 88GSD-119. Also occurs at southwestern Tiburon Island and in the Boleo Formation near Santa Rosalia, B.C.S.

PLATE 4



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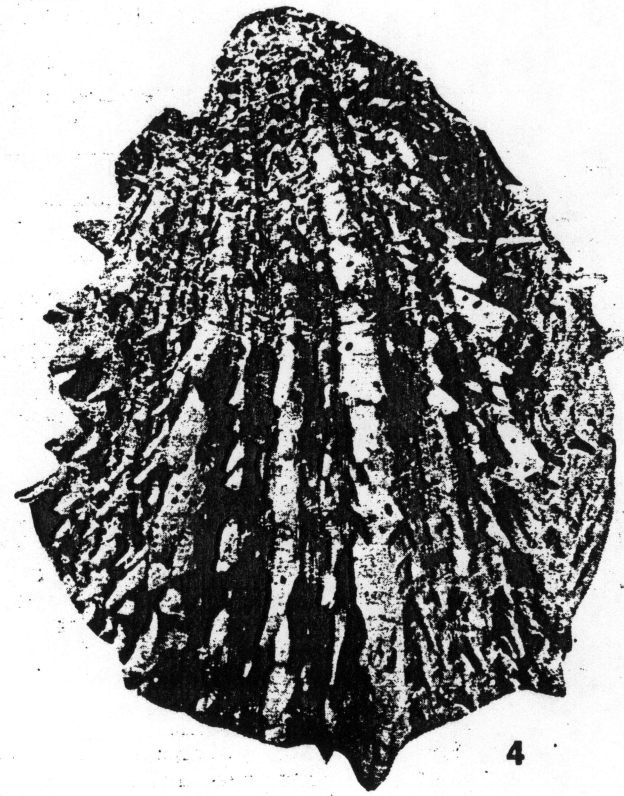

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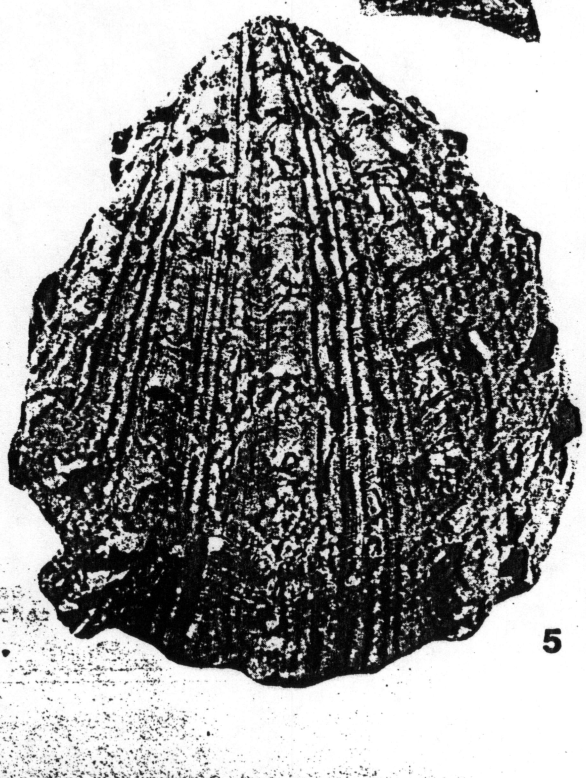

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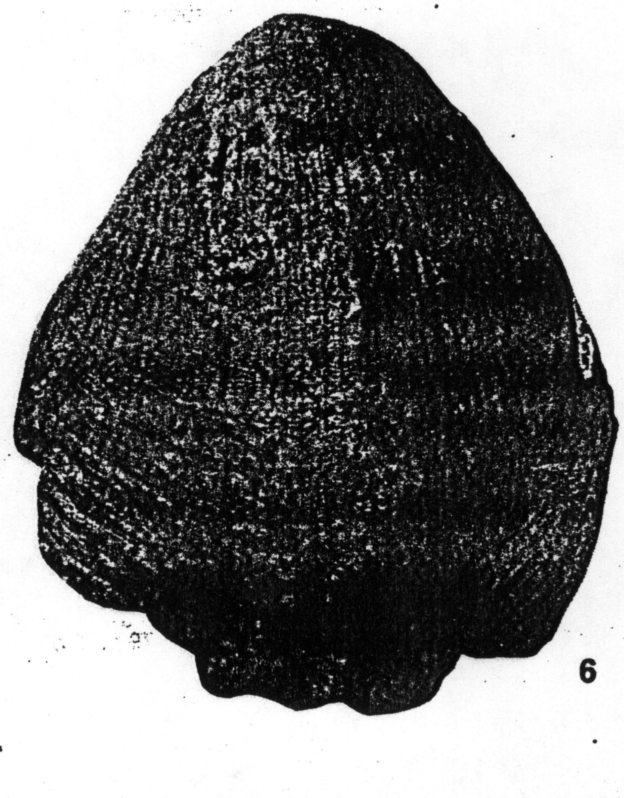

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