San Joaquin Geological Society Ridge Basin Field Trip November 3, 2018 Part 2: General Geology

PURPOSE

Welcome to the 2018 San Joaquin Geological Society Fall Field Seminar. Ridge Basin is located in the central part of the Transverse Ranges of southern California, near the "big bend" of the San Andreas Fault. Over the course of the trip, we will focus on the interplay of tectonics and sedimentation, and relate similarities in depositional styles oil fields one might be working in the San Joaquin Basin.

We will introduce you to the different depositional systems and rock types found within Ridge Basin. The depositional systems vary from alluvial fans to marine basin-plain deposits; tectonic environments include compressional, extensional and transform styles

At the end of the one-day field trip, we hope you will:

- Have a basic understanding of the depositional systems in Ridge Basin, and their relationship to the different tectonic styles during development of the basin.
- Have a general understanding of the tectonic framework in which Ridge Basin developed, in the context of the dynamic tectonic history of southern California.
- Have a basic understanding of the infill history of Ridge Basin.
- Have a general understanding of the provenance of infill sediments in the basin.
- Understand how the depositional systems and structures observed in Ridge basin can create high- or low-quality oil reservoirs.

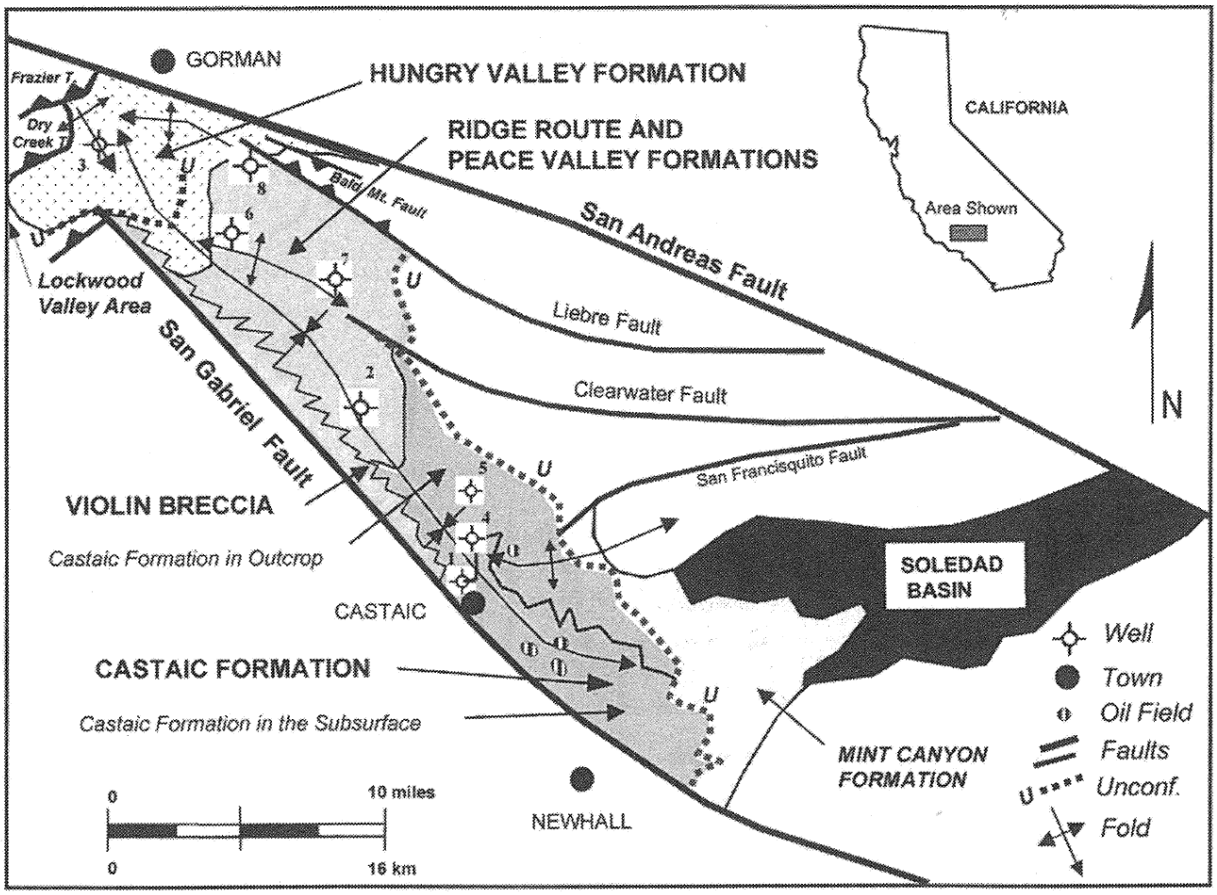
Field Trip Guide for Ridge Basin Excursion
San Joaquin Geological Society
November 3, 2018
Dan Schwartz, Leader

ABSTRACT

Ridge Basin is a prominent, northwest-southeast-oriented basin between the San Gabriel Fault to the southwest and the San Andreas Fault to the northeast. The basin developed during a tectonically active period in the late Miocene to early Pliocene (11-5 Ma), during which ~14,000 m of strata accumulated in a shingled sequence as a result of right lateral offset along the San Gabriel Fault. At the end of the Miocene and into the early Pliocene, the main North America-Pacific plate boundary transferred to east of Ridge Basin onto the San Andreas fault. Coarse gneissic debris, sourced from the Alamo-Frazier Mountain region, and known as the Miocene Violin Breccia, accumulated along, and was displaced by, the San Gabriel fault. The Violin Breccia along with the Miocene marine Devil Canyon conglomerate (Modelo Formation), which abuts the Violin Breccia across the San Gabriel fault, have been used to restore displacement on the San Gabriel fault, and thereby constrain the tectonic history of Ridge Basin. In addition to the Violin Brecca, Ridge Basin is filled with the marine Castaic Formation, the marine to continental Ridge Route Formation, and the lacustrine Peace Valley Formation, and the alluvial Hungry Valley Formation, which overlaps the San Gabriel Fault at the northern end of Ridge Basin. Ridge Basin strata provide visible examples of geological processes in an active tectonic setting. The sedimentary fill of Ridge Basin can be used as an analog for some of the main producing fields in the San Joaquin Basin, such as the Pleistocene Tulare Formation from Midway Sunset to Belridge and Lost Hills.

General structure and stratigraphy of the Ridge Basin

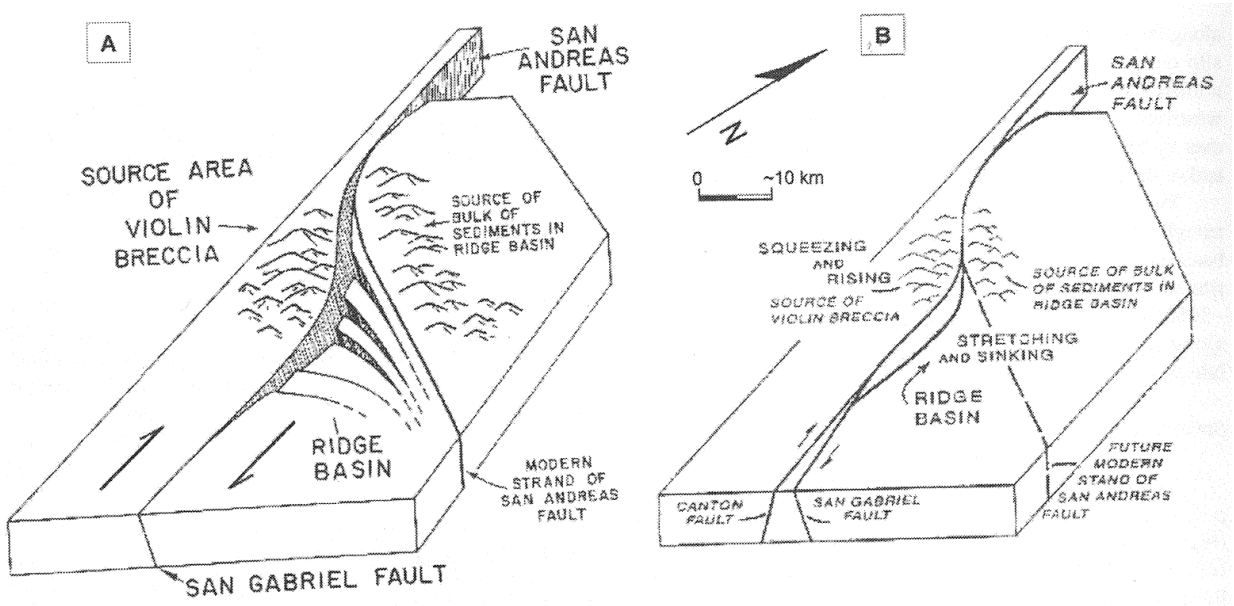
Figure 9 is a generalized map from Crowell (2003) GSA volume 367 illustrating the distribution of the main formations being evaluated during the field trip and the main tectonic features. Stops will enable viewing of stratigraphic units from the bottom to the top of the fill succession (e.g Castaic, Violin Breccia, Ridge Route and Peace Valley, and Hungry Valley). Stops 1 and 6 are overviews of the stratigraphy and the basin geometry. Stop 2: will enable viewing of the Castaic and Ridge Route Formations (Marple Canyon Member). Stop 3: Ridge Route (Fisher Spring Member) and Peace Valley Formations (Paradise Valley Member). Stops 4 & 5: Violin Breccia, Ridge Route (Frenchman's Flat Member) and Peace Valley Formations (Osito Canyon Member). Stops 7 & 8: Ridge Route (Apple Canyon Member) and Peace Valley Formations (Alamos Canyon Member). Stop 9: Hungry Valley Formation.



Generalized map of Ridge Basin and Soledad Basin, showing the distribution of the four major depositional systems (Violin Breccia, Castaic, Ridge Route and Peace Valley, and Hungry Valley), oil fields, and key wells in Ridge Basin, Mint Canyon Formation in Soledad Basin, and major structural and cultural features. Outcrops are depicted with solid lines and inferred subsurface extensions with dashed lines (adapted from Stanton, 1966; Crowell, 1982b; Link and Stitt, 1987). Wells include: (1) Continental Alexander 1, (2) Paradise Development Mary Austin 1, (3) Sun Schmidt 1, (4) British American General 41-13, (5) Texas Daries 1, (6) Continental McCue U.S.L. 1, (7) Continental Elbe U.S.L. 1, and (8) Pine Canyon Davidson 1.

Figure 9. Generalized map from Crowell (2003) GSA volume 367 illustrating the distribution of the main formations being evaluated during the field trip and the main tectonic features. Stops will enable viewing of stratigraphic units from the bottom to the top of the fill succession (e.g Castaic, Violin Breccia, Ridge Route / Peace Valley, and Hungry Valley Formations).

Ridge Basin Structure



. Block diagrams illustrating the fault-bend basin origin for Ridge Basin (Crowell, 1982a; this volume, Chapter 3). A: This earlier published block diagram illustrates the origin of Ridge Basin at a left-stepping sigmoidal bend in the San Andreas fault system (Crowell, 1974a, 1982a). The Clearwater, Liebre, and other faults are contractional and shown as normal and reverse faults that are downthrown to the south. B: The later (published in this volume) block diagram shows the origin of Ridge Basin and connection of the San Gabriel fault as a double or braided sigmoidal bend to San Andreas fault in late Miocene time (Crowell, this volume, Chapter 6). A constraining bend on the northwest side of the basin raised the source area for the Violin Breccia. The adjoining releasing bend formed Ridge Basin as a depositional site and is considered to be a fault-bend basin (Ingersoll and Busby, 1995). Ridge Basin formed by stretching and sinking of crust adjacent to this sigmoidal bend.

Figure 10. Block diagram from Crowell (2003) illustrating fault bounded nature of the Ridge Basin. During much of the deposition the San Gabriel Fault was active. The San Andreas Fault did not become active until the Pliocene. Note the asymmetric nature of the basin and the source terrains on opposite sides of the faults.

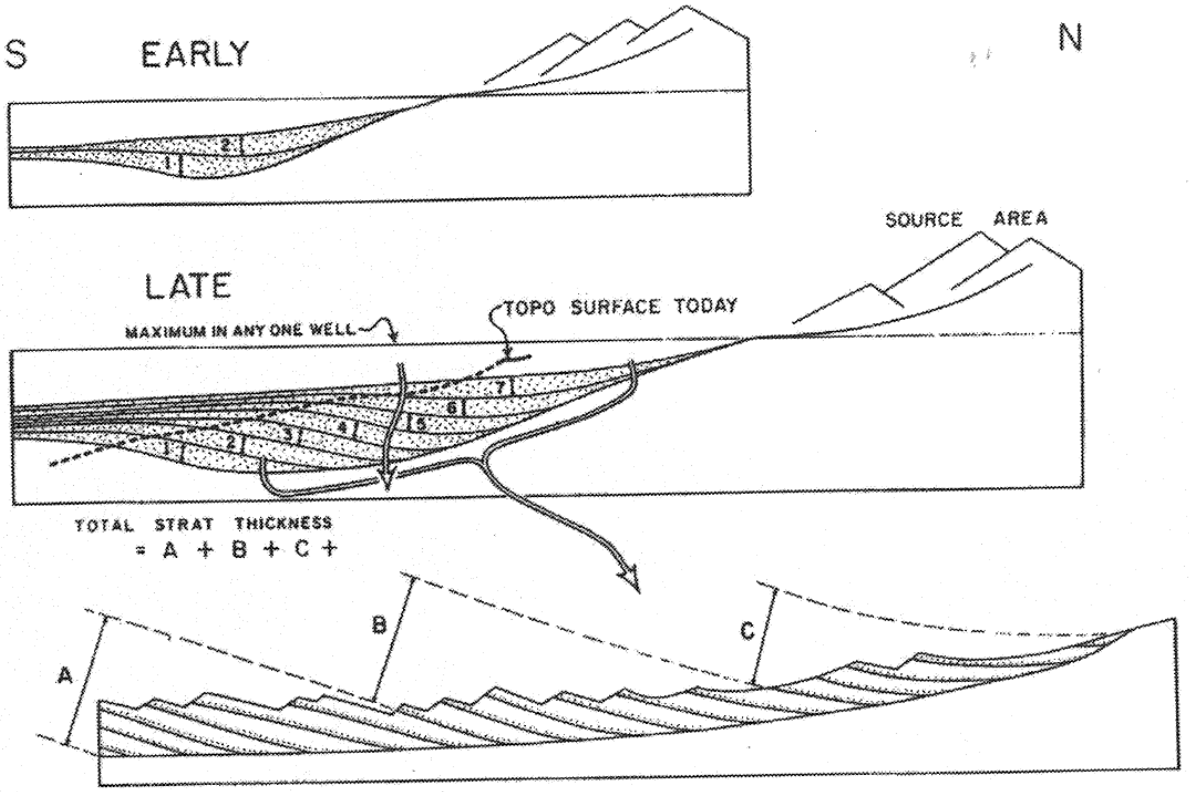
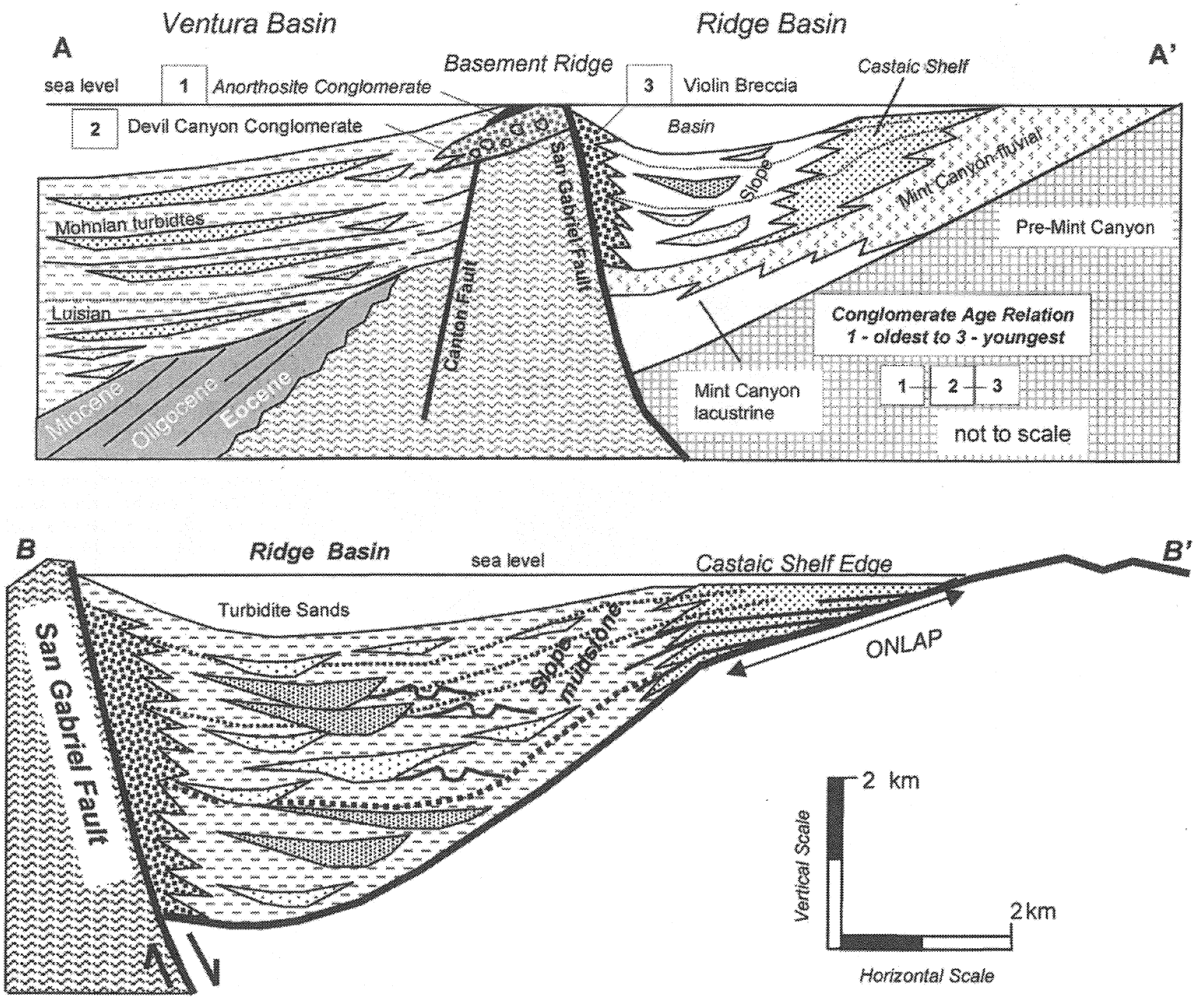


Diagram showing arrangement of stratal units within Ridge Basin, parallel to depositional trough. The depocenter is depicted as migrating relatively northwestward, parallel to the San Gabriel fault and toward the principal source area, interpreted to lie to north of the basin and now displaced dextrally many kilometers by the San Andreas fault. Top: At an early stage. Below: At a late stage before regional uplift and erosion. The total stratigraphic thickness within the basin is obtained by measuring thicknesses along the topographic surface today. A well drilled either vertically (or one where drilling is normal to bedding) would penetrate only part of the total thickness. From Crowell (1982a, Fig. 7).

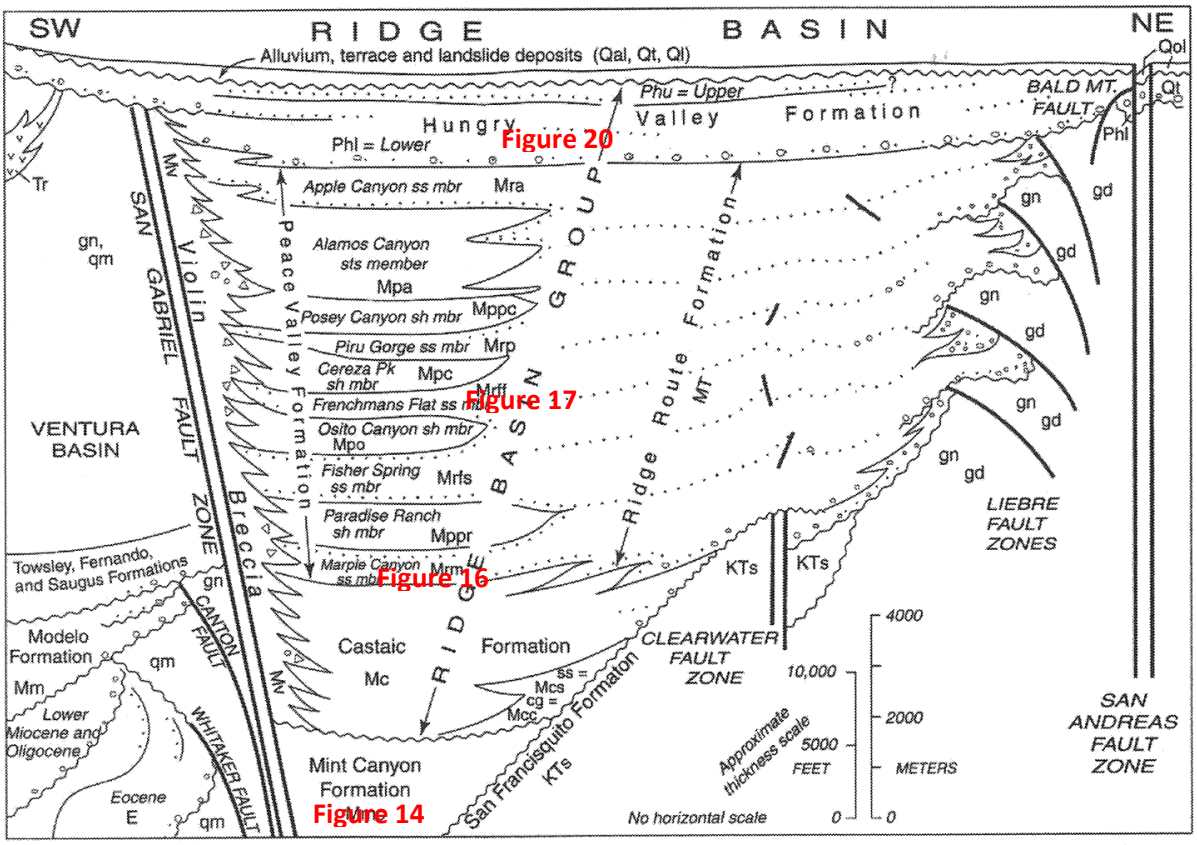
Figure 11. Diagram from Crowell (2003) illustrating the depositional pattern associated with the growing nature of the Ridge Basin. While the basin was structurally not very deep, the pull-apart nature enabled very thick successions to be deposited.



Sketch of sections A–A′ and B–B′ highlight the major lithologic and sedimentary facies of the Castaic Formation and Violin Breccia (adapted after Stitt, 1986; Link and Stitt, 1987). Diagrammatic north-south cross section A–A′ is for the Mohnian (late Miocene) foraminiferal stage across the southern Castaic and eastern Ventura Basins (after Stitt 1982, 1986). The shelf is wide here, whereas the slope and basin plain facies are narrow. The northwest-southeast sketch of section B–B′ is a dip profile across northern Castaic Basin, highlighting the shelf and basin transition and zone of stratal onlap (after Stanton, 1967). This end of the basin has a narrow shelf edge and more pronounced wide slope and basin development. See Figure 20 for location of the sketch sections. Turbidite sandstone lenses shown by dotted patterns, with dots both close together and far apart. Castaic shelf facies of coarse sandstone and calcite-cemented sandstone shown with dots of intermediate spacing. Dashed lines show thickening toward the basin trough.

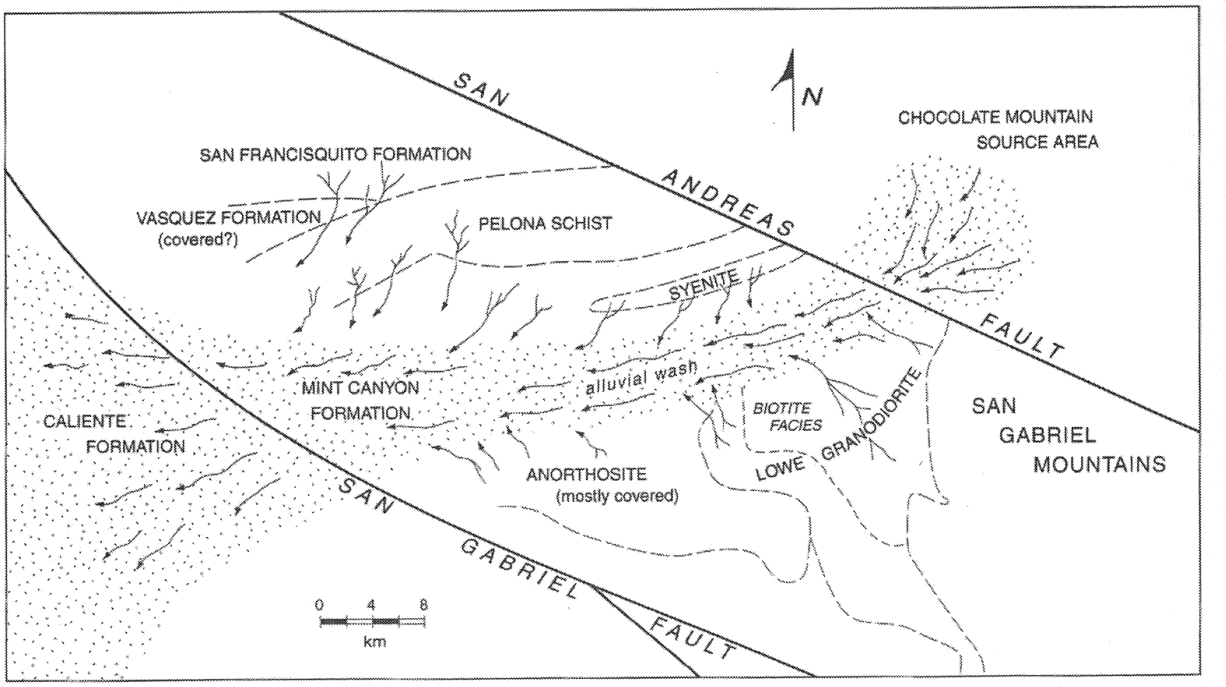
Figure 12. Sketch diagrams from Crowell (2003) illustrating the juxtaposition of the eastern Ventura Basin and the Ridge Basin on opposite sides of the San Gabriel Fault. Note in figure B-B' the pronounced asymmetry of the basin with the Violin Breccia confined at the San Gabriel fault side of the basin. The Castaic Formation was deposited in a shelf environment that onlapped granitic and metamorphic terrain associated with the San Gabriel batholith and its country rock. Stop 2 will enable viewing of the Castaic at Templin Hwy and Old Ridge Route. Stop 4 will enable viewing of the Violin Breccia at Frenchman's Flat along the Piru Creek.

Ridge Basin Stratigraphy



Diagrammatic cross section of Ridge Basin showing stratigraphic and structural relationships projected up and down dip into a single inclined section. Schematic and not to scale. Symbols and abbreviations as on Figure 5 and Plate 1. Other abbreviations: E—beds SW of San Gabriel Fault (mainly Eocene); KTs—San Francisquito Formation (mainly Paleocene); Tr—volcanic rocks of Frazier Mountain. Pre-Tertiary basement rocks: gd—mainly granodiorites; gn—mainly gneisses; qm—mainly quartz monzonites. (Modified from Crowell and Link, 1982, Fig. 2; Link, 1982a, p. 12.

Figure 13. Diagram of the basin fill succession and the complex naming convention within Ridge Basin. General stratigraphy maps and sections are referenced by figure number in red.



Clast source areas and postulated drainage pattern during deposition of the lower part of the Mint Canyon and Caliente Formations before displacements began on the San Gabriel and San Andreas faults.

Figure 14. Map displaying the envisioned Middle Miocene drainage system within Ridge Basin prior to displacement of either the San Gabriel or the San Andreas Faults. There was an established drainage system from the Chocolate Mountains, the San Gabriel Mountains, and the Pelona Schist country rock that flowed westward into the Ventura Basin. With the right lateral offset on the San Andreas Fault, the source area (Chocolate Mountains) and the alluvial wash are currently displaced approximately 315 kilometers (~200 miles). The Middle Miocene Mint Canyon Formation flowed westward into the Caliente Formation. These units have been displaced across the San Gabriel Fault by 70 kilometers (see figure 18 in this guidebook, from Ehlert in Crowell, 2003).

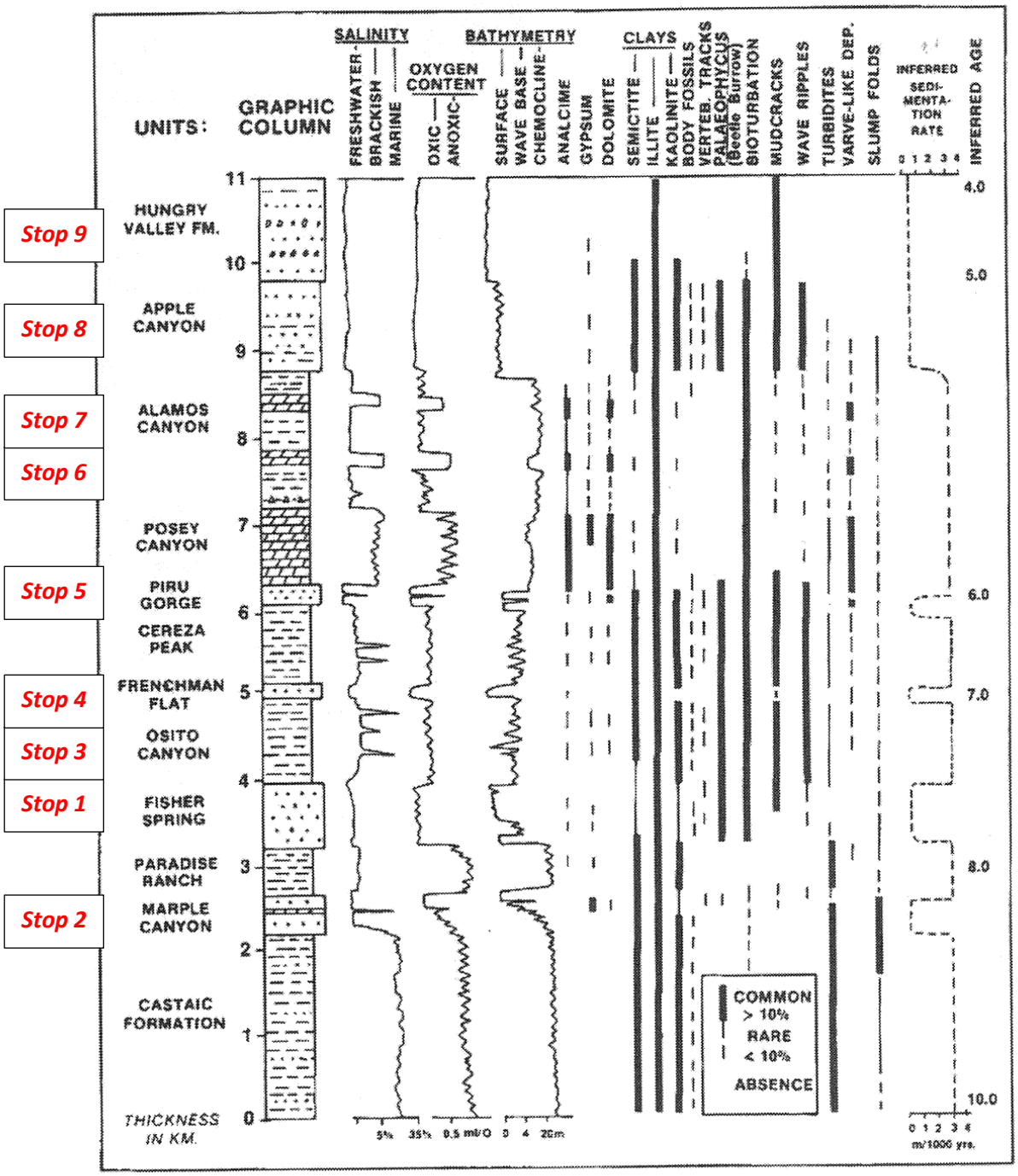


Diagram of paleobathymetry, paleosalinity, inferred sedimentation rates and oxygen content for Ridge Basin (modified after Smith, 1981, 1982b; Link, 1982c). The stratigraphic succession is taken in the axis of Ridge Basin and occurrence and frequency of distinctive mineralogy, sedimentary structures, and biota are highlighted (modified after Smith, 1982b; Ensley and Verosub, 1982).

Figure 15. Diagram illustrating depositional and chemical features of the Ridge Basin through the Miocene and Pliocene. Stops will be made at the Marple Canyon, Paradise Ranch, Fisher Spring, Osito Canyon, Frenchman Flat, Piru Gorge, Alamos Canyon, Apple Canyon, and Hungry Valley Formations or Members.

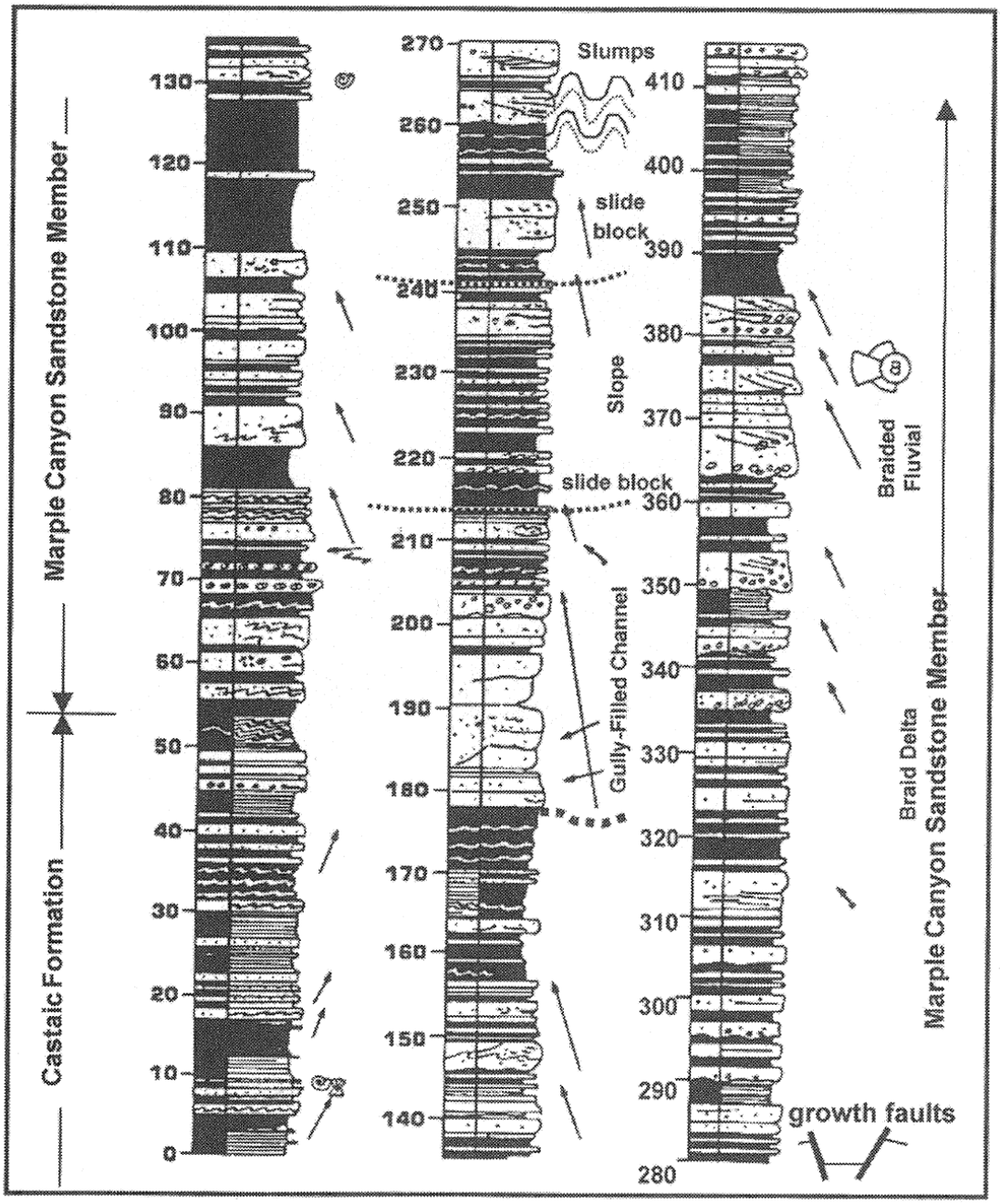
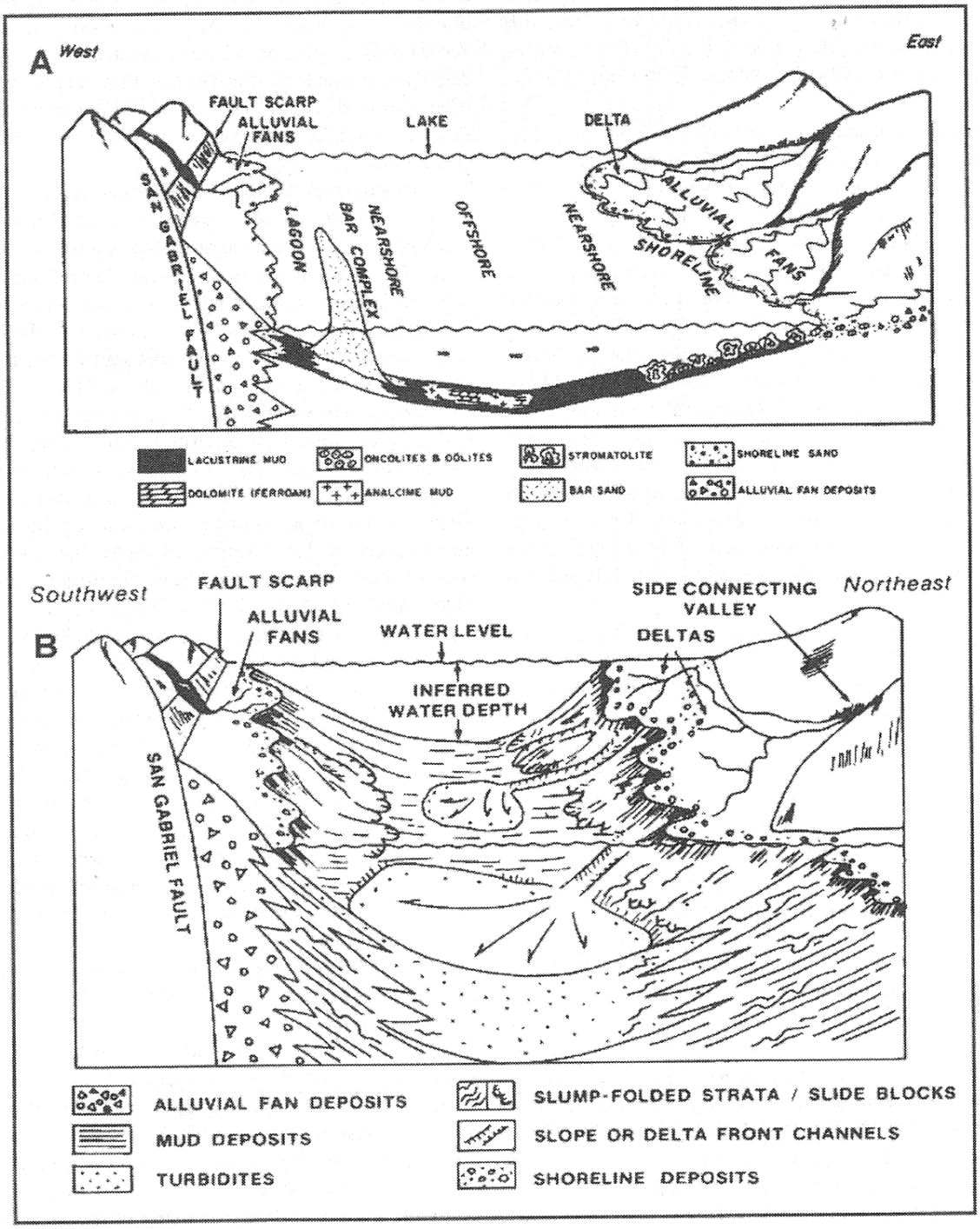
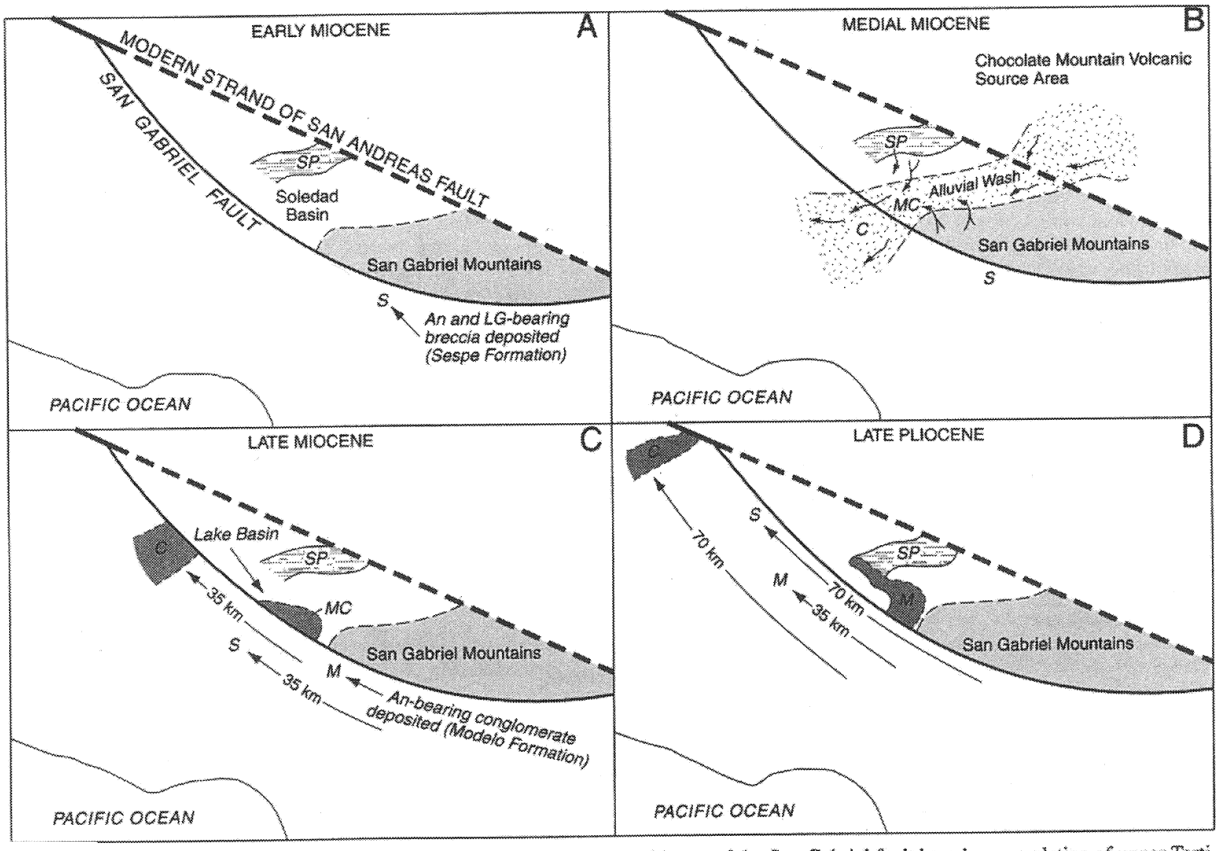


Figure 16. Measured section of the Castaic Formation and overlying Marple Canyon Sandstone Member of the Ridge Route Formation as viewed at the intersection of Templin Highway and Old Ridge Route (Stop 2). The transition from deep water marine to shallow water deltaic and finally fluvial facies is well displayed at these outcrops.



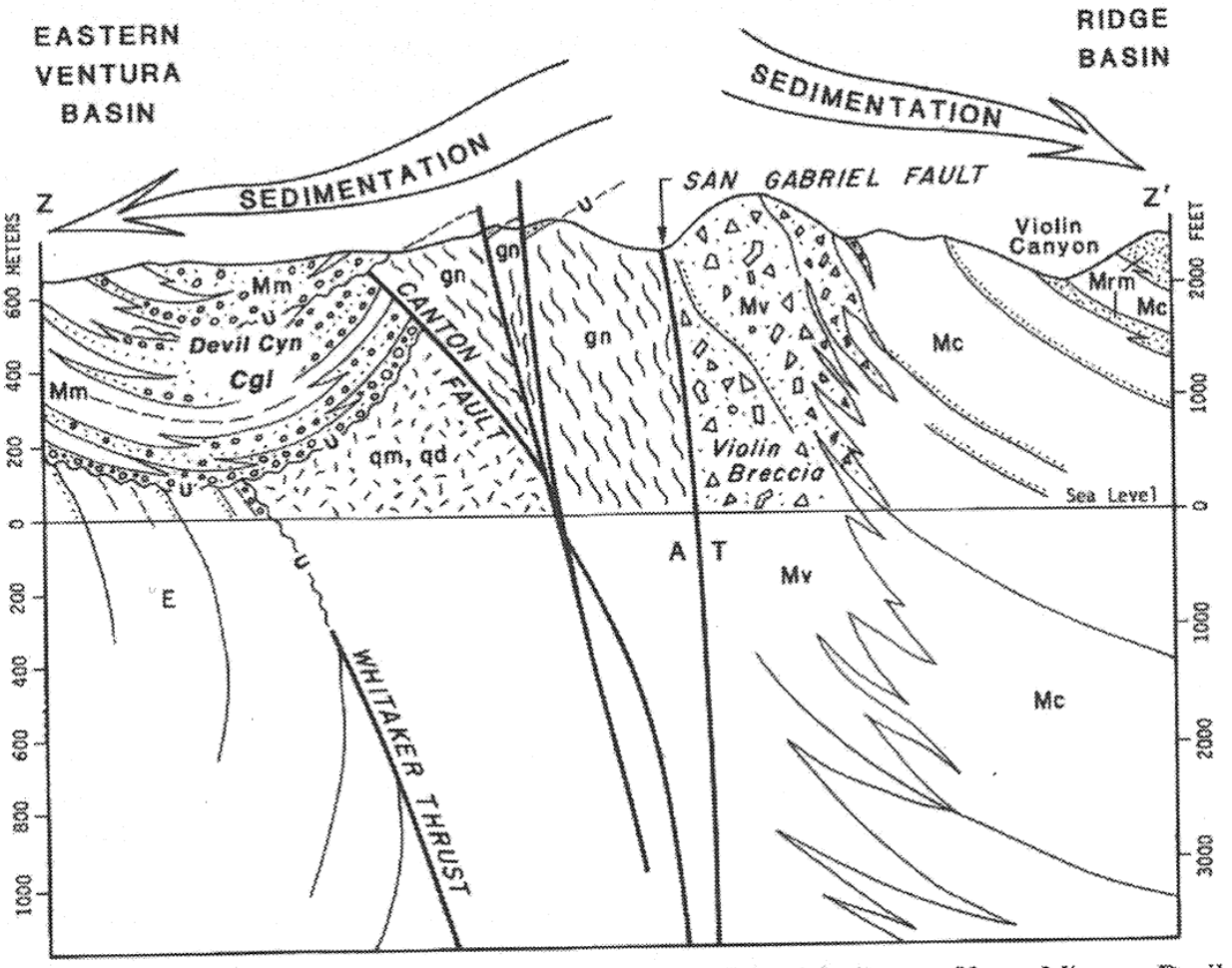
Lacustrine depositional models for Ridge Basin. A: Shallow fresh-water lacustrine model for Ridge Basin at Osito and Cereza Peak Shale time, showing lagoonal, nearshore and offshore lacustrine, bar complexes, and shoreline facies (Link and Osborne, 1978). B: Deep fresh-water model during deposition at Paradise Ranch Shale time (adapted from Link and Osborne, 1978). Turbidites and various types of sediment-gravity flows accumulated in the axis of the depositional basin. The sediments are derived from updip fluvial and deltaic systems, and from the margins of the basin.

Figure 17. Diagram of depositional model for Osito and Cereza Peak Shales (Stops 4 and 5) and Paradise Ranch Shale (Stop 3).



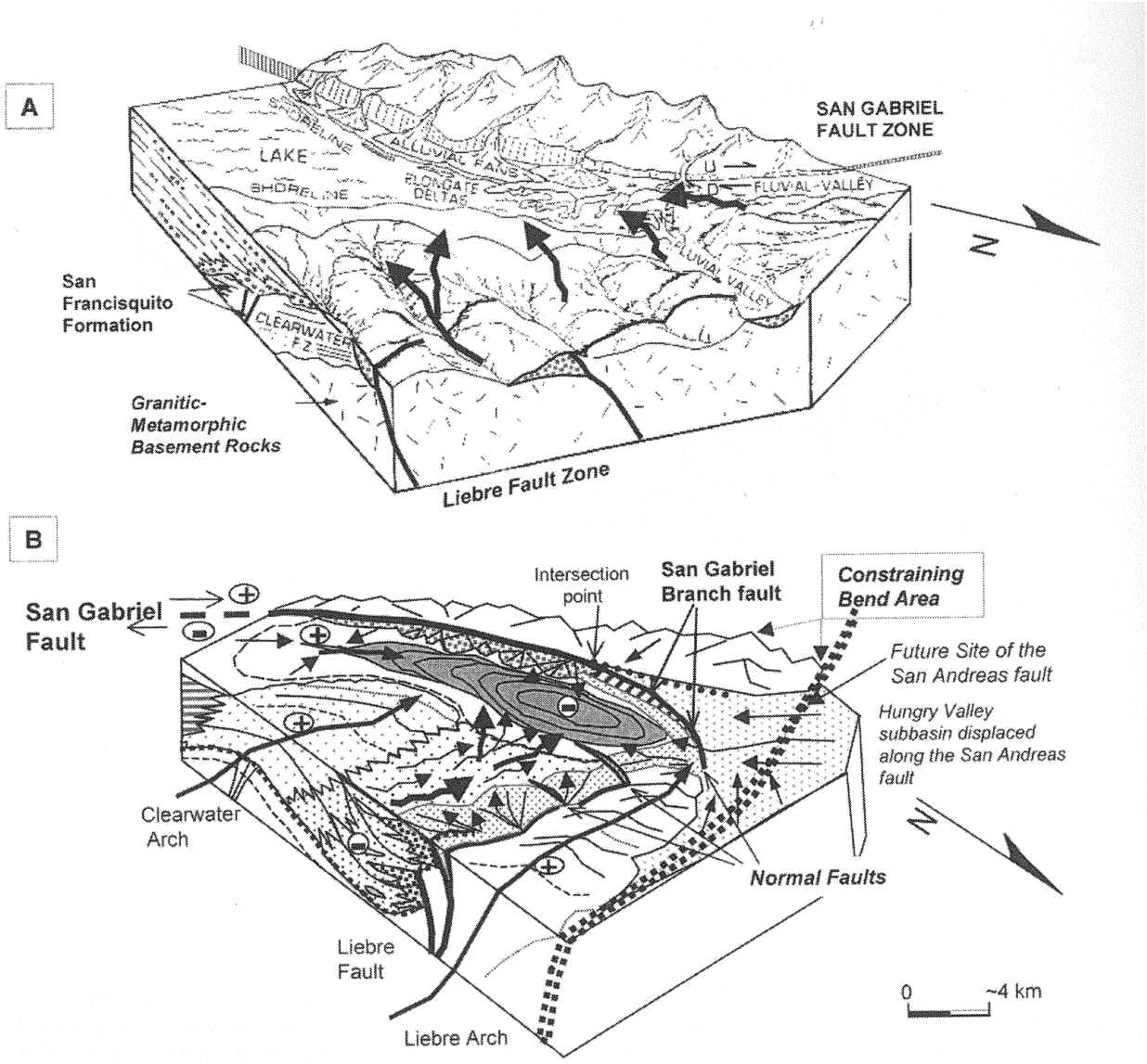
Sequence of paleogeographic diagrams depicting the movement history of the San Gabriel fault based on correlation of upper Tertiary sediments. MC—Mint Canyon Formation, C—Caliente Formation, SP—Sierra Pelona, M—Modelo Formation, S—Sespe Formation. See text for explanation.

Figure 18. Paleogeographic maps of the Ridge Basin from Early Miocene to Late Pliocene illustrating lateral offset of depositional units along the San Gabriel Fault. Maximum displacement of the Mint Canyon and Caliente Formations is 70 kilometers. Maximum displacement of the Mint Canyon from the Chocolate Mountain source terrain is 320 kilometers. (Ehlert in Crowell, 2003)



Sedimentation "double mismatch" across San Gabriel fault zone. Upper Miocene Devil Canyon Conglomerate (Modelo Formation), derived from the northeast, now lies faulted against Violin Breccia of the same age, derived from the southwest. The two source areas have been displaced by right slip on the fault zone. T—Displacement toward observer. A—Displacement away from observer. Other abbreviations: E—beds SW of San Gabriel Fault (mainly Eocene); gn—mainly gneisses (pre-Tertiary basement rocks); Mc—Miocene Castaic Formation; Mm—Miocene Modelo Formation; Mrm—Miocene Marple Canyon sandstone; Mv—Miocene Violin Breccia; qd—mainly quartz diorites (pre-Tertiary basement rocks); qm—mainly quartz monzonites (pre-Tertiary basement rocks). Symbols and line of cross section (Z–Z') as in Crowell (this volume, Chapter 1, Pl. 1). From Crowell (1982a, Fig. 5).

Figure 19. Cross sections across the Ridge and eastern Ventura Basin showing the mis-match in stratigraphy caused by the 70 kilometer offset across the San Gabriel Fault.



Two tectonostratigraphic models for Ridge Basin at end of Ridge Route and Peace Valley and beginning Hungry Valley time. A: An older published block diagram illustrates Ridge Basin forming at a compressional left-stepping releasing bend of the San Gabriel fault. The majority of the sediments infilling the basin was derived from the northeast and north, with minor contributions from Violin Breccia source areas derived from the northwest (after Link, 1984). A prominent clastic wedge is derived from the Liebre fault side of the basin with small clastic wedges forming along the San Gabriel fault side. The Clearwater fault zone and arch show little effect on sedimentation in this model. B: A revised block diagram (published here) showing the extensional right-stepping releasing bend model with normal faults and the positive (+) influence of the Clearwater and Liebre arches. Sediments are derived from the northeast and east through the Ridge Route subbasin, from north and northwest along the trace of the San Gabriel fault zone, and locally from the southeast via clastic wedges. The Clearwater arch probably influenced shoreline and braided-fluvial sedimentation both around and over the crest of the structure, deflecting paleocurrents to the southwest and northwest. Both models have a constraining-bend highlands to the northwest along the San Gabriel fault and local highlands to the northeast associated with the Liebre fault zone. By late Hungry Valley time, the basin ceased to grow and was truncated by the San Andreas fault.

Figure 20. Block diagrams from the 1980's and 2000's illustrating changes in interpretation of the depositional setting and tectonic control of the Hungry Valley Formation (Stop 9).