

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 obliterated* 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 Trinidad), 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 Rosalia 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 Rosalia.

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.

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. atilira* 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. University of California Riverside loc. 7267.

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.

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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