Upper Cretaceous, Paleocene, and Eocene Sedimentary Rocks & Fossils, La Jolla, California

Highlights of the Spring, 2026 Field Trip for the Pacific Section Society for Sedimentary Geology (SEPM)

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Principal Organizers and Trip Leaders: Patrick Abbott, Bill Bartling, Ron Kies, and Eugenia Sanginés, with field contributions by Todd Wirths, Tom Deméré, and Mario Caputo

Introduction

Toward the end of 2025, Pat Abbott, Emeritus Professor of Geology, SDSU, and past president of Pacific Section SEPM, coordinated the planning of a long-awaited field trip for the Society to revisit the unparalleled outcrops of world renown sedimentary rocks at Tourmaline Surfing Park, La Jolla Bay, and Torrey Pines State Beach along coastal San Diego **(Figure 1)**. Pat, and his co-leaders and guidebook contributors, Bill Bartling from Prescott, Arizona and Ron Kies from Half Moon Bay, California **(Figure 2)** offered fresh insights on the origin of the San Diegan Cretaceous, Paleocene, and Eocene rocks. Local San Diego residents and members of the San Diego Association of Geologists joined others from Seattle, San Francisco, Los Angeles, and Houston to partake in this field excursion. While most of the out-of-towners opted for indoor lodging, Pacific Section executive committee members, Ray Ingersoll and Mario Caputo, preferred to be serenaded by the celebratory sounds of family weekenders at Campland on the Bay at north San Diego Bay **(Figure 1)**.

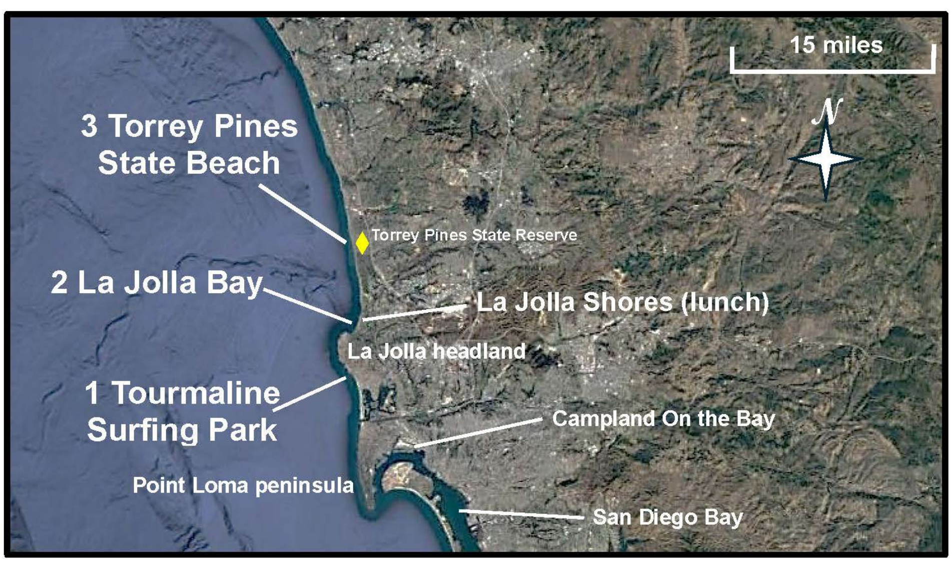


Figure 1. Map of the field-trip localities: Tourmaline Surfing Park, La Jolla Bay, and Torrey Pines State Beach, numbered from south to north in the order in which they were explored during the trip. Image modified from Google Earth.

Figure 2. The field-trip organizers and leaders: Pat Abbott, Eugenia Sanginés, Bill Bartling, and Ron Kies, from left to right, at Tourmaline Beach on a day of the field-trip rehearsal, November, 2025. Photo credit: a graciously accommodating surfer.

Trip co-organizer and co-planner, Eugenia Sanginés of Sante Fe, New Mexico **(Figure 2),** served as past president and past editor for the Pacific Section and is skillfully involved again as production editor in preparing for print PS-SEPM Book #125, *Upper Cretaceous, Paleocene, Eocene Sedimentary Rocks and Fossils, La Jolla, California* **(Figure 3)**, a handsome addition to the Pacific Section SEPM catalog of publications. Book contents address: Deposition, structure, tectonics, and oil and gas exploration for Cretaceous and Eocene strata in San Diego over several chapters (Abbott, Bartling, and Kies), Paleoecologic interpretations of macroinvertebrate fossil assemblages from the Eocene Mount Soledad Formation (Wirths), The sedimentologic imprint of the Paleocene-Eocene Thermal Maximum event in San Diego (Abbott, Kies, and Filewicz), Architecture of the submarine-fan system of the Cretaceous Point Loma Formation (Abbott, Bartling, and Kies), Eocene sea-level history preserved in the back-barrier Delmar Formation (Deméré and Wood), The nature of peak high tides and sea level in the San Diego region (Flick), and Offset of the Eocene Ballena River Valley across the Elsinore fault zone (Abbott, Kies, and Kerr).

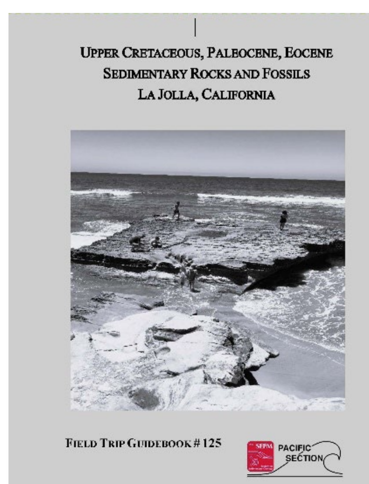


Figure 3. PS-SEPM Field-trip Book #125 *Upper Cretaceous, Paleocene, Eocene Sedimentary Rocks and Fossils, La Jolla, California*, co-edited by Abbott, Sanginés, and Caputo (2026).

Heartfelt appreciation is extended to Bill Bartling and his daughter, Ellen Bartling, for enhancing the proceedings of the field trip. Bill kindly and generously provided his portable equipment to create a full audio-visual recording of the field trip that will certainly enrich the field-trip chronicles of the Pacific Section SEPM. Ellen, as audio-visual engineer and advisor on use of equipment, coordinated the entire onsite production by employing microphones to amplify and record presenter's voices and directing the placement of video cameras at designated outcrops. Bill has been editing and refining the recording, which he will make available when completed. He is further designing short animations of physical processes that illustrate how select sedimentary structures develop. His animation series will be powerful tools for geoscience educators. Ellen along with Diane Murbach, a prominent member of the San Diego Association of Geologists and secretary for the San Diego Geological Society, further documented the field trip with photographs, some of which are used in this field-trip recap **(Figure 4)**.

Figure 4. Exemplary photographers, Ellen Bartling (left) and Diane Murbach (right), standing behind a three-dimensional depiction of topography (tan) and bathymetry (blue) of La Jolla Shores and La Jolla Bay. The model is a tribute to Walter Munk, physical oceanographer formerly of Scripps Institution of Oceanography. It is displayed at Kellogg Park, La Jolla Shores adjacent to the tiled "Map of the Grand Canyons of La Jolla" on the right. Photo credit: Monte Murbach.

Saturday Morning, April 25, 2026
Tourmaline Beach Surfing Park at Pacific Beach, California

Thirty-two people, including trip leaders, congregated around 8:30 a.m. in the parking lot crowded with surfers at the western end of Tourmaline Street. Name tags and field guides were distributed, and the event began as we followed Pat, Eugenia, Ron, Bill, and Ellen to the backshore of Tourmaline Beach. In his signature style, Pat Abbott **(Figure 5)** introduced listeners to the depositional setting interpreted from sedimentary rocks of the Upper Cretaceous Cabrillo Formation, upper Paleocene to lower middle Eocene Mount Soledad Formation, and Pliocene San Diego Formation.

Figure 5. A prologue by Pat Abbott highlights the Late Cretaceous-early Paleogene geologic setting at Tourmaline Beach. Photo credit: Ellen Bartling.

Instability of the tectonically evolving coast and continental borderland of the San Diego region influenced alluvial, marginal marine, and deep marine depositional systems during Late Cretaceous to early Paleogene time. A part of that history is recorded in submarine-fan sedimentation of the Upper Cretaceous Cabrillo Formation. Plutonic and volcanic pebbles and cobbles comprise upward-coarsening, matrix- and clast-supported conglomerates. Debris flows triggered by enormous earthquakes channeled the igneous gravel clasts into underlying sand at the valley floor of an inner submarine fan **(Figure 6)**. Local boulder-sized clumps of levee strata were sloughed from channel walls and entrained and deposited with the flows.

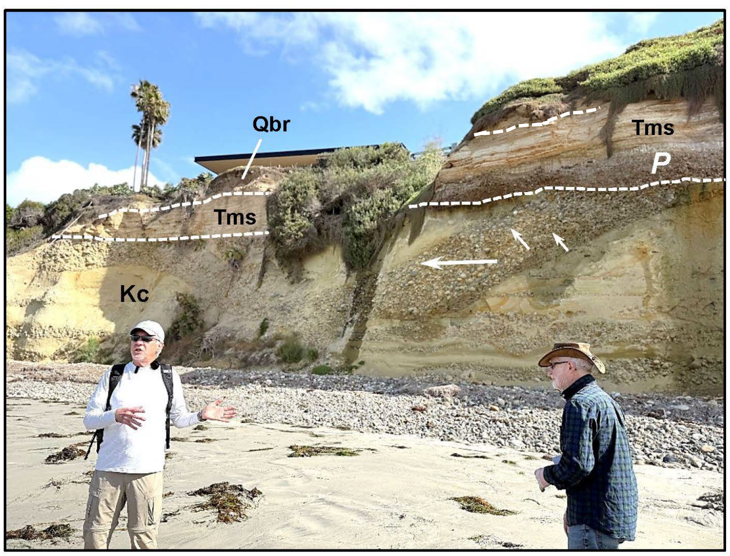


Figure 6. Bill Bartling (left) describes upward-coarsening debris-flow beds (thin white arrows) that prograded to the left into channel (bold white arrow) of an inner submarine fan of Cretaceous Cabrillo Fm (Kc). Black rhyodacite gravels in the Cabrillo contrast the reddish-purple Paleocene-Eocene Poway-type porphyritic rhyolite gravels (white letter, ***P***) in the Mount Soledad Formation (Tms). Marine and nonmarine gravelly sandstone on the upper Pleistocene Bird Rock terrace (Qbr) at the top. Ray Ingersoll (right) is intrigued by the interpretation. Notations added to photo by Ellen Bartling.

Black rhyodacite gravel clasts in Cretaceous submarine-fan conglomerates contrast the gravel clasts in Paleocene-Eocene alluvial and submarine-fan conglomerates, which are composed of reddish-purple, Poway-type, porphyritic rhyolite gravels known from Paleogene conglomerates throughout San Diego County and on the California Channel Islands -San Miguel, Santa Cruz, and Santa Rosa. Cretaceous gravels in the Cabrillo Formation were sourced from igneous rocks that today lie at the southern extension of the Peninsular Ranges batholith in Baja California, Mexico. Paleogene Poway-type gravels are thought to have been weathered from Jurassic bedrock in the State of Sonora on mainland Mexico. Depocenters of the Cretaceous and Paleogene alluvial and submarine-fan systems were shifted along multiple strands of parallel, right-lateral strike-slip faults and positioned down-dip of different source terranes over time to account for the contrasting gravel populations in the rocks.

After about 15 m.y. of erosion and nondeposition, inner submarine-fan strata of the Cabrillo Formation at Tourmaline Beach were buried by sediments deposited in fluvial, fan delta, and submarine-fan environments of the upper Paleocene-lower middle Eocene Mount Soledad Formation **(Figures 7A, B)** and marked the arrival of Poway-type clasts (conglomerate bed marked with the white letter, ***P***, in **Figure 6**). The original east-west alignment of Cretaceous-Paleogene depositional systems was modified later by crustal motions in the San Andreas transform system and clockwise rotation of the Transverse Ranges (San Gabriel and San Bernardino Mountains) that translated the Cretaceous-Paleogene rocks to their present geographic locations.

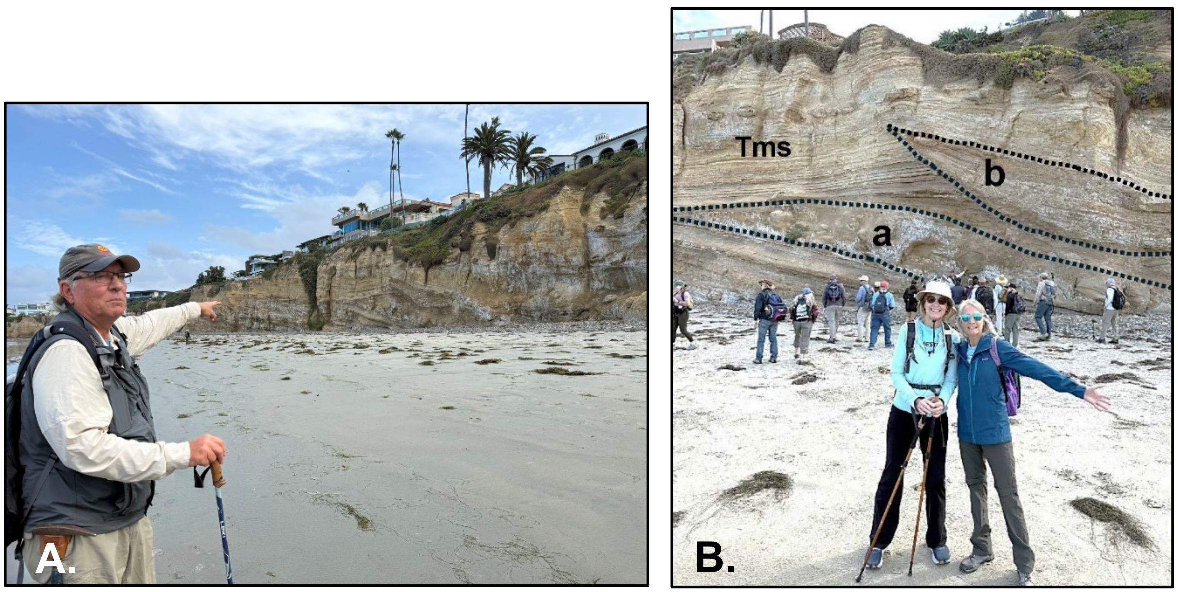


Figure 7. Anatomy of a submarine fan in the Mount Soledad Formation at Tourmaline Beach. **A.** Ron Kies explaining internal sedimentary architecture, a detail of which is shown in photo B. Photo credit: Diane Murbach. **B.** Complex channelizing of sedimentary debris. Lower channel (a) filled with slump blocks and chaotically bedded sandstone, siltstone, and mudstone. Upper channel (b) filled with slumped and chaotically bedded levee and slope material. Exposure is several meters south (to the right) of that pictured in **Figure 6**. Sarah Gray (left) and Diane Murbach (right) stand in foreground. Notations added to photo by Monte Murbach.

Todd Wirths of Brian F. Smith and Associates Environmental Services (BFSA) shared conclusions from his study of molluscan fossils recovered from a borehole drilled inland from the sea cliff and from other samples from the Mount Soledad Formation at Tourmaline Beach **(Figures 8 and**

9). He interpreted mixed death assemblages (i.e. *thanatocoenoses*) of invertebrate species transported from both inner and outer continental-shelf communities and deposited more deeply on an upper continental slope. The assemblages reflect an interval of late early to early middle Eocene time known as the provincial molluscan Domengine stage.

Figure 8. Todd Wirths shares his thoughts with Ron Kies, Diane Murbach, and Scott Ruhg (left to right) and other onlookers about invertebrate fossil assemblages studied from the Mount Soledad Formation (Tms) at Tourmaline Beach. Photo credit: Ellen Bartling.

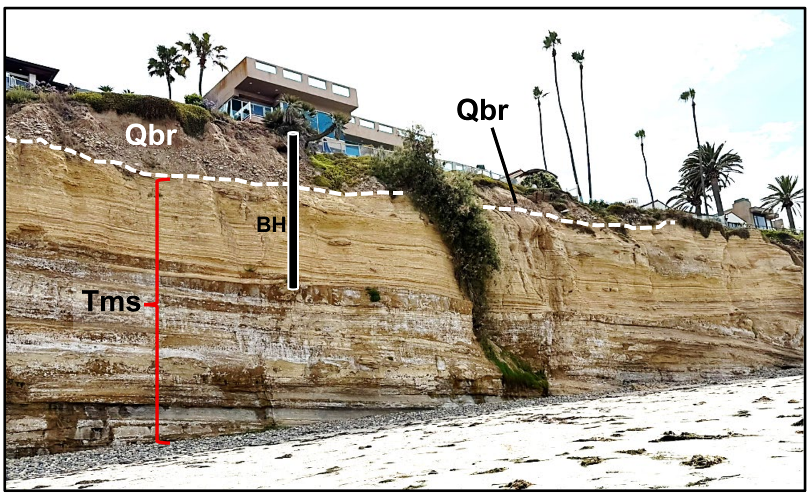
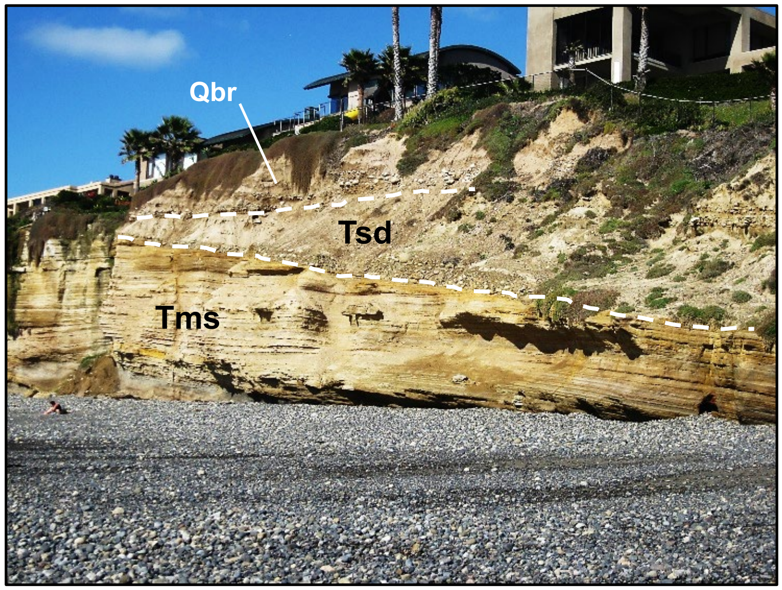


Figure 9. Sedimentary beds of the Mount Soledad Formation (Tms, red bracket) exposed in a section of sea cliff just north of the beach access from the parking lot at Tourmaline Beach. For perspective, the position of borehole (BH) from Todd Wirths's study is projected into the plane of the cliff. Houses are built on marine and nonmarine gravelly sandstone deposited on the upper Pleistocene Bird Rock marine terrace (Qbr), toe of which is shown by the white dashed wavy line. Notations added to photo by Ron Kies.

In the cliff at Tourmaline Beach, the trace of the *toe* or seaward erosional edge of the 80,000-year-old Bird Rock marine terrace marks the localized unconformity between the abrasion surface of the terrace itself and the underlying middle Eocene Mount Soledad Formation. Gravelly sandstones, on which seaside houses are built, comprise upper Pleistocene unnamed marine and nonmarine deposits on the Bird Rock terrace **(Figures 6, 9,** and **10)**.

The Pliocene San Diego Formation is an evenly laminated lithic sandstone with abundant whole and fragmented pectinid fossils deposited on a nearshore shelf at or below fair-weather wave base. It lies unconformably on the Mount Soledad Formation and is overlain unconformably by upper Pleistocene unnamed marine and nonmarine gravelly sandstones on the Bird Rock terrace **(Figure 10).**

Figure 10. Younger lithostratigraphic units at Tourmaline Beach: lower to middle Eocene Mount Soledad Fm (Tms), Pliocene San Diego Fm (Tsd), and upper Pleistocene unnamed marine and nonmarine beds on the Bird Rock terrace (Qbr). White dashed contacts below and above the San Diego Fm (Tsd) are angular unconformities. Exposure is several meters further south (to the right) relative to that pictured in **Figure 7**. 2013 photo by Mario Caputo.



Saturday Noon Lunch – Kellogg Park, La Jolla Shores, California

From Tourmaline Beach, we scattered in vehicles to Kellogg Park at southern La Jolla Shores **(Figure 1)**, where Pat and Eugenia arranged for a local delicatessen to prepare and deliver a deluxe lunch for us.

Saturday Afternoon, April 25, 2026
La Jolla Bay, California

Cliff exposures of the younger Cabrillo Formation seen earlier at Tourmaline Beach showed the internal structure of only the inner or upper portion of the Cretaceous submarine-fan system of San Diego. Around La Jolla Bay immediately south of La Jolla Shores, sea cliffs display facies deposited in marginal-marine, middle and outer or lower submarine-fan, and basin-plain environments preserved in the older Cretaceous Point Loma Formation **(Figure 11).** In general, the vertical facies succession from outer submarine fan in the Point Loma Formation to inner submarine fan in the Cabrillo Formation reflects the basin-ward progradation of the Cretaceous submarine-fan system.

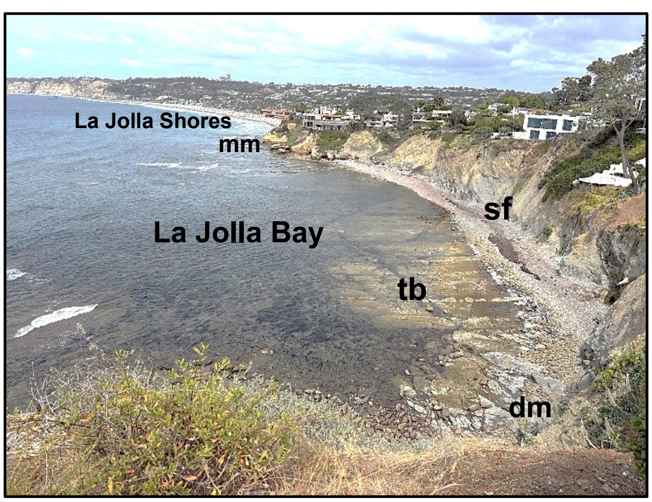


Figure 11. View to the north from topographic terrace overlooking La Jolla Bay and sea cliff of the Point Loma Formation; photo snapped near trace of the Country Club fault (Rose Canyon fault system) approximately at bend of the sea cliff at lower right corner of photo. Southward from La Jolla Shores, around a short headland and at the head of a small cove, marginal marine strata (mm) are exposed. The marginal marine facies grades farther south to facies of a submarine fan (sf) and deep marine basin (dm). Wave-truncated beds with up-dip terminations dip southward (tb). Notations added to photo by Diane Murbach.

Trekking across Cretaceous bedrock and tide pools, we rounded a promontory to a smaller cove, where lithic sandstones near the base of the Point Loma Formation preserve cross-beds of subaqueous dunes **(Figure 12A)**, some of which show bidirectional paleocurrent directions. Trace fossils and fragments of rudistid and inoceramid clams (Cretaceous index fossils) suggest a 76-million-year-old nearshore environment similar to the modern one we had just trekked across. Continuing southward on a pebbly, cobbly beach, we were alerted to fragments of mollucs, corals, bryozoans, brachiopods, and sea-urchin spines that littered a bed of sandstone up to a meter thick. The fossil content and grain texture and fabric suggest that the sandstone is a "condensed bed," having been deposited in marine water no more than a meter deep. Burying the condensed bed are several tens of meters of gray mudstone and thin interbeds of tan turbidite sandstones **(Figure 12B)** deposited at a depth of nearly 1,000 meters in a marine basin that was rapidly subsiding and astoundingly deepening on a down-dropping fault block. Suspension-settling of mud in the deepening basin plain established a foundation for the Cretaceous San Diegan submarine fan.

As the deep marine fan was supplied with terrestrial sediment at the head of a submarine canyon, it prograded across a muddy basin plain. Currents deposited upward-fining and variably upward-thinning and upward-thickening beds of partial to complete Tabcde units of Bouma turbidites of an outer submarine fan. Some turbidite bedding features seen are: 1) upper-flow-regime plane laminations (Bouma Tb) and lower-flow-regime ripple laminations (Bouma Tc), 2) pelagic mud interval (Bouma Te), 3) burrow-, load-, and flame-structures at bases of sandstones, and 4) wavy and lenticular siltstone and sandstone beds of sediment-starved ripples **(Figure 12C).** Upward thickening lenticular beds of sandstone occupy channels of a middle submarine fan and display dish structures typical of fluidized sediment gravity flows. Dish structures appear as concave-upward shapes. They generally form by pore water expelled easily upward through pipes or conduits during sediment settling and compaction. Horizontal, semi-permeable zones akin to laminations are broken through to create the concave "dishes" with upturned edges; they are useful sedimentary structures for determining stratigraphic-up orientations of bedding **(Figure 12D)**.

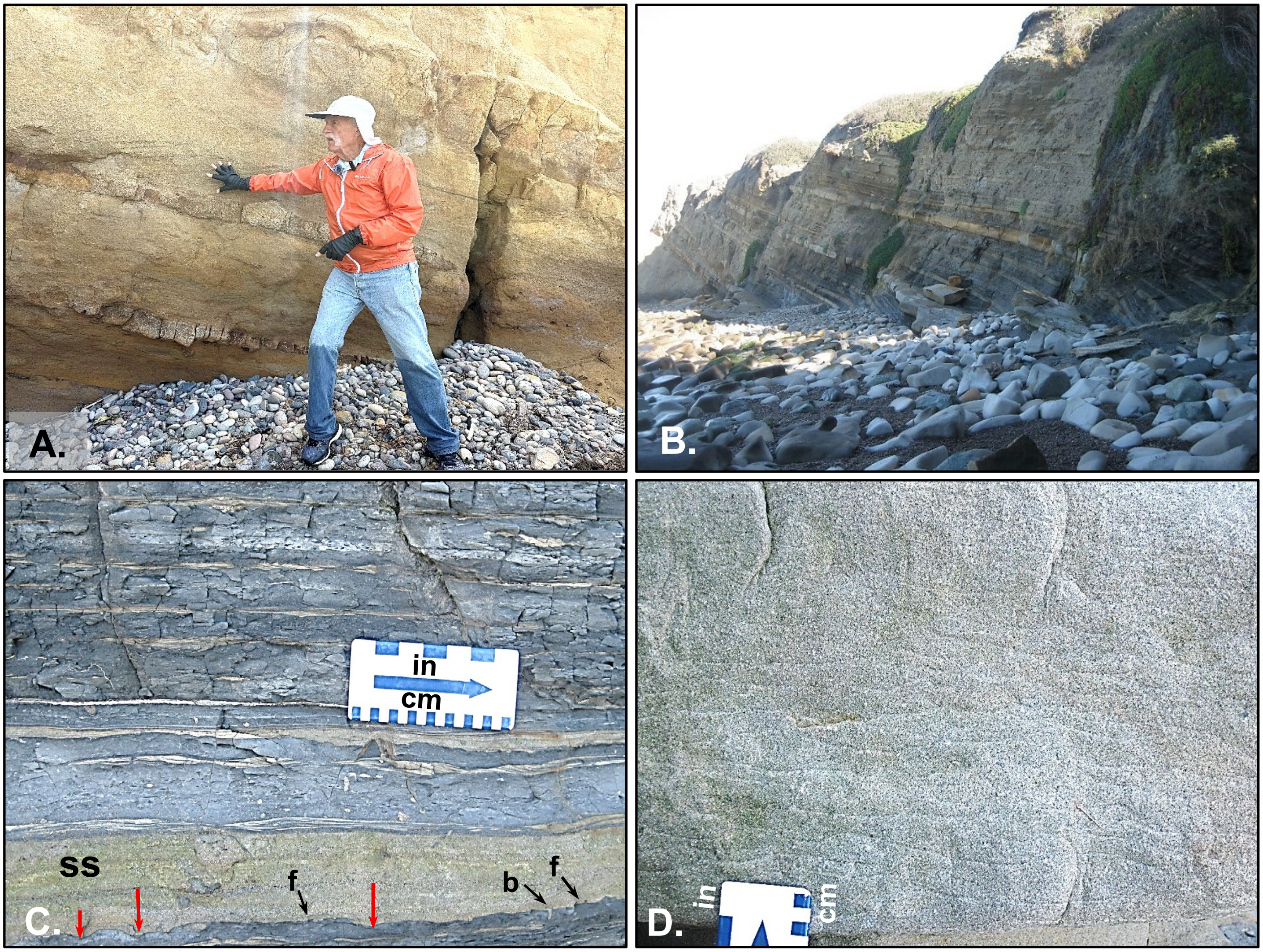


Figure 12. Some sedimentary features of the Upper Cretaceous Point Loma Formation in the cliffs around La Jolla Bay. **A.** Pat has his right hand on a cross-bed set (foresets dip left) of a subaqueous dune, intertidal facies. Photo credit: Ellen Bartling. **B.** Gray pelagic mudstone interlayered with tan, upward-thinning turbidite sandstones deposited in rapidly deepening marine basin. **C.** Some details of turbidite bedding: gray mottled whitish-green sandstone (ss) with local burrow (b), load (red arrows), and flame (f) structures overlain by medium gray mudstone interlayered with light gray wavy and lenticular siltstone-sandstone beds (starved ripples). **D.** Dish structures in sand-filled channel of middle submarine fan. Photos B, C, and D by Mario Caputo.

Saturday Night Dinner

A sumptuous indoor dinner was planned by Pat and Eugenia at Italian *Osteria Romantica* **(Figure 13)** within walking distance of La Jolla Bay and La Jolla Shores. Served were bread with three different *primi piatti* (salads), three different *secondi piatti* (main courses), and finished with a *dolci* (dessert) of tiramisu. Individuals paid for their own alcoholic beverages. After dessert in the banquet room, Pat signaled for everyone's attention, and expressed gratitude for their attendance and participation on the weekend field trip. Then he introduced Senior Advisor for the Pacific Section, Ray

Ingersoll, who announced the names of past President, Karen Grove as recipient of a Lifetime Honorary Membership in PS-SEPM, and President, Adam Woods and Membership Manager, Wayne Henderson, both as recipients of Pacific Section's highest honor for 2026, the A. Eugene Fritsche Lifetime Achievement plaque. At the end, I, as managing editor for PS-SEPM expressed heartfelt appreciation to all the trip participants on behalf of the Pacific Section, recognized Eugenia Sanginés for her talents as production editor of the guidebook, and presented awards to the principal trip organizers and leaders: Pat Abbott, Bill Bartling, and Ron Kies for their time and effort since November, 2025 in planning and executing the spring field trip for the Pacific Section.

Figure 13. Field-trip banquet at Italian restaurant, *Osteria Romantica* in La Jolla, California. Photo credit: Diane Murbach.

Sunday Morning, April 26, 2026
Torrey Pines State Beach south to Bathtub Rock and Hang Glider Canyon

Slightly after 9:00 a.m., field-trippers assembled near the first life-guard stand where Pat Abbott reviewed the sedimentary character of Cretaceous rocks seen the previous day and contrasted them with the Paleocene and Eocene sedimentary rocks to be seen here on this second field-trip day. Selected outcrop stops along a southerly walk on the sandy backshore and foreshore beach from Torrey Pines State Beach to Hang Glider Canyon (formerly named Indian Trail Canyon) at Black's Beach **(Figure 14)** showcased the following: 1) a protected, muddy back-barrier environment of the greenish Delmar Formation in interbedded vertical contact with the overlying sandy nearshore shelf and coastal barrier of the orangish Torrey Sandstone, 2) the intricate sediment fill of an impressively large shelf-edge submarine canyon, 3) a newly discovered basal facies of the Delmar Formation, and 4) evidence for the Paleocene-Eocene Thermal Maximum (PETM) event recorded in Paleocene-Eocene sedimentary rocks.

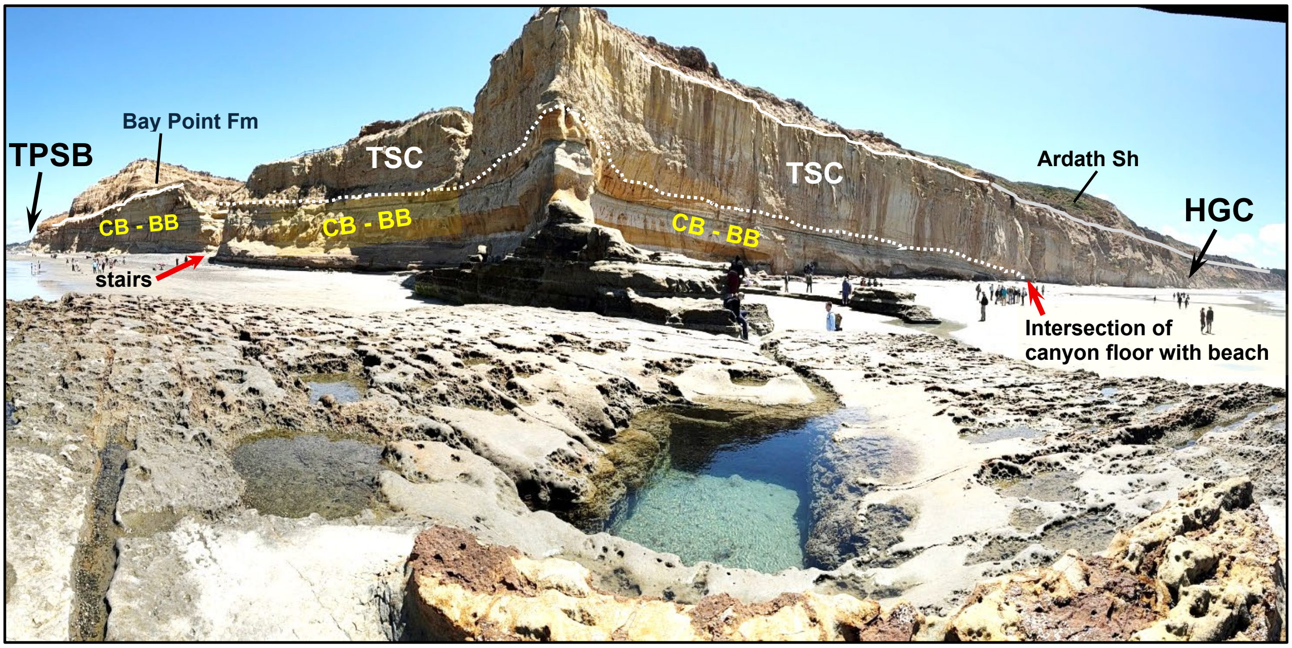


Figure 14. Panoramic east-facing view spanning the distance from Torry Pines State Beach (TPSB) south to Hang Glider Canyon (HGC). Bathtub Rock of resistant Delmar Fm in foreground. White dotted line marks facies transition between coastal barrier-back barrier system (CB-BB) of the Delmar Fm and Torrey Ss and the compelling sedimentary fill of the Eocene Torrey Submarine Canyon system (TSC). Upper Pleistocene Bay Point Fm lies on the Nestor marine terrace. North is from right to left. Notations added to photo by Diane Murbach.

A composite nearshore shelf and marginal-marine depositional system developed along the coastal San Diego region during middle Eocene time, and is recorded in the Delmar Formation and Torrey Sandstone. Stratigraphic relations and sedimentary facies of the Delmar Formation can be viewed from the town of Del Mar southward to just beyond Bathtub Rock and in Hang Glider Canyon **(Figure 14)**. The lithostratigraphic unit is typified by interbedded fossiliferous mudstones and cross-stratified sandstone lenses. Mollusc communities inhabited a back-barrier lagoon and intertidal flat, carved with tidal creeks and flooded episodically by storm currents. Tom Deméré **(Figure 15)** of the San Diego Natural History Museum focused our attention on mudstone beds with a dense array of invertebrate fossils in the Delmar Formation. Tom's emphasis was on the random orientations of the high-spired gastropod, *Potamides*, and the stable upward-convex orientations of disarticulated oyster valves of *Acutostrea*. He suggested that the once-living molluscs had been reworked by high-energy flooding and deposited not far from where they lived within the back-barrier tract **(Figure 16)**.

The Torrey Sandstone accumulated as a system of coastwise nearshore shoals, sand bars, and barrier islands, through which inlets funneled tidal and storm currents into the back-barrier environment of the Delmar. Channels scoured the back-barrier area as flood- and ebb-oriented subaqueous dunes deposited sets of bidirectional cross-beds. Subaqueous ripples migrated in decelerating tidal currents over dunes and deposited localized sets of climbing ripple cross-laminations **(Figure 17).** With rising relative sea level, the shoreline retreated gradually landward, and the nearshore barrier system of the Torrey Sandstone migrated across and buried lagoon and tidal flat mud and silt, and mollusc communities of the Delmar Formation to form a transgressive facies succession.

Figure 15. Tom Deméré (yellow arrow) at an outcrop of the Delmar Formation, Torrey Pines State Beach, with Ray Ingersoll behind him keeping him honest! Photo credit: Diane Murbach.

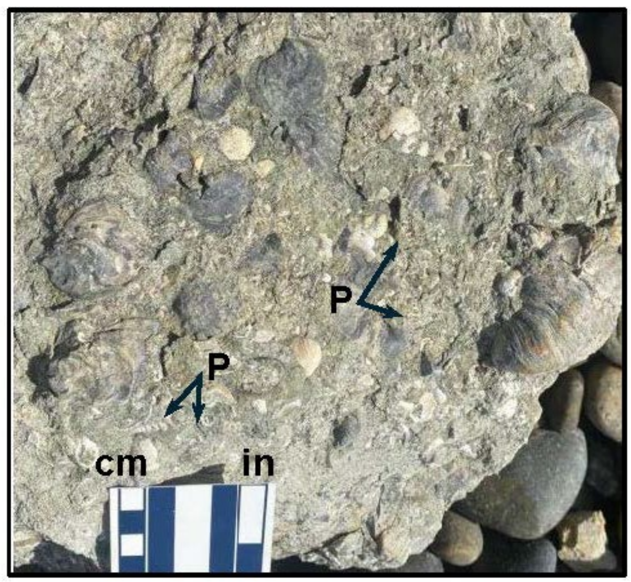


Figure 16. *Acutostrea-Potamides* fossil assemblage in the Delmar Formation, Torrey Pines State Beach. *Potamides* shells are highlighted with black arrows and the letter, **P**. Oyster valves are convex up. Notations added to photo by Bill Bartling.

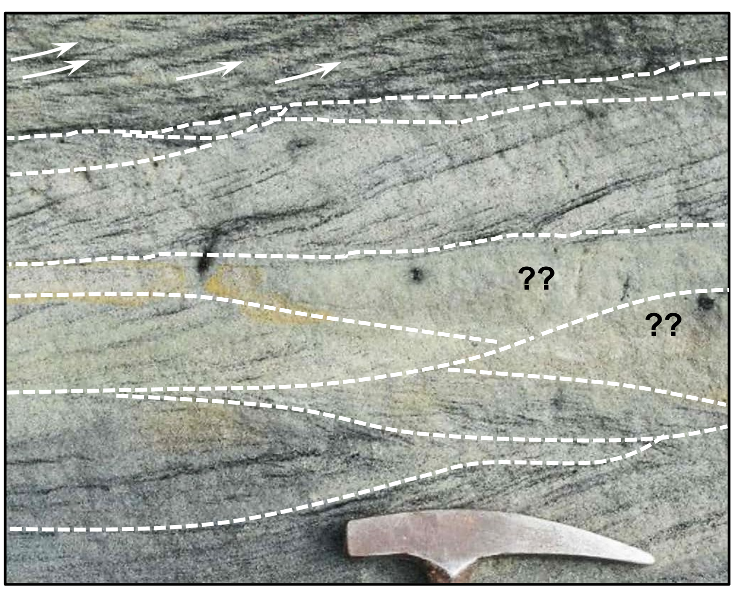


Figure 17. Complex sets of bidirectional cross-bed foresets and sets of climbing ripple cross-laminations in the silty sandstone fill of a tidal-channel in the Delmar Formation. Lower and upper bounding surfaces of sets are marked with curved white dashed lines. White arrows near the top of the photo show direction of ripple migration and angle of ripple climb based on faint ripple foresets dipping to the right. Notations added to photo by Bill Bartling.

The seaward erosional edge or toe of the ~120,000-year-old Nestor terrace marks the unconformable contact with the Torrey Sandstone in the sea cliff. One-to-two meters of whitish, fine-grained, fossiliferous, poorly lithified gravelly sandstone is recognized as the upper Pleistocene Bay Point Formation, deposited on the wave-abraded surface of the Nestor and was later buried by thicker upper Pleistocene to Recent brown, sandy alluvium and paleosol **(Figure 18)**.

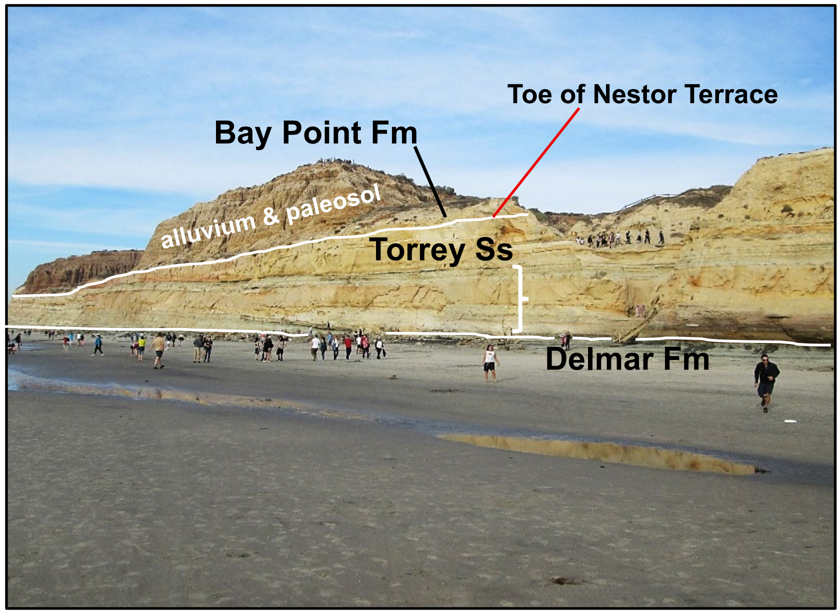


Figure 18. Stratigraphic succession at Torrey Pines State Beach. White bracket encloses a zone of upward-thinning greenish Delmar mudstone beds that grade vertically into upward-thickening orangish beds of the Torrey Sandstone. The seaward edge or toe of the marine Nestor terrace marks the unconformable contact with the Torrey Sandstone. The whitish 1-2 meters of poorly lithified fine-grained sandstone comprises the upper Pleistocene marine Bay Point Formation and is overlain by brown Pleistocene and Recent alluvium and paleosol. Photo credit: Mario Caputo.

The smooth vertical cliff (labeled TSC in **Figure 14)** of the uppermost Torrey Sandstone together with the overlying middle Eocene Ardath Shale and Scripps Formation (viewable farther south) constitute an intricate sediment-filling of an enormous submarine canyon that can be traced from about the stairs ascending to the Beach Trail at Torrey Pines State Reserve **(Figure 14)** to as far south as the research pier at the Scripps Institution of Oceanography. During late early Eocene time, eustatic sea level dropped and exposed the nearshore shelf and marginal-marine deposits of the Delmar and Torrey Formations to weathering and deep canyon erosion. Over time, the extensive subaerially-incised canyon was submerged during the next sea-level rise to become a shelf-edge submarine canyon. Sediment gravity flows filled the canyon with an upward-fining, three-part succession of pebbly sandstone, plane-laminated and convoluted sandstone, and pelagic mudstone with channelized siltstones and sandstones. The name, Eocene Torrey Submarine Canyon, coined in an earlier study, has been applied mainly to the complex sediment fill of this ancient submarine canyon and to the canyon itself in some reports. The floor of this Eocene submarine canyon is the unconformity surface that truncates the Delmar and Torrey Formations, dips southward, and intersects the modern beach surface south of Bath Tub Rock **(Figure 14)**.

The field-trip stop farthest south for the day was at Hang Glider Canyon **(Figures 14 and 19)** to view: 1) a paleosol that records the Paleocene-Eocene Thermal Maximum (PETM), and 2) a newly found representative section of basal strata of the Delmar Formation. At the mouth of and further in Hang Glider Canyon is an enigmatic paleosol that developed in a conglomerate bed **(Figure 19)** deposited in the subaerial part of a fan delta. The conglomerate has been tentatively assigned to the Mount Soledad Formation. At the time of soil development, chemical weathering was intense and pervasive enough to nearly destroy recognizable traits of component Poway-type rhyolitic gravels. Ghostly gravel-sized outlines of former clasts embedded in a kaolinitic paleosol, and partly intact gravels in the lower part of the conglomerate bed confirm the identity of the Poway gravel clasts. The kaolinitic paleosol at Hang Glider Canyon represents the imprint in San Diego of the Paleocene-Eocene Thermal Maximum (PETM) that affected worldwide climate during late Paleocene and early Eocene time. Global ocean and atmosphere temperatures were elevated by a sizeable output of CO_2 with basalt eruptions at the oceanic ridge in the North Atlantic Ocean at the end of Paleocene time. Consequently, global climate was hot, humid, and rainy. The abnormally high content or *spike* in carbon content in terrestrial rocks and marine fossils at this time prompted the defining of its occurrence in rocks as a Global Boundary Stratotype Section and Point (GSSP) for the Paleocene-Eocene boundary.

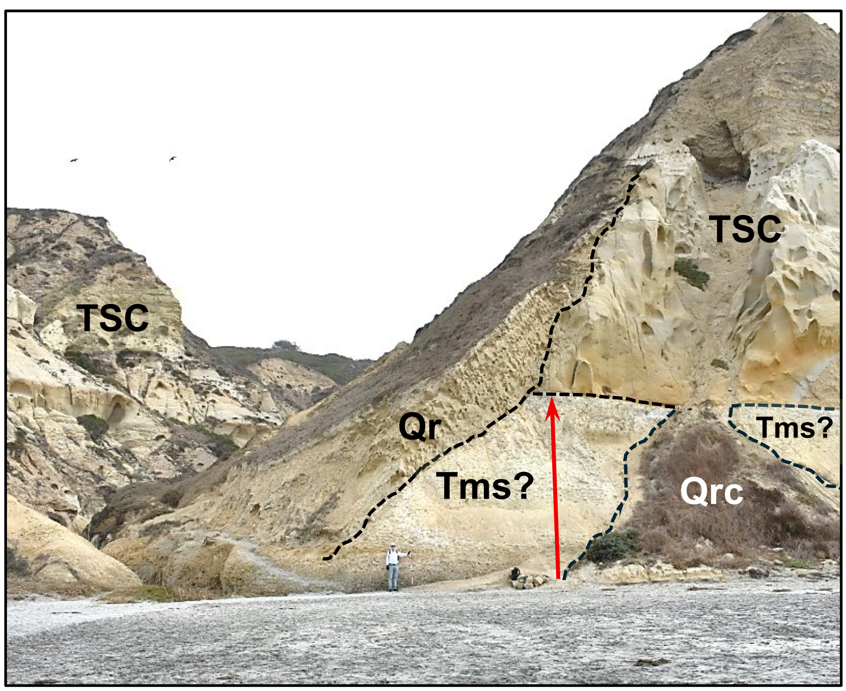


Figure 19. The entrance to Hang Glider Canyon, about 2.5 miles south of the first lifeguard stand at Torrey Pines State Beach. Pat Abbott is standing to the right of trail along the base of the south wall of the canyon. Paleocene-Eocene Thermal Maximum (PETM) is recorded in the whitish unit of probable Mount Soledad Formation (Tms?) at base of sea cliff. Paleosol interval is partly covered by runoff cone (Qrc) at mouth of gully and overlain by pebbly sandstones in the basal part of the Torrey Submarine Canyon fill (TSC). Red arrow indicates upward increase in effects of chemical weathering on Poway-type gravels. Qr: sediment deposited by slope runoff. Two dark spots in upper left are sea birds. Notations added to photo by Ron Kies.

Inside Hang Glider Canyon, Tom Deméré and colleague, Melissa Wood recently discovered a 10-meter-thick basal section of the Delmar Formation not exposed anywhere else in the San Diego area. In comparison, the familiar vertical pattern of sedimentary facies in the Delmar Formation at Torrey Pines State Beach differs from that at Hang Glider Canyon. At Torrey Pines, the Delmar is typified by a much thicker succession of laminated and densely fossiliferous lagoon and tidal flat mudstones interbedded with channelized, cross-stratified tidal-creek sandstones in transitional contact with the overlying coastal barrier of the Torrey Sandstone. The Delmar section at Hang Glider Canyon is a vertical succession of interlayered thin conglomerates, hummocky cross-stratified sandstones, plane-laminated sandstones, and burrowed mudstones with fossil molluscs that inhabited a brackish-water lagoon. Hummocky cross-strata especially suggest sedimentation on a nearshore shelf disturbed by storm waves impinging the seafloor at ocean depths below fair-weather wave base. The surface with 1-2 meters of relief at the top of the section records headward erosion by the Eocene Torrey Submarine Canyon and is overlain by pebbly sandstone at the base of the canyon fill.

When combining the section of Delmar Formation at Hang Glider Canyon with the composite section of Delmar, Torrey, and Ardath Formations between Torrey Pines State Beach and Hang Glider Canyon, a complete interpretive vertical succession unfolds for lower middle Eocene rocks of San Diego: 1) an *upward-shallowing succession* from marine nearshore shelf to marginal marine lagoon and tidal flat of the lower Delmar Formation, followed by 2) an *upward-deepening succession* from lagoon and tidal flat of the upper Delmar to barrier beach, tidal inlets, and proximal nearshore shelf of the Torrey Sandstone to the shelf-edge filling of the Torrey Submarine Canyon with sedimentary facies of the Ardath and Scripps Formations.

At the conclusion of the coastal San Diego field trip, field-trip participants returned leisurely north to their vehicles and reveled in what they observed in the rocks and in what they gleaned from discussions with Pat Abbott, Ron Kies, Bill Bartling, Todd Wirths, and Tom Deméré at the selected outcrop stops. They exchanged wishes with one another for a safe return home and hopes for reuniting on a future field trip.