Geologic Report on the Lithologic Structure and Stratigraphy of El Adobe Ranch, New Idria, San Benito County, California

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for

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Abstract

The El Adobe Ranch is a semi-arid region situated in the Diablo Range, along the southern limb of the Vallecitos Syncline. Stratigraphically, the basement rocks are of Franciscan Assemblage, with late Paleocenic Lodo Fm., Early Eocenic Yokut Fm., Mid-Eocenic Kreyenhagen Shale, and Quaternary Deposits expressed on the surface. The region is structurally complex, with antiformal/synformal folding throughout the Yokut Fm., and extensive left lateral strike slip, oblique, and reverse/thrust faulting throughout all lithologies. A stratigraphic column, geologic map, and three cross sections – Plates 1,2, and 3 respectively – were constructed to ascertain the geologic history of the mapping area. The data collected were then extrapolated to a larger reference frame to better understand the tectonics behind the North American and Pacific Plates.

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Introduction

Greater Locality Map (Figure 1.0)

Locality

Between Coalinga and Soledad, The El Adobe Ranch is located north of the long neglected New Idria Mercury Mine, in San Benito County. The Ranch lies alongside the San

Carlos Creek, off Highway 25. The GPS coordinates (latitude, longitude) of the mapping area are approximately 36°26'24.83"N by 120°39'24.43"W.

Setting

In the Diablo Range portion of the Coast Ranges, The El Adobe Ranch is an arid, dusty ranch in northern-central California. The mapping area is characterized by gentle rolling hills, landslides, sturdy mounds, and sheer cliffs. The mapping area covers about 15,000 square feet, with New Idria road and the San Carlos Creek cutting through the center.

Purpose

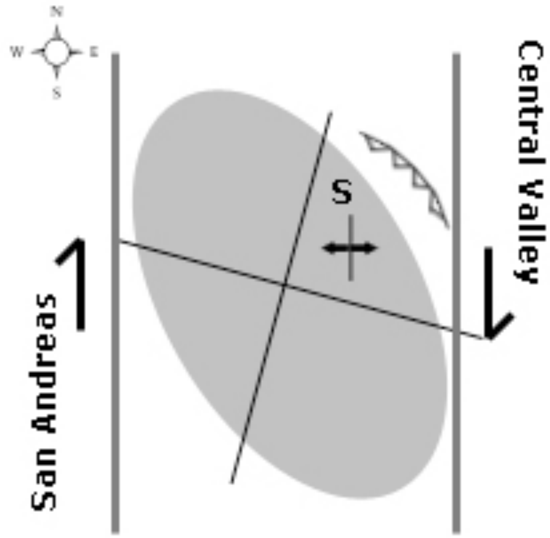
The first objective of this exercise was to map the contacts between the Lodo Fm., Yokut Fm., and Kreyenhagen Fm., and interpret their depositional and transport history through a geologic map and stratigraphic column. The stratigraphic and geologic map will from here on be referred to as Plate 1 and Plate 2, respectively. The second objective was to identify and map all landslide activity present. The third objective was to interpret the kinematics of the region by constructing cross sections of unconformable and complex areas. The geologic cross sections as a whole will from here on be referred to as Plate 3, whereas individual cross sections will be identified by their respective letter – e.g. A-A’, B-B’, or C-C’. Areas of significant geologic importance will be referred to by the word ‘Site’ followed by their respective number – e.g. Site 1, Site 2, etc – and their precise location is shown on Plate 2.

Methods

A Brunton compass was used to measure the attitude of bedding planes. A Jacob Staff was used to accurately construct a stratigraphic column of the Yokut Formation. Topographic inspection and a stereoscope were used to identify landslides.

Regional Geologic Setting

The El Adobe Ranch is located on the southern limb of the Vallecitos Syncline in a region characterized largely by the interaction between three geologic features – Sierra Nevada volcanism, the Franciscan complex, and the Great Valley Basin. Subduction of the Farallon Plate created The Central Valley sequence, trapping Franciscan Assemblage below it. Based on "piercing point" offset measurements, between 20 and 40 million years ago the Farallon Plate was replaced by the Pacific Plate through subduction beneath the North American Plate. The San Andreas Fault System marks the tectonic contact between the North American and Pacific plates, exhibiting right lateral strike slip movement. Along the transform boundary, strike slip shearing from the San Andreas Fault combined with westward compressional movement creates a shear coupling mechanism.



Shear Coupling (Figure 1.1)

In the shear coupling model, as shown in figure 1.1, the short quarter of the oval labeled 's' is experiencing oblique, lateral stress from the movement of the San Andreas Fault system. Combining this lateral stress with extension in the Coast Ranges is expressed by extensive folding characterized by the Vallecitos Syncline in the southern Diablo Range. More evidence for the shear coupling model lies in the oblique strike of the Vallecitos Syncline – after extensive lateral movement and shear stress a slight angularity is expected in the uplifted region. Extrapolating this model to a larger scale characterizes the Diablo Range as a transpressional fold zone with extensive thrust faulting. According to Coleman (1996), the tectonically-based transpression also exposed the serpentinite near New Idria.

The sandstones present in the El Adobe Ranch tend to be arkosic which indicates a grainitic source. This is due to erosion from transport depleting the quartz and feldspar mineralogy of the granite, transforming it to purely a lithic rock. For the most part, the Franciscan Assemblage is obscured by the Coast Range thrust structure, but near New Idria piercement structures expose the basement rocks (Irwin, 1990). Irwin also noted that New Idria's asbestos-rich serpentinite is a transformation of the Franciscan ophiolite basement assemblage. The Franciscan basement is also expressed in upper members of the Yokut Formation in the form of red, blue, and black chert clasts of pebble size. The form of serpentinite and blueschist present in the New Idria 'window' occur in mélange zones along fault shear zones. Most of the sandstone in the New Idria region is arkosic, which generally has a granitic source. It is theorized the provenance is to the south, possibly of Sierran origin. It is worth noting that the San Joaquin Ridge is emergent around the time the New Idria's serpentinite was exposed.

Rock Descriptions

Three rock formations were analyzed -- Lodo Formation, Yokut Formation, and Kreyenhagen Shale – and their interactions were mapped and interpreted to explain the lithologic history of the El Adobe Ranch. Thick vegetation, quaternary colluvium, and landsliding merge to obscure stratigraphic measurements. However, field observations did not stray largely from professional reports of the area. The following units are listed from oldest to youngest.

Lodo Formation (Tl)

The Lodo Formation outcrops in the south-southwest portion of Plate 2, and is largely covered by quaternary alluvium deposits. Lodo Fm. is very erosion resistant and is characterized in the topography as dip-slope hills, also known as cuestas. Thus, the attitude of Lodo mounds is measureable through topography, without any visible outcrop.

The Lodo Formation is characterized by a light grey to beige color when fresh and a tan-red to orange color when weathered. The sandstone facies of Lodo Fm. are composed of a very fine, well rounded, and well sorted sand grain (200-250 micron), whereas its mudstone facies have a microcrystalline grain with no matrix. Both facies have calcareous framework, are well indurated, and contain mainly quartz and feldspar, with some biotite mica. This minerology characterizes the sandstone as arkosic arenite, which was deposited primarily in massive, planar beds. According to Welton and Nilsen (1974; 1981), the Lodo Fm. contains foraminifers and elasmobranchs and has an average thickness of 1200 feet, with a maximum thickness of

6000 feet. According to Nilson (1981), the fossils indicate Paleocenic or early Eocenic deposition. Detritus, flute cast structures, and burrow patterns were found in out of place Lodo Formation boulders. The orientation of the flute cast structures at the base of some bedding planes indicate a northerly paleocurrent flow. The thickness, detritus, and fossil appendage of Lodo Fm. indicate deposition from a turbidity flow into a gigantic submarine basin. Burrow fossils and fine grain size in cantua sandstone boulders indicate low energy deposition in the sandstone facies. According to Irwin (1990), the high feldspar composition indicates a granitic source rock, possibly part of the Salinian block.

Yokut Formation (Ty)

The Yokut Formation is split into five subsections, alternating at irregular intervals between sandstone and shale units. The Yokut Fm. sandstone's minerology is largely quartz and feldspar, at a roughly even ratio, labeling them arkosic arenite. Nilsen (1981) remarks that the high mineral content of this sandstone indicates a granitic southern provenance. Yokut Fm.'s thickness ranges between .5-122 meters according to Nilsen (1981), but was measured to a thickness of 216 meters near Site 6 on Plate 1. This implies this area is either less erosion prone than the area from the reference, or a different facies of the Yokut Fm. altogether. Admittedly, the reasoning behind this discrepancy could also be imprecise or inaccurate measurement techniques.

The shale members within the Yokut Formation are representative of a deeper marine facies. One explanation of the oscillating sandstone-shale-sandstone layering is a varying sea level through time. Shale beds are indicative of episodic sea level highs – shale's microscopic grain is generally representative of a deep marine deposition. Sandstone beds are representative of episodic sea level lows, as sandstone tends to be deposited in a high energy, chaotic environment. The appearance of hummocky cross stratification in some sandstone beds may be indicative of a stormy, hurricane prone depositional environment.

The first member of Yokut Fm., Ty_1, has a thickness of about 25 meters. The first 20 meters of Ty_1 is white arkosic friable sandstone with a coarse, subangular grain and pebbly cross bedding. The pebbles in the cross bedding are mainly black, blue, or red conglomerate with a finer grain size and different mineralogy. Ty_1 was deposited in massive, planar beds. The top of the formation is characterized by a brown shale cobble layer with orange weathering. The depositional environment for the lower sandstone facies was probably a high energy, shallow marine environment, possibly at the end of a turbidity flow. The shale cobbles are probably just colluviums from upper members, or may be due to an oscillating sea level.

The following members are lumped together as Yokut Upper, Tyu, since a layer of float generally obscures the boundaries between the members. The sharpest contact is between the first two members of Yokut, whereas the other members tend to have more gradational contacts. The sharp contact between Yokut members 1 and 2 is marked on Plate 2 as a contact line with crosses at a regular interval.

The second member of Yokut, Ty_2, is primarily poorly indurated fissile brown/tan shale. Ty_2 has a thickness of about 50 meters, with sparse gypsum deposits distributed chaotically throughout. Depositional folding and carbonaceous shales are present, but rare. Well indurated friable arkosic arenitic sandstone cobbles are present, but may be from landsliding or float transport from higher members. Gypsum deposits are sporadically placed in float. Deposition of the second member probably occurred in a deep marine environment, as indicated by the carbonaceous shale in this unit – the $CaCO_3$ was probably derived from dead microorganism's shells.

The third member, Ty_3, is thirty meters thick and is composed primarily of moderately indurated beige coarse friable sandstone. Ty_3 sandstones are feldspar and quartz rich, with some biotite mica. Ty_3 weathers to an orange-red color, indicating iron oxidation. Thin brown fissile mudstone interbedded slivers are present at the ~10 meter and 30 meter marks. Burrow holes and fossil hash are visible near the top of Ty_3, in a large sandstone outcrop. Dark blue and black chert clasts are chaotically distributed throughout Ty_3.

The fourth member, Ty_4, is a 35 meter thick brown shale unit with a primarily calcareous cementation. Some red/orange weathering on certain outcrops indicates secondary iron or quartz cementation. Bivalve fossils and sporadic gypsum deposits are indicative of a similar depositional environment to Ty_4 – a low energy, deep submarine environment. The transition from Ty_4 to Ty_5 is very gradational compared to the other contacts.

The fifth member, Ty_5, is a 60 meter thick beige-red coarse arkosic arenite sandstone unit. Red chert clasts of a Franciscan origin are interspersed throughout, along with some bivalve fossils and shell hash. Hummocky cross stratification is visible towards the top of Ty_5, indicating a high energy depositional environment.

Antiformal folding is visible in the upper members of the Yokut Fm. south of Site 3. This folding is absent in the overlying Krayenhagen shale, which indicates syndepositional folding in the upper Yokut Formation. The details and mechanism behind Yokut Fm. fold structures is further discussed in the structural geology section.

Kreyenhagen Shale (Tk)

According to Nilsen (1981), Kreyenhagen Shale is 600 to 3000 ft thick and was deposited in the Eocene. Kreyenhagen Shale is landslide-prone and susceptible to erosion. Beige, porous, angular fragments of Kreyenhagen Shale are randomly interspersed throughout the northern region of the mapping area.

Quaternary Landslide (Qls)

Landslide material is composed of sand, dirt, vegetation, and/or lithic clasts that moved catastrophically from a high elevation to a lower elevation.

Quaternary Colluvium (Qc)

Sand, dirt, and clasts of arbitrary composition deposited from an eroding slope. Colluvium is Located mainly in areas of heavy weathering on poorly indurated slopes.

Quaternary Alluvium (Qal)

Flat, river deposited dirt and sand with randomly distributed pebble to cobble sized clasts of various compositions and characteristics.

Geologic Structure

Fold Structures (*For the table of all fold structures, see the index)*

Folding is visible in upper members of the Yokut Formation, south of Site 3. The folds oscillate from anticlinal to synclinal folds at an irregular interval. This folding must have happened syndepositionally with the Yokut Fm. since there are no apparent folds in the Kreyenhagen shale. More evidence against Kreyenhagen Shale folding is that it has a drastically different strike from the trend of the fold axes; in fact they are almost perpendicular to one another. The folding event must have been pre-Kreyenhagen deposition, which indicates it may have been due to a pre-San Andrean mechanism of shearing/transpression.

Fault Structures (*For the table of all fault structures, see the index)*

Faulting in the El Adobe Ranch tends to come in two forms. The most common being left lateral strike slip, with some oblique motion. The other form is low angle reverse faulting across lithologic units, also known as thrust faulting. All lateral faulting trends approximately north-south, with a slight westward orientation. Dip slip faulting is mainly observed through lithologic offset, slickenlines, and/or drag folding, whereas thrust faulting was mainly inferred by stratigraphic repetition or age unconformities.

Justification and Interpretation of Faulting

Gonzo the Great and Elmo's Fault

East of Site 1, near an abandoned mine offset in the Tyu – Tk contact is apparent, although hard to place precisely due to alluvium and landslide deposits. The left lateral strike slip Gonzo the Great Fault is justified here to explain the contact offset. Elmo's Fault runs roughly parallel to Gonzo the Great Fault, but is insignificant comparatively.

Animal Fault

Slightly north of Site 5 is an angular unconformity in which a heavily molested Ty_4 or Ty_5 block lies above Kreyenhagen Shale. The apparent motion of the Yokut Fm. is upward, with inferred left lateral strike slip. This means the hanging wall moved up with respect to the footwall at a high angle, thus a reverse fault must be present along the Ty-Tk contact.

Miss Piggy's and Kermit the Fault

South of Site 5 is a truncation of Ty_1-Ty_2 contact. Bedding here has a near vertical dip with slickenline measurements taken. Approximately along strike is the Animal Fault, however, the area between these two faults is heavily obscured by shrubbery.

The Rizzo and Swedish Chef Faults

Situated south of Site 2 is an abrupt truncation of the Ty_1 – Ty_u contact, offsetting the contact by 300 feet north. No kinematic fault indicators were located; however, the apparent motion best infers this fault as a left lateral strike slip – the Rizzo Fault. The large contact offset is displayed schematically on the left side of the C-C' cross-section, the left Ty_1 block is being moved upwards stratigraphically. Another unconformity in this area is an old on top of young contact, Lodo Fm. on top of Yokut Fm. which implies another structure must be present along this contact. The Ty_1 was stuffed under Tl and was tilted significantly, and the Yokut Fm. here dips drastically steeper here than to the east. Slickenlines on the upper Lodo Fm. provide more evidence of the kinematics of this fault. The low angle of this fault and hanging wall moving upwards relative to the footwall indicates it must be a thrust fault – the Swedish Chef Thrust.

The Waldorf, Statler, and Dohoho Faults

West of Site 4 is a structurally complex area colloquially referred to as "The Pit of Despair." A block of Lodo Formation is being transported laterally north at near strike slip motion, with Yokut Formation being transported in the opposite direction. This implies that at least one left lateral fault must intersect the boundary between the two formations – the Statler Fault. More evidence for the Statler Fault is present in Slickenline measurements in the nearby area. The Statler and Gonzo the Great Faults have similar strikes and may be one continuous left lateral strike slip fault. Tempting as it is to connect the two, obscuring the ground between the two faults for ~1000 feet is thick vegetation and a possible quaternary landslide. Slightly west of this is a one thousand foot offset of the Ty_1 – Ty_2 contact, which is best explained by another left lateral fault – Waldorf Fault. Drag folding in Yokut Fm. near the topographic saddle provides more evidence for the Waldorf Fault. Bounded between these two faults is an out of place Ty_1 block sandwiched between Ty_2 deposits. This stratigraphic repetition can be explained by a very low angle reverse fault – the Dohoho Thrust.

Structural Conclusion

Overall, left lateral strike slip and oblique reverse faulting is to be expected in the Diablo Range, especially along a major synclinal structure like the Vallecitos Syncline. Northwestward torsion from the San Andreas Fault System provides the stress required to overcome the friction between the lithologic units at El Adobe Ranch. To obtain equilibrium, right lateral shear stress from the San Andreas Fault System must be compensated with left lateral shear stress, as observed. Thus, most if not all of the major faulting events must be post-San Andrean.

Geomorphology

Gentle rolling hills exemplify the northern region of the mapping area; sheer cliffs of slippery sand and dirt in the center; and sturdy mounds compose the south. Topographic lows, especially near river beds tend to be covered with quaternary alluvium deposits. Well indurated calcareously cemented Lodo Fm. Dip-slope mounds, or cuestas, are visible on near Site 6 and south of the mapping area. Landsliding is frequent near the north and northeast regions of Plate 2, especially within the Kreyenhagen Shale unit, and to a lesser extent in the Upper Yokut Formation. Quaternary colluvium meanders along the northern region of the mapping area near the Yokut Fm. – Kreyenhagen Shale contact. East of Site 1 is an intact slide block made of Upper Yokut Formation. This is likely a Ty_3 or Ty_4 slide block since it is situated slightly south of a major land-slide, surrounded by Kreyenhagen Shale.

Geologic History

1. Lodo Formation sandstone and shale units deposited in massive beds in deep submarine canyon. An oscillating sea level deposits alternating sandstone – shale beds, termed the Yokut Formation. Over 40 million years ago, the Lodo and Yokut Fm. beds experienced a tilting event giving them a ~35° northward dip.
2. From 40 million years ago to 20 million years ago the Farallon Plate was subducted beneath the North American plate, to be replaced by the Pacific Plate. The tectonic boundary between the two plates is expressed on the surface by extensive right lateral strike slip faulting, known as the San Andreas Fault System.
3. Extension in California's Coast Ranges generates a shear coupling mechanism with the San Andreas Fault System, characterized by extensive folding in much of central California. Kreyenhagen Shale is then deposited after this folding event.
4. To relieve the shear stress generated by the San Andreas Fault System, left lateral faults form throughout the Diablo Ranges.
5. Folding and low angle reverse/thrust faulting in the Diablo Ranges expose the Franciscan basement rocks in certain 'windows', also known as piercement structures. Shortening due to shear coupling also gives rise to extensive diapirism, as shown by New Idrian serpentinized mantle peridotite (Coleman, 1990) intrusions.
6. Quaternary alluvium is transported and deposited along stream and river beds. Cross cutting relationships indicate landsliding occurred after alluvium deposits.

Landsliding occurred due to poorly put together hilly surfaces, especially in Kreyenhagen Shale regions. Quaternary colluvium deposits on valley floors due to erosion of the Yokut and Kreyenhagen formations.

7. On the surface, erosional forces rapidly batter the topography of El Adobe Ranch. On a much longer timescale, left lateral strike slip and oblique faulting continuously relieve the shear stresses endured from the San Andreas Fault System.

Table Index

Table of Fold Structures (Figure 1.3)

The fold structures are listed from west-most (first) to east-most (last).

Type	Location	Aspect Ratio (Width/Height)	Units Affected	Relative Timing
Anticline	South of Site 3 (west-most fold)	Very wide	Yokut Fm. Upper (Ty_4, Ty_5)	Post-Ty_5, Pre-Kreyenhagen deposition (Early Eocene)
Syncline	South of Site 3	Narrow, tall	Yokut Fm. Upper (Ty_4, Ty_5)	Post-Ty_5, Pre-Kreyenhagen deposition (Early Eocene)
Anticline	South of Site 3	Wide	Yokut Fm. Upper (Ty_4, Ty_5)	Post-Ty_5, Pre-Kreyenhagen deposition (Early Eocene)
Anticline	South of Site 3 (east-most fold)	Wide	Yokut Fm. Upper (Ty_4, Ty_5)	Post-Ty_5, Pre-Kreyenhagen deposition (Early Eocene)

Table of Fault Structures (Figure 1.4)

Name	Location	Length (ft)	Features	Type of Fault	Units Affected	Relative Timing
Elmo's Fault	East of Site 1	400	Slickenlines (27° S), Dip (64°W). NOTE: Slickenlines on out of place rock.	Left Lateral Dip Slip	Upper Yokut Fm.	Post Yokut Fm. or syndepositional with Yokut Fm.
Gonzo the Great	East of Site 1	>1500	Slickenlines (20° NW), dip	Left Lateral	Upper Yokut Fm.	Post Kreyenhagen

Fault			(80°W), Yokut Fm. offset by ~2000 ft. laterally.	Strike Slip	Kreyenhagen Shale	deposition
Swedish Chef's Thrust	Site 2	200	Slickenlines (64°SW) stratigraphic age reversal (Lodo Fm. on Ty1 on Tyu). Yokut Fm. pushed below Lodo Fm.	Thrust Fault	Yokut Fm. and Lodo Fm.	Post Yokut deposition
Rizzo the Fault	Site 2	600	Ty1 offset by 300 ft. Structurally related to Swedish Chef's thrust	Left Lateral Strike Slip	Yokut Fm. and Lodo Fm.	Post Ty_1 deposition, possibly syndepositional with Tyu
Waldorf Fault	Site 4	1000	Ty1 offset by 2000 ft.	Left Lateral Dip Slip	Yokut Fm.	Syndepositional with Yokut Fm.
Dohoho Thrust	Site 4	300	Stratigraphic repetition, Ty1 -> Tyu below Ty1 -> Tyu	Low Angle Reverse Fault	Yokut Fm.	Syndepositional with Yokut Fm.
Statler Fault	Site 4	1500	Yokut Fm. and Lodo Fm. Offset by 1500 ft.	Left Lateral Strike Slip	Yokut Fm. and Lodo Fm.	Post Yokut Fm. deposition
Kermit the Fault	Southwest of Site 5	400	Ty1-Tyu contact offset by 200 ft. West block shifted downward.	Left Lateral Dip Slip	Yokut Fm.	Post Yokut Fm. deposition
Miss Piggy's Fault	South of Site 5	2100	Yokut Fm. offset by 300 ft.	Left Lateral Strike Slip	Yokut Fm. and Lodo Fm.	Post Yokut Fm. deposition
Animal Fault	Site 5	350	Yokut Fm. offset by 600	Left Lateral	Yokut Fm. and	Post Kreyenhagen

			ft. West block shifted downward	Dip Slip	Kreyenhagen Shale	Shale deposition

References

Google Inc. (2009). Google Earth [Software]. Available from earth.google.com

Coleman, R.G., 1996, New Idria Serpentine: A Land Management Dilemma: Environmental & Engineering Geoscience, v. 2, p. 9-22.

Dibblee, T.W., Jr., 1981, Regional geology of the central Diablo Range between Hollister and New Idria, *in* Frizzell, V., ed., Geology of the central and northern Diablo Range, California: Los Angeles, Society of Economic Paleontologists and Mineralogists, Pacific Section, Annual Meeting Field Trip, Guidebook, v. 2, p. 5-11.

Dickinson, W.R., Ducea, M., Rosenberg, L.I., Greene, H.G., Graham, S.A., Clark, J.C., Weber, G.E., Kidder, S., Ernst, W.G., and Brabb, E.E., 2005, Net dextral slip, Neogene San Gregorio–Hosgri fault zone, coastal California: Geologic evidence and tectonic implications: Geological Society of America Special Paper, v. 391, p. 1-43.

Irwin, W.P., 1990, 3. Geology and plate tectonic development, *in* Wallace, R.E., ed., The San Andreas Fault System, California: Washington, U.S. Geological Survey Professional Paper, v. 1515, p. 61-80.

Nilsen, T.H., 1981, Early Cenozoic stratigraphy, tectonics and sedimentation of the central Diablo Range between Hollister and New Idria, *in* Frizzell, V., ed., Geology of the central and northern Diablo Range, California: Los Angeles, Society of Economic Paleontologists and Mineralogists, Pacific Section, Annual Meeting Field Trip, Guidebook, v. 2, p. 21-34.

White, R.T., 1940, Eocene Yokut Sandstone north of Coalinga, California: Bulletin of the American Association of Petroleum Geologists, v. 24, p. 1722-1751.