



# INVERTEBRATE PALEONTOLOGY OF THE WILSON GROVE FORMATION (LATE MIOCENE TO LATE PLIOCENE), SONOMA AND MARIN COUNTIES, CALIFORNIA, WITH SOME OBSERVATIONS ON ITS STRATIGRAPHY, THICKNESS, AND STRUCTURE

*By*

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## CONTENTS

Abstract	6
Introduction	6
Previous Work	7
Discussion	12
Stratigraphy of the Wilson Grove Formation/geologic setting	12
Deep marine facies	14
Shallow marine facies	15
Transitional marine/continental facies	15
Thickness of the Wilson Grove Formation and its relevance	15
Basement structure	18
Faunal composition, preservation, and paleoecology	19
Faunal composition and preservation	19
Paleoecology	19
Bennett Valley	21
Bloomfield Quarry	21
Burdell Mountain	27
Ebibias Creek	27
Meacham Hill and vicinity	27
Petaluma	30
River Road	30
Roblar Road and vicinity	30
Salmon Creek and vicinity	33
South Valley Ford	33
Spring Hill	35
Steinbeck Ranch	36
Tomales Bay	37
Whittaker Bluff and vicinity	37
Wilson Grove	41
Other miscellaneous outcrops	45
Age	45
Numerical age	46
Paleontologic age	46
Age controls from units associated with the Wilson Grove Formation	46
Summary	47
Acknowledgements	49
References cited	49
Appendix 1 – Faunal notes	57
Appendix 2 – Fossil localities and occurrences	65

### Plates

1. Outcrop of the Wilson Grove Formation with location of fossil localities, cross sections, and locality names (in red) used in text.
2. Cross-sections and graphic thickness determination for the Wilson Grove Formation, and a composite stratigraphic section with approximate location of fossil localities

### Figures

1. Schematic cross-section showing the stratigraphic relationship of the Wilson Grove and Petaluma Formations in northern Marin and southern Sonoma Counties, California 13
2. Outcrop of coarse-grained sandstone interbed near the base of the Wilson Grove Formation at “The Elephants” between Tomales and Dillon Beach 14
3. Hummocky cross-stratification at Steinbeck Ranch with diagrammatic illustration of

stratification in photograph	16
4. Road cut along US Highway 101 showing a marine interbed of the Wilson Grove Formation in the Petaluma Formation at Meacham Hill	17
5. Monterey-clast conglomerate approximately 0.25 mile north of Intersection of Gravenstein Highway and Stony Point Road	18
6. Composite section of the Wilson Grove Formation with approximate position of major fossil localities and collections	20
7. Outcrops of the Wilson Grove Formation at the intersection of Stony and Pepper Roads	29
8. Outcrop of the Roblar tuff of Sarna-Wojcicki (1992) underlain by continental conglomeratic beds of the Petaluma Formation exposed near the intersection of Trenton-Healdsburg Road and River Road	31
9. Skull of primitive balanopterid whale from Steinbeck Ranch	38
10. Basal conglomerate exposed west of Whittaker Bluff on the north shore of Estero San Antonio	40
11. Measured section of the uppermost Wilson Grove Formation exposed on the west side of the hill on the west side of Eastside Road at Wilson Grove	42
12. Partial whorl resembling those of the benthic foraminifer <i>Anomalinoidea salinasensis</i>	47
13. Schematic cross-section showing age determinations and stratigraphic relationship of the Wilson Grove, Cotati, and Petaluma Formations in northern Marin and southern Sonoma Counties	48
Tables	
1. Annotated faunal list of taxa reported by Osmond (1905) from outcrops near Estero San Antonio	8
2. Annotated faunal list of taxa reported from Wilson Grove Formation by Osmond (1905)	8
3. Annotated faunal list of taxa reported from the Wilson Grove Formation by Dickerson (1922)	9
4. Annotated faunal list of taxa reported from the Wilson Grove Formation by Johnson (1934) and identified by C.W. Merriam	10
5. Annotated faunal list of taxa reported from the Healdsburg Quadrangle by Travis (1952)	11
6. Annotated faunal list of taxa reported from near Mark West Creek by Cardwell (1958) and identified by L.G. Hertlein	11
7. Composite list of invertebrate taxa from the Wilson Grove Formation, Marin and Sonoma County, California	22
8. Composite faunal list from outcrops at and near Bloomfield Quarry, Sonoma County	26
9. Composite faunal list from outcrops at and near Ebabias Creek, Sonoma County	28
10. Composite faunal list from outcrops at and near Meacham Hill, Sonoma County	28
11. Composite faunal list from outcrops at and near River Road, Sonoma County	31
12. Stratigraphic range of extinct taxa reported from outcrops at River Road, Sonoma County	32
13. Annotated faunal list of taxa reported by Bedrossian (1974) from outcrops along Roblar Road, Sonoma County	34
14. Composite faunal list from outcrops at and near Roblar Road area, Sonoma County	35
15. Composite faunal list from the Wilson Grove Formation around Salmon Creek, Sonoma County	36
16. Composite faunal list from outcrops at and near Steinbeck Ranch, Sonoma County	37
17. Composite faunal list from outcrops at and near Whittaker Bluff, Sonoma County	39
18. Annotated faunal list from Wilson Grove Formation at Wilson Grove reported by Dickerson (1922)	42
19. Annotated faunal list from Wilson Grove Formation at Wilson Grove reported by Weaver (1949)	43
20. Composite faunal list from outcrops at and near Wilson Grove, Sonoma County	44
21. Stratigraphic ranges of extinct taxa reported from outcrops of the Wilson Grove Formation at Wilson Grove	45

## Abstract

The Wilson Grove Formation is exposed from Petaluma north to northern Santa Rosa, and from Bennett Valley west to Bodega Bay. A fauna of at least 107 invertebrate taxa consisting of two brachiopods, 95 mollusks (48 bivalves and 46 gastropods), at least eight arthropods, and at least two echinoids have been collected, ranging in age from late Miocene to late Pliocene.

Rocks and fossils from the southwest part of the outcrop area, along the Estero de San Antonio, were deposited in a deep-water marine environment. At Meacham Hill, near the Stony Point Rock Quarry, and along the northern margin of the outcrop area at River Road and Wilson Grove, the Wilson Grove Formation was deposited in shallow marine to continental environments. At Meacham Hill, these shallow water deposits represent a brackish bay to continental environment, whereas at River Road and Wilson Grove, fossils suggest normal, euhaline (normal marine salinity) conditions.

A few taxa from the River Road area suggest water temperatures slightly warmer than along the adjacent coast today because their modern ranges do not extend as far north in latitude as River Road. In addition, fossil collections from along River Road contain the bivalve mollusks *Macoma addicotti* (Nikas) and *Nuttallia jamesii* Roth and Naidu, both of which are restricted to the late Pliocene. The late Miocene Roblar tuff of Sarna-Wojcicki (1992) also crops out northeast of the River Road area and underlies the late Pliocene section at Wilson Grove by almost 300 m. Outcrops in the central part of the region are older than those to the northeast, and presumably younger than deposits to the southwest. The Roblar tuff of Sarna-Wojcicki (1992) occurs at Steinbeck Ranch in the central portion of the outcrop area. At Spring Hill, also in the central part of the outcrop area, the sanddollar *Scutellaster* sp., cf. *S. oregonensis* (Clark) has been recently collected. This species, questionably identified here, is restricted to the late Miocene from central California through Oregon. Outcrops at Salmon Creek, northeast of Steinbeck Ranch and also in the central part of the outcrop area, contain *Aulacofusus? recurva* (Gabb) and *Turcica brevis* Stewart, which are both restricted to the Pliocene, as well as *Lirabuccinum portolaensis* (Arnold) known from the early Pliocene of central and northern California and into the late Pliocene in southern California. These data suggest an overall pattern of older rocks and deeper water to the south and west, and younger rocks and shallower water to the east and north.

Outcrops to the southwest, south of the Bloomfield fault, are not well dated but presumably are older than the late Miocene Roblar tuff of Sarna-Wojcicki (1992). Fossils in this part of the section are rare and are not useful in determining a precise age or environment of deposition for the lower part of the Wilson Grove Formation. However, sedimentary sequences and structures in the rocks here are useful and suggest probable outer shelf and slope water depths. *Lituyapecten turneri* (Arnold) which occurs in this part of the section has previously been restricted to the Pliocene, but its occurrence below the Roblar tuff of Sarna-Wojcicki (1992) indicates a revised late Miocene age for this taxon.

Three possibly new gastropods (Mollusca) are reported here: *Calyptraea (Trochita)* n. sp. and *Nucella* sp., aff. *N. lamellosa* (Gmelin), both from the Bloomfield Quarry area, and *Acanthinucella?* n. sp. from the River Road area. These species are not described here because this venue is deemed insufficient for the description of new taxa.

## Introduction

The Wilson Grove Formation is about 1,800 m-thick and crops out in Sonoma and a small part of Marin counties, central California (Plate 1). Fossils and Ar/Ar dating of volcanic rocks suggest a late Neogene (late Miocene to late Pliocene) age for this formation. Several laterally varying depositional environments are represented in the Wilson Grove Formation, ranging from a shelf/slope environment to the southwest, to a shallower, nearshore environment, which grades into continental deposits of the Petaluma Formation to the northeast and east. The Wilson Grove Formation was deposited in a basin separate from the contemporary Purisima Formation on the San

Francisco Peninsula and Ohlson Ranch Formation in northwestern Sonoma County and southern Mendocino County, which also have similar paleoenvironments (Peck, 1960; Powell, 1998).

Over 158 fossil collections were examined during this study, resulting in the identification of about 107 invertebrate taxa (two brachiopods, 95 mollusks, at least eight arthropods, and at least two echinoid), from collections at the California Academy of Sciences (CAS), the Invertebrate Paleontology section, Los Angeles County Museum (LACM), the Museum of Paleontology, University of California at Berkeley (UCB), University of California at Davis (UCD), and U.S. Geological Survey Menlo Park (USGS M), now housed at the UCB. A few of the collections examined have locality data that does not match the fossils examined (e.g., Neogene California fossils with a locality description that says Cretaceous of Texas) and, although listed in the appendix, they were not used during the present study and are not counted above. Additional field collections were made over a 6-year period by the authors. These new collections are listed in the appendix and will be deposited at UCB at the conclusion of this study. They are mostly from outlying areas that had not been extensively collected previously.

This study is part of a larger paleontological analysis of late Neogene marine strata of the northern California for use in developing a regional synthesis of geology and geologic hazards in the area. It is preceded by a report of the Purisima Formation of the San Francisco Peninsula and Santa Cruz Mountains (Powell, 1998) and will be followed by work on the Santa Margarita Formation in the Salinas Valley. Future work planned includes a more in-depth look at the Purisima Formation from collections at CAS, LACM, and UCB, and late Miocene through Pliocene age rocks in the East Bay.

## Previous Work

The earliest geological research on rocks now attributed to the Wilson Grove Formation was that of Whitney (1865). He mentions rocks at Estero San Antonio that rest unconformably on the Franciscan Complex and are assigned to the Miocene.

Gabb (1866; 1869) describes four mollusk taxa from outcrops of the Wilson Grove Formation at the Estero de San Antonio [*Aulcofusus? recurvus* (Gabb) (as *Neptunea recurva* n.sp.), and *Megascurula remondii* (Gabb) (as *Metula? remondii*, n.sp.)], "...on the Russian River," [*Astyris gausapata* (Gould) (as *Columbella (Alia) richthofeni*, n.sp.)], and "...on Mark West Creek" [*Protothaca staleyi* (Gabb) (as *Dosinia staleyi*, n.sp.)]. Gabb (1866; 1869) considered outcrops at Estero San Antonio to be Miocene and on the Russian River, and on Mark West Creek to be Pliocene, in agreement with this study.

Lawson (1894) described the geomorphology of the north San Francisco Bay region beginning in the Pliocene, but makes no mention of fossils from rocks now attributed to the Wilson Grove Formation. According to him, the region is an uplifted Pliocene peneplain that was deformed and has been eroding since its initial uplift. It has been slightly down-warped during recent time, as evidenced by the flooded valleys of estuarine Estero Americano, Estero San Antonio, Walker Creek, and Tomales Bay.

Osmont (1905) was the first to geologically map a significant part of northern Marin and western Sonoma counties. He refers to rocks now attributed to the Wilson Grove Formation as both the San Pablo(?) Formation and Wilson Ranch beds. He called rocks below a prominent tuff (undoubtedly the Roblar Tuff of Sarna-Wojcicki, 1992) San Pablo and rocks above the tuff horizon Wilson Ranch beds. These rocks were referred to the Merced Formation by Dickerson (1922) and later to the Wilson Grove Formation by Fox (1983). Osmont (1905) reports a small molluscan fauna from his San Pablo Formation that consists of eight taxa (five bivalves and three gastropods; Table 1) that were collected near the mouth of Estero San Antonio. He attributes these outcrops doubtfully to the Miocene. Later in the same paper Osmont (1905) refers to the marine beds of Wilson Ranch probably exceeding 2,000 feet [600 m] and carrying typical Merced fossils. The fossils Osmont lists consist of 15 molluscan taxa (seven bivalves and seven gastropods; Table 2). He considers these beds different from his San Pablo Formation, but later authors have combined the two under one formation (Dickerson, 1922; Fox, 1983).

Table 1. Annotated faunal list of taxa reported by Osmont (1905) from outcrops near Estero San Antonio

**Mollusca**

**Bivalvia**

*Compsomyax subdiaphana* (Carpenter) [as *Clementia subdiaphana* Carpt.]

*Lituyapecten turneri* (Arnold) [? as *Pecten caurinus* Gould]

*Nuculana* sp. [as *Leda* sp.]

*Siliqua* sp. [as *Machaera patula* Dixon]

*Solen* sp.

**Gastropoda**

*Aucalofusus recurva* (Gabb) [as *Neptunea recurva* Gate]

*Crepidula princeps* Conrad [as *C. grandis* Middendorff]

Naticidae, indeterminate [as *Natica* sp.]

Table 2. Annotated faunal list of taxa reported from Wilson Grove by Osmont (1905)

**Mollusca**

**Bivalvia**

*Anadara trilineata* (Conrad) [as *Arca trilineata* Con.]

*Clinocardium nuttallii* Conrad [as *Cardium corbis* Martyn]

*Macoma nasuta* (Conrad)

*Mactromeris albaria* (Conrad) [? as *Standella nasuta*(?) Gld.]

*Protothaca staleyi* (Gabb) [as *Tapes staleyi* Gabb]

*Solen* sp.

*Tresus pajaroanus* (Conrad) [as *Schizothoerus Nuttali* Con.]

**Gastropoda**

*Crepidula princeps* Conrad [as *Crepidula grandis*(?) Midd.]

*Cryptonatica affinis* Broderip [as *Natica clausa* Brod. and Sby.]

*Megasurcula* sp. [as *Pleurotoma* sp.]

*Nassarius californicus* (Conrad) [? as *Nassa near californiana* Con.]

*Neptunea tabulata* (Baird) [as *Chrysodomus tabulatus* Baird]

*Nucella transcoana* Arnold [? as *Purpura saxicola* Val.]

*Olivella biplicata* (Sowerby)

*Polinices lewisii* (Gould) [as *Natica lewisii* Gld.]

Dickerson (1922) briefly discusses the Merced Group in the Santa Rosa Valley reporting an irregular upper surface of the underlying Franciscan Complex, with up to 150 m (400 to 500 ft) of relief. He also reports fossils from Wilson Grove, Sonoma County, and Burdell Mountain. From the Wilson Grove area he reports a small fauna of 22 molluscan that is discussed under the Wilson Grove area heading, below. Other fossils from Sonoma County consist of 37 mollusks (21 bivalves and 16 gastropods), and one arthropod (Table 3). In Table 3 we annotate Dickerson's faunal list so that it now consists of 35 taxa [34 mollusks (17 bivalves and 17 gastropods), and one arthropod]. His last locality, locality 572 (CAS 572), is on Burdell Mountain, Marin County. As discussed below outcrops at Burdell Mountain are not considered part of the Wilson Grove Formation.

Rathbun (1926), in a compilation of northeast Pacific Crustacea, described two crabs (*Hemigrapsus* sp. and *Chloridella sonomana* Rathbun) from the Wilson Grove Formation near Santa Rosa. Rathbun's locality is east of known outcrops of the Wilson Grove Formation and represents one of the marine interbeds of the Wilson Grove Formation in the Petaluma Formation.

In a Doctoral dissertation from the University of California at Berkeley, Johnson (1934) discusses the Merced Formation north of San Francisco Bay and assigns it to the middle Pliocene, stating that it contains both marine and fluvial deposits. Johnson (1934) lists a fauna of 23 taxa, mostly mollusks, identified by C.W. Merriam (Table 4). Unfortunately, it is unclear where his

Table 3. Annotated faunal list of taxa reported from the Wilson Grove Formation by Dickerson (1922)

**Mollusca**

**Bivalvia**

*Anadara trilineata* (Conrad) [as *Arca trilineata* Conrad]  
*Clinocardium meekianum* (Gabb) [as *Cardium* cf. *meekianum* Gabb]  
 Cardiidae, indeterminate [as *Cardium*, sp.]  
*Cryptomya californica* Conrad [as *C. californica* Conrad and *C. ovalis* Conrad]  
*Glycymeris* sp., cf. *G. gabbi* Dall [as *Glycymeris* sp., cf. *G. grewingki* Dall]  
*Lityapecten turneri* (Arnold) [as *Pecten turneri* Arnold]  
*Macoma brota* Dall? [as *M. edentula*(?) Broderip and Sowerby]  
*Macoma nasuta* (Conrad)  
 Mactridae, indeterminate [? as *Spisula* cf. *falcata* (Gould), *S. voyi* (Gabb), *S.* cf. *voyi* (Gabb), *S.*(?) sp.]  
*Mactromeris albaria* (Conrad) [as *Spisula albaria* (Conrad)]  
*Mya* sp.  
*Panope abrupta* (Conrad) [as *P. generosum* (Conrad)]  
 Pectinidae, indeterminate [as *Pecten* cf. *turneri* Arnold]  
*Protothaca staleyi* (Gabb) [as *Paphia staleyi* Gabb]  
*Solen* sp. [as *S. sicarius* Conrad]  
*Tresus pajaroanus* (Conrad) [as *Schizothoerus* cf. *pajaroensis* Conrad.]  
 Veneridae, indeterminate [as *Saxidomus*(?) sp.]

**Gastropoda**

*Calyptraea* sp. [as *C. inornata* Gabb]  
*Crepidula* sp., cf. *C. onyx* Sowerby [as *C. adunca* Sowerby]  
*Crepidula princeps* Conrad [as *C. grandis* Gabb and *C. princeps* Conrad]  
*Cryptonatica affinis* Broderip [? as *Natica consors* Dall and *N.* cf. *consors* Dall.]  
*Lirabuccinum portolaensis* (Arnold) [as *Chrysodomus portolaensis* Arnold]  
*Mediargo mediocris* (Dall) [as *Trophon*(?) sp.]  
*Megasurcula remondi* (Gabb) [as *Bathytoma carpenteriana fernandoana* Arnold]  
*Nassarius californicus* (Conrad) [as *Nassa* near *californiana* Con.]  
*Nassarius grammatus* (Dall) [as *Nassa moraniana* Matin]  
*Natica janthostoma* Deshayes [in part as *N. cansors* Dall]  
 Naticidae, indeterminate [in part as *N. cansors* Dall]  
*Neverita reclusiana* Deshayes [in part as *N. cansors* Dall]  
*Nucella? imperialis* Dall [as *Chrysodomus imperialis* Dall]  
*Nucella transcoana* Arnold [? as *Thais papillus* (Linnaeus)]  
*Olivella biplicata* (Sowerby)  
*Ophiodermella* sp., cf. *O. graciosa* Arnold [as *Drillia mercedensis* Martin]  
 Trochidae, indeterminate [as *Astralium* sp.]

**Arthropoda**

**Crustacea**

*Balanus* sp.

specimens were collected. Judging from the faunal list and knowing where taxa occur in the Wilson Grove Formation from this study, his taxa appear to have been collected from several different localities, or are an amalgamation of other published faunal lists.

Keen and Bentson (1944) report *Columbella richthofeni* Gabb from the Merced Formation of the Russian River area, and *Aulacofusus? recurva* (Gabb) (as *Neptunea recurva* Gabb) from the Merced Formation along Estero San Antonio, near Tomales Bay. Both of these occurrences now refer to the Wilson Grove Formation.

In an extensive survey of the geology of the north of San Francisco Bay, Weaver (1949) mentions the Merced Formation from the west side of Burdell Mountain, at the mouth of Tomales Bay, around Petaluma, from the type area on the San Francisco Peninsula, and in Sonoma County. As mentioned above, the Burdell Mountain outcrops are no longer referred to the Wilson Grove

Formation. The latter two areas are mentioned only in comparison with other outcrops in the area covered by Weaver (1949).

Table 4. Annotated faunal list of taxa reported from the Wilson Grove Formation by Johnson (1934) and identified by C.W. Merriam

## **Mollusca**

### **Bivalvia**

*Anadara trilineata* (Conrad) [as *Arca trilineata* Conrad]  
*Chlamys* sp., cf. *C. hastata* (Sowerby) [as *Pecten* cf. *hastatus*]  
*Clinocardium meekianum* Gabb [as *Cardium meekianum* Gabb]  
*Lituyapecten* sp., cf. *L. turneri* (Arnold) [as *Pecten* cf. *turneri* Arnold]  
*Macoma nasuta* (Conrad)  
Mactridae, indeterminate [as *Spisula brerirostra*]  
*Mactromeris albaria* (Conrad) [as *Spisula albaria* Conrad]  
*Protothaca staleyi* (Gabb) [as *Venerupis staleyi* and (?) *Venerupis staleyi*]  
*Securella?* sp. [as *Securella securis* (Shumard)]  
*Solen sicarius* (Conrad)  
*Swiftopecten* sp., cf. *S. parmeleei* (Dall) [as *Pecten (Pallium)* cf. *etcheconi*]  
*Tresus* sp., cf. *T. nuttalli* (Conrad) [as *Schizothearus* cf. *nuttalli*]  
*Tresus pajaroanus* (Conrad) [? as *Schizothoeris* cf. *pajaroana*]  
*Tresus?* sp. [as *Schizothaeris*(?) n. sp.]  
*Zirfaea* sp. [as *Zirphaea* sp.]

### **Gastropoda**

*Aulacofusus? recurva* (Gabb)  
*Crepidula princeps* Conrad  
*Diodora* sp. [? as *Fissurella* sp.]  
*Nassarius californicus* (Conrad) [? as *Nassa mendica*]  
*Nassarius grammatus* (Dall) [? as *Nassa moraniana*]  
*Ophiodermella* sp., cf. *O. graciosa* Arnold [? as *Drillia* cf. *mercedensis* Martin]

Geological maps including rocks now attributed to the Wilson Grove Formation were made by Johnson (1934), Gealey (1951), Travis (1952), and Wagner and Bortugno (1982). Based on the areal distribution of the Merced Formation, Johnson (1934) suggested that the formation was deposited in a bay with marine and continental sediments included in the eastern portion of the formation. His fluvial Merced beds are best developed on the east of the Santa Rosa Valley in the vicinity of Mark West Creek . . . Travis (1952) published a geologic map of the Sebastopol 15 quadrangle map, although the quadrangle was previously mapped by Johnson (1934) and was only slightly modified by Travis (1952). He lists a fauna of 21 taxa, which is here revised to 17 taxa [15 mollusks, including 10 bivalves and 5 gastropods, one possible coral, and one possible barnacle (Arthropoda)] (Table 5) from six localities. Travis (1952) specimens could not be located and evaluated during the present study. Gealey (1951) made short mention of the Merced in the Healdsburg Quadrangle, citing a thickness of about 150 m (500 ft).

Cardwell (1958) noticed an interfingering relationship between conglomerate and fossiliferous sandstone in the Santa Rosa Valley from borehole data. He also lists nine mollusks from near Mark West Creek (Table 6). Cebull (1958) describes the geology of the Mare Island, Sears Point and Richmond 7.5 quadrangles, including the Merced Formation (now Petaluma Formation by Wagner and Bortugno, 1982) west of the Tolay fault. He makes no mention of rocks now attributed to the Wilson Grove Formation.

Higgins (1960), in a paper on the Ohlson Ranch Formation, showed faunistic differences between the type Merced, the Sonoma County Merced, and the Ohlson Ranch formations. He reports that the lithology of the Ohlson Ranch and Sonoma County Merced formations did not

differ, but suggests that the two formations were deposited in separate basins because the Franciscan Complex crops out between the two areas. Therefore, he uses the name Merced Formation for outcrops in Sonoma County and vicinity, and Ohlson Ranch Formation for outcrops in northern Sonoma County and southern Mendocino County.

Table 5. Annotated faunal list of taxa reported from the Healdsburg Quadrangle by Travis (1952).

**Coelenterata**

Coral(?)

**Mollusca**

**Bivalvia**

*Anadara trilineata* (Conrad)

*Cryptomya californica* Conrad

*Glycymeris* sp.

*Lituyapecten* sp., cf. *L. turneri* (Arnold) [? as *Pecten (Patinopecten) healeyi* Arnold]

*Macoma nasuta* (Conrad)

*Macoma* sp. [as *Macoma* cf. *M. secta* (Conrad) and *Macoma* sp.]

*Mactromeris albaria* (Conrad) [as *Spisula albaria* Conrad]

Mactridae, indeterminate [as *Spisula* sp.]

*Solen* sp.

*Tellina* sp.

Veneridae, indeterminate [? as *Marcia angustifrons* (Conrad)]

**Gastropoda**

*Crepidula princeps* Conrad

*Miopleiona* sp. [as *Miopleionia* sp.]

*Nassarius californicus* (Conrad)

Naticidae, indeterminate [as *Polinices* sp.]

*Olivella* sp., cf. *O. biplicata* (Sowerby) [? as *Olivella pedroana* Arnold]

**Arthropoda**

**Crustacea**

*Coronula*(?) sp.

Table 6. Annotated faunal list of taxa reported from near Mark West Creek by Cardwell (1958) and identified by L.G. Hertlein (CAS)

**Mollusca**

**Bivalvia**

*Anadara trilineata* (Conrad) [as *Arca trilineata* Conrad]

*Clinocardium* sp., cf. *C. meekianum* (Gabb) [as *Cardium* cf. *C. meekianum* Gabb]

*Macoma nasuta* Conrad

*Protothaca staleyi* Gabb

*Siliqua* sp. [as *Siliqua* sp., cf. *S. patula* Dixon]

**Gastropoda**

*Calicantharus fortis* (Carpenter) [as *Calicantharus fortis* Carpenter cf. *C. f. angulatus* Arnold]

*Nassarius grammatus* (Dall) [as *N. moranianus* Martin]

*Polinices lewisii* Gould

*Nucella trancosana* Arnold? [as *Thais emarginata ostrina* Gould]

Bedrossian (1970) conducted a faunal and paleogeographic study of the Merced Formation in Sonoma County and northern Marin County. She identified a fauna of about 58 invertebrate taxa [indeterminate bryozoan(s), 52 mollusks (29 bivalves, 23 gastropods), at least three arthropods, also indeterminate worm tubes, burrows, and vertebrates]. In addition she gives a general paleogeographic

interpretation and suggests a large, relatively shallow, late Pliocene embayment for the Merced Formation in Sonoma County.

Several new taxa were described during the 1970 s and 1980 s. A new bivalve mollusk from the family Sanguinolariinae was described from the River Road outcrops by Roth and Naidu (1974). They refer these outcrops to the Pliocene, but not latest Pliocene, and suggest deposition on a silty sand bottom in 15 to 40 meters depth . Two new barnacles (Arthropoda: Crustacea) and three other barnacles are described by Zullo and Naidu (1982) from the basal Wilson Grove Formation at Bloomfield Quarry. They assign these fossils to the late Miocene, based on the overlying Roblar tuff of Sarna-Wojcicki (1992), and suggest a rocky intertidal or immediately subtidal environment exposed to moderate or heavy surf for the basal section exposed at Bloomfield Quarry. Both these conclusions (age and environment) are in agreement with our results here.

Fox (1983) was the first to use the name Wilson Grove Formation. He designated a type locality between Wilson Grove and Mark West Creek and includes in the formation all rocks mapped by Travis (1952) as Merced Formation. He assigned an age of late Miocene to Pliocene for the formation and discusses its correlation with the type Merced Formation on the San Francisco Peninsula. Allen (2003) correlated the Wilson Grove and Petaluma formations with Tertiary units in the East Bay based on similar clasts, stratigraphy, tephra units, paleocurrent, and paleontologic data.

In recent years, the authors and others have published a number of abstracts dealing with various aspects of the geology and paleontology of the Wilson Grove Formation. These include Holland and Allen (1998), Allen and others (1999, 2000), and Powell and Allen (2001). The area of Steinbeck Ranch has received significant attention in these recent studies. Holland and Allen (1998) discuss the geology of the section exposed at Steinbeck Ranch, while Allen and others (1999) announced the discovery of a pygmy mysticete whale fossil from the same area. Powell and Allen (2001) presented preliminary results of this study to the 2001 North American Paleontology Convention.

## Discussion

### Stratigraphy of the Wilson Grove Formation/geologic setting

Late Neogene sedimentary rocks in Sonoma County and parts of northwestern Marin County were found to contain a fauna similar to the type Merced Formation on the San Francisco Peninsula. As a result, many early authors referred these beds to the Merced Formation (Dickerson, 1922; Johnson, 1934; Keen and Bentson, 1944; Weaver, 1949; Gealey, 1951; Travis, 1952; Cardwell, 1958; Cebull, 1958; Higgins, 1960; Bedrossian, 1970; Roth and Naidu, 1974; Wagner and Bortugno, 1982). The Sonoma County Merced Formation was separated from the type Merced (and Ohlson Ranch Formation) by Higgins (1960), but it was not until Fox (1983) that the formation was formally described.

Fox (1983) describes the Wilson Grove Formation as consisting chiefly of massive sand and minor amounts of gravel and tuff, and the type area as between Wilson Grove and Mark West Creek, 2 1/2 km due south. Blake and others (2002) describe the Wilson Grove Formation as mostly massive or thick-bedded, buff-weathering, light-gray, fine-grained quartz-lithic arenite [that] includes locally beds of mollusk- and gastropod-shell hash, pebble to boulder conglomerate, and tuff. Allen (2003) describes the general lithology of the Wilson Grove Formation as thickly-bedded feldsarenite sandstone with interbedded conglomerate along the eastern portion of the formation and suggests the Wilson Grove and Petaluma formations interfinger in an area between Cotati and Trenton.

We herein restrict the Wilson Grove Formation to rocks of marine origin and the Petaluma Formation as rocks of continental origin. Rocks that have taxa that reflect estuarine conditions are included in the Wilson Grove Formation. In general the Wilson Grove Formation is easily distinguished based on color and lithology even though it interfingers along the eastern margin of the outcrop area with the Petaluma Formation. An exception is the occasional marine bed(s) in a

predominately nonmarine section in the Bennett Valley. Here marine beds may be distinguished exclusively on the basis of their fossil content. In general, the Wilson Grove Formation is a thick sequence of clastic sedimentary rocks unconformably underlain by the Franciscan Formation, overlain by Quaternary sediments, and interfingering, to the east, with the most contemporary Petaluma Formations. These relationships are illustrated in Figure 1.

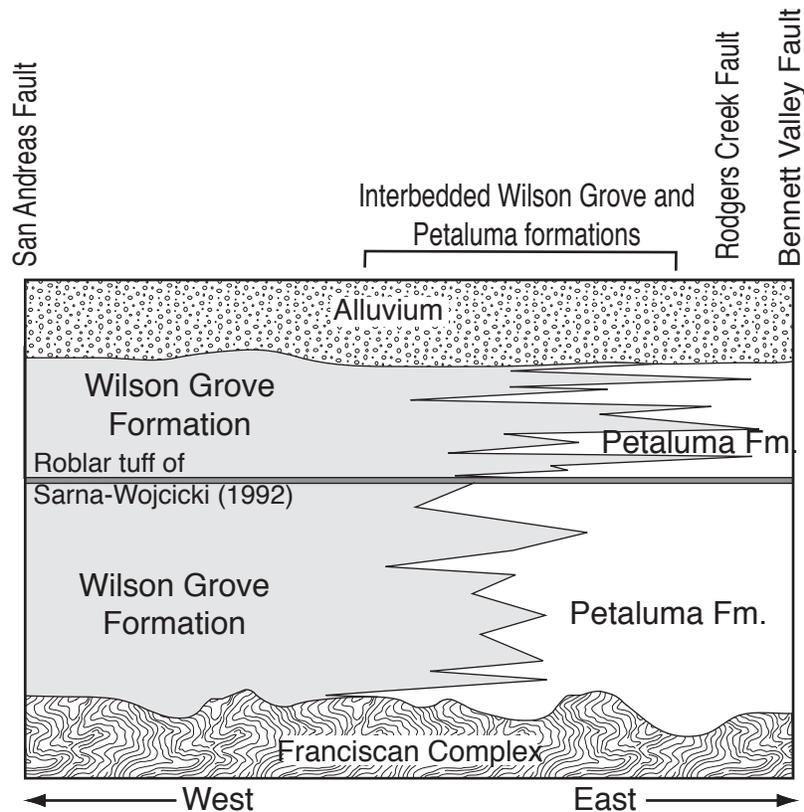


Figure 1. Schematic diagram showing the stratigraphic relationship of the Wilson Grove and Petaluma formations in northern Marin and southern Sonoma Counties, California.

The Wilson Grove Formation can be divided into three distinct marine environments represented by lateral variation in lithology, associated sedimentary structures, and in some cases, fauna. These three environments represent: 1) A deep marine facies along the western margin, 2) a shallow marine facies in the central portion of the formation and 3) a marine and estuarine environments along the eastern margin of the outcrop area where the Wilson Grove Formation is interfingering with the non-marine Petaluma Formation.

**Deep marine facies.** The lithology of this facies is predominantly fine- to medium-grained, well-sorted, sub-angular, feldsarenite sandstone with a local, pebble to boulder conglomerate, 2- to 5 m-thick at the base. A laterally discontinuous, coarse-grained sandstone interbed 15-20 m thick is locally present in the lower part of the unit (Travis, 1952; Holland and Allen, 1998; Allen and Holland, 1999; Figure 2). Foraminifers collected from near the base of the Wilson Grove Formation from this facies represent mixed shelf and neritic forms (Allen, 2003). The deep marine facies is recognized in the southern and southwestern part of the outcrop area and is well exposed at Dillon

Beach, Fallon, Tomales, the Estero San Antonio area, and Whittaker Bluff (Plate 1). At Whitaker Bluff and Estero San Antonio exposures show hummocky cross stratification, wavy-parallel stratification, and planar stratification. Burrows are present in most outcrops and are locally abundant.



Figure 2. Outcrops of coarse-grained sandstone interbed near the base of the Wilson Grove Formation at "The Elephants" between Tomales and Dillon Beach. The truck is on a road behind the outcrop and is not an accurate scale. The outcrop is actually about 10 m high.

The deep marine facies are interpreted as being deposited on the continental slope with periodic sediment influx from the continental shelf sediments (Allen, 2003). The interbeds, some of which contain shelfal foraminifers, appear to be channelized, gravity flows thought to be associated with the Delgada Fan system (Allen and Holland, 1999; Allen, 2003). This is, in part, based on palinspastic restoration of central California during the late Neogene that brings the Delgada Fan adjacent to outcrops of the Wilson Grove Formation during late Miocene time (Allen, 2003), as well as, the occurrence of the Roblar tuff of Sarna-Wojcicki (1992) in both areas (Sarna-Wojcicki, 1992; Allen and Holland, 1999).

Overall, fossils are rare in this facies. Those that are found are commonly associated with concretionary beds, but also occur randomly throughout the sediment. Mollusks here are commonly disarticulated and in many cases broken, suggesting reworking. This makes them of limited value in determining the paleoenvironment represented by this lithofacies. One collection along the north side of the Estero San Antonio (UCMP B5543) contains echinoids questionably attributed to indeterminate *Brisaster* [identified by R. Mooi, CAS]. In the northeastern Pacific *Brisaster*, principally *B. latifrons* (Agassiz), occurs in water depths between 20 and 1900 m and generally on fine grained sediments (Maluf, 1988).

Shallow marine facies. This lithofacies is predominantly composed of thick-bedded to hummocky-cross stratified (Figure 3), fine-to medium-grained sandstone, and is exposed over most of the outcrop area. At Bloomfield Quarry, the base of the formation is exposed and consists of a basal conglomerate of locally derived Franciscan Complex clasts. The Roblar tuff of Sarna-Wojcicki

(1992) occurs at least 60 m above the base of the formation at this locality (Plate 2, cross section I-I). Nearby at Steinbeck Ranch, the tuff is at least 100 m above base, owing to the irregular basement topography of the underlying Franciscan Complex (Plate 2, cross-section H-H ). The predominant lithology above the Roblar tuff of Sarna-Wojcicki (1992) is thick-bedded to hummocky-cross stratified, well-sorted, sub-angular, fine- to medium-grained, feldsarenite sandstone. This lithofacies is projected across the Bloomfield fault and overlies the deep marine facies to the southwest. Excellent exposures of this lithofacies occur just south of the Bloomfield fault at Tremary Ranch, Steinbeck Ranch, also west of Petaluma, near Sebastopol, and along River Road.

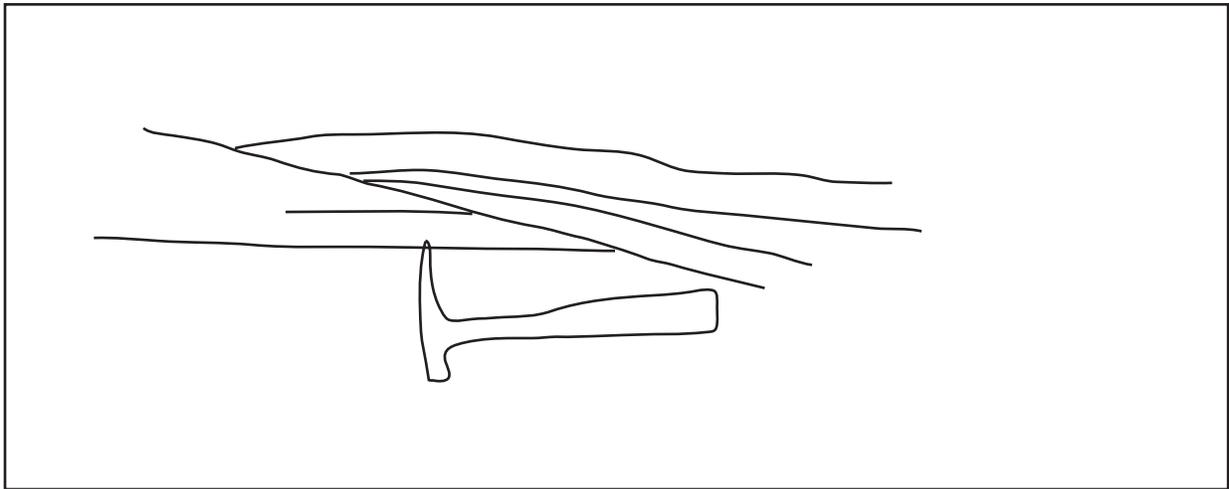


Figure 3. A. Hummocky cross-stratification at Steinbeck Ranch. Hammer is 30 cm long. B. Diagrammatic illustration of the stratification in the photograph. Photograph by J. Allen, 1998.

Fossils from this lithofacies commonly form distinct calcite cemented beds often of disarticulated and broken shells, although the shells also occur scattered randomly throughout the sediment. In both cases distribution patterns suggests transport. Generally faunas from this lithofacies are poorly preserved and limited in the number of species represented, making ecological interpretations marginally useful.

Transitional marine/continental facies. This lithofacies is commonly composed of medium- to coarse-grained, angular, sandstone beds interbedded with very well rounded, pebble conglomerate beds containing abundant Franciscan Complex and Monterey Group derived clasts (Figures 4, 5). The Petaluma Formation as described Allen (2003) contains Franciscan Complex clasts and, further up-section, Monterey Formation derived clasts and lacks significant amounts of volcanic clasts. Petaluma Formation conglomerate beds in this area have been mapped as fresh water Merced, Merced Formation, Petaluma Formation, and Cotati Member of the Wilson Grove Formation by various authors (Johnson, 1934; Weaver, 1949; Wagner and Bortugno, 1982; Fox, 1983; and Davies, 1986), often without criteria for determining the formations name. Areas containing interfingering marine sandstone and continental conglomeratic beds are here interpreted as a transition zone between the Wilson Grove and Petaluma Formations.

Fossils from the marine part of this lithofacies are common to abundant in some beds, absent to rare in others, and in all cases preservation is poor. Where abundant fossils are found few species are present. Poor preservation makes ecologic and age interpretation imprecise. However, low diversity of taxa coupled with large numbers of individuals is characteristic of estuarine environments (Hedgpeth, 1957), which we suggest here for these outcrops. Fossils from the continental Petaluma Formation have been reported elsewhere (Osmont, 1905; Merriam, 1915; Morse and Bailey, 1935; Peterson, written communication, 2002; Repenning, oral communication, 2002).

Thickness of the Wilson Grove Formation and its relevance. A maximum thickness of about 820 m (2,700 ft) has been reported in the literature for the Wilson Grove Formation (Bedrossian, 1974), and other reported thickness are less (Osmont, 1905; Dickerson, 1922; Johnson, 1934; Travis, 1952; Bedrossian, 1970; Fox, 1983). The Wilson Grove Formation shows a small but pervasive dip to the northeast. The Bloomfield fault is the only major stratigraphic interruption. Therefore, we assumed a nearly continuous section, from southwest to northeast, and calculated a thickness for the Wilson Grove Formation on both sides of the Bloomfield fault. We determined a stratigraphic thickness of at least 1,500 m in the block south of the Bloomfield fault and about 295 m north of Bloomfield fault (Plate 2, thickness cross sections 1 and 2). This results in a maximum original stratigraphic thickness of about 1,795 m for the Wilson Grove Formation (Plate 2), although at any site the preserved thickness will be considerably less. The Roblar tuff of Sarna-Wojcicki (1992), the only significant marker bed in the formation, occurs near the base of the Wilson Grove Formation in the block northeast of the Bloomfield fault and is absent southwest of the fault (Travis, 1952; Blake and others, 2002; Allen, 2003). Therefore, we suggest that the Roblar tuff of Sarna-Wojcicki (1992) and overlying section were originally on the block southwest of the Bloomfield fault, but have been removed by uplift and erosion. This makes the Wilson Grove Formation southwest of the Bloomfield fault older than 6.25 Ma, the age of the Roblar tuff of Sarna-Wojcicki (1992), and most of the section northeast of the Bloomfield fault younger than 6.25 Ma.

These thickness calculations assume the basement close to the surface along Estero Americano and near Valley Ford are topographic highs, and the Wilson Grove Formation was deposited around and eventually, over these basement islands (Plate 2, cross section A-A). However, if uplift in this area is the result of faulting and the Wilson Grove Formation is repeated here, then a restored thickness of only about 880 m (2,900 ft) is present south of the Bloomfield fault. We can find no evidence for faulting or that the Wilson Grove Formation is repeated in the southern block, so we favor the 1,500 m thickness for the formation in this area.

Basement structure. The top of the Franciscan Complex on which the Wilson Grove Formation was deposited has been interpreted both as a highly irregular contact by Dickerson (1922) and as a peneplain or plateau by Johnson (1934) and Fox (1983). We suggest that the surface is a combination of both. In many areas the surface is apparently flat lying, in some areas substantial relief in the basement is evident (Plate 2). Dickerson (1922) reported relief of 120 to 150 m (400 to 500 ft) on the top of the underlying Franciscan Complex basement, although our thickness and structural sections suggest a much greater relief (i.e., up to 670 m near Estero Americano; Plate 2, cross sections A-A and F-F). Topographic high areas (i.e., Hill 724 east of Bodega) cannot be

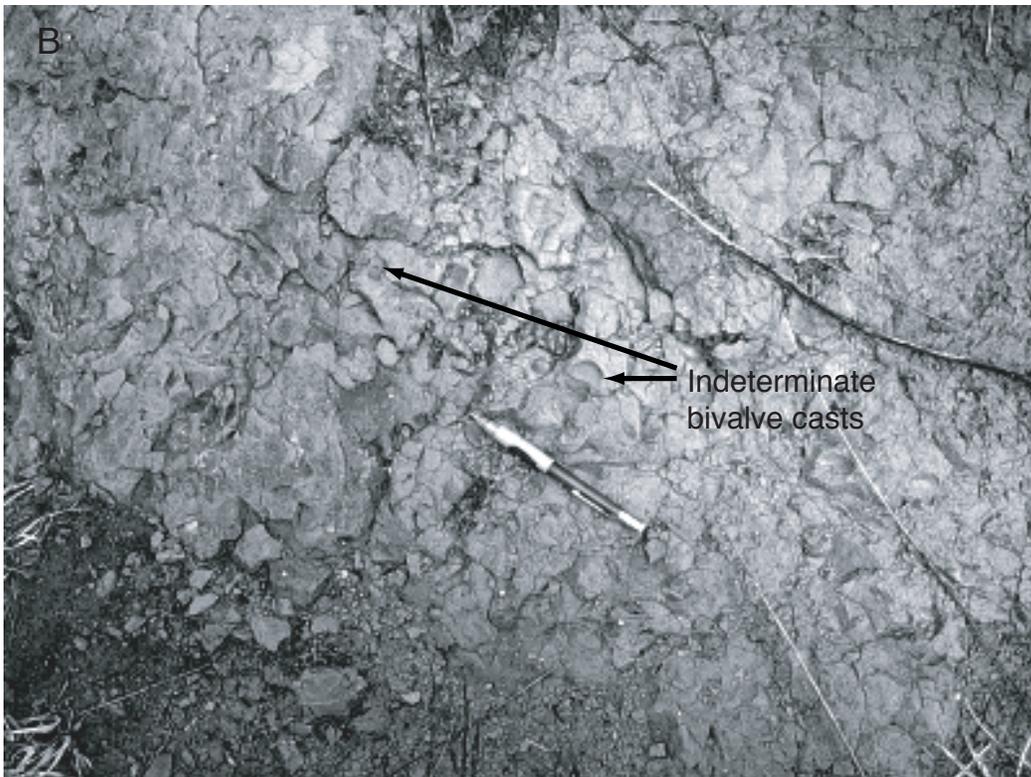
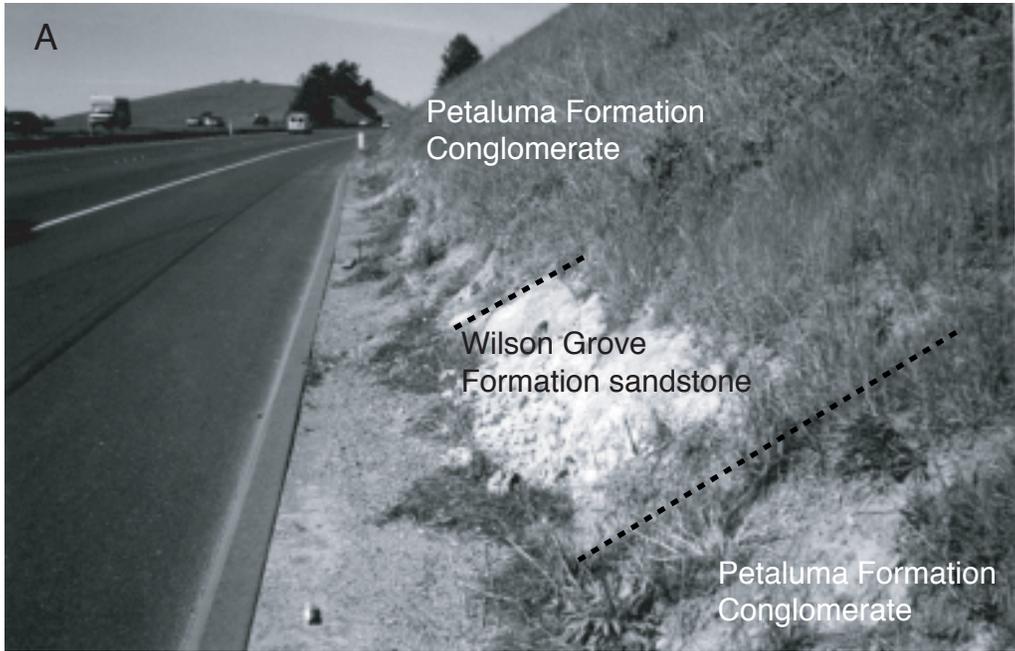


Figure 4. A. Road cut along U.S. Highway 101 showing a marine interbed of the Wilson Grove Formation in the Petaluma Formation at Meacham Hill. B. Close-up showing fossils in the Wilson Grove Formation sandstone interbed (Fossil locality USGS JA-1 on Plate 1). Photograph by J. Allen 2001.

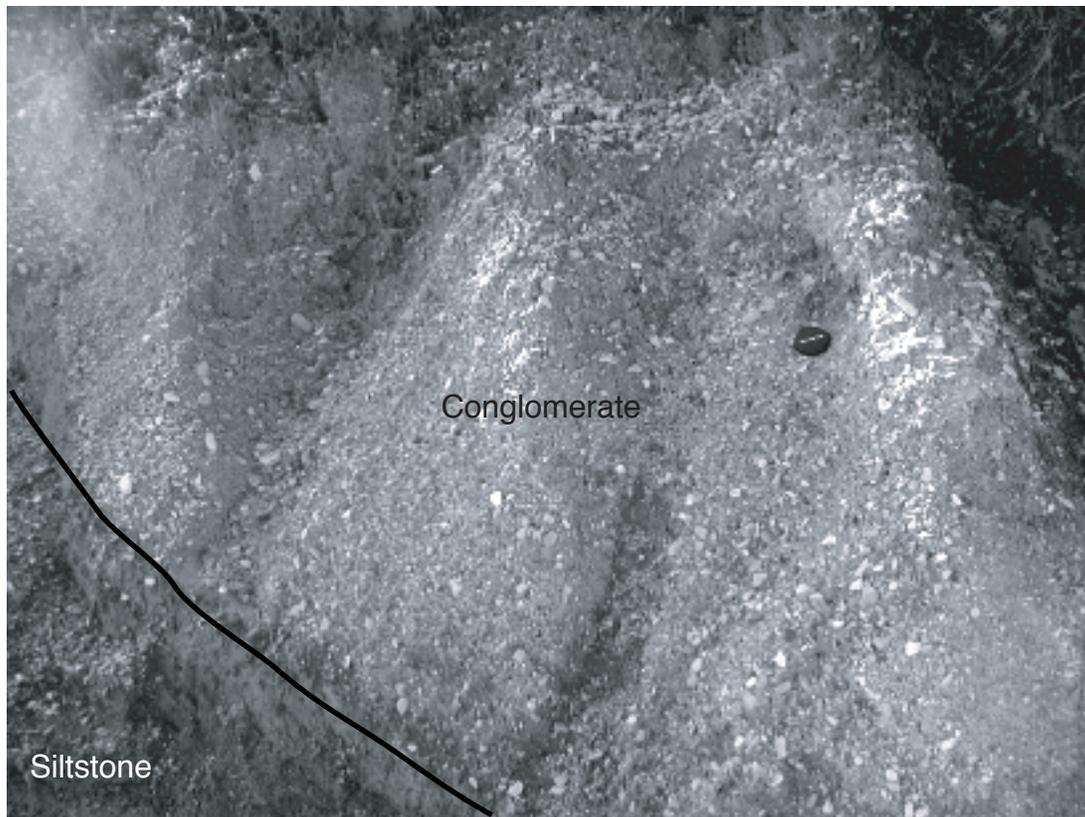


Figure 5. Monterey-clast conglomerate approximately 1/4 mile north of the intersection of Gravenstein Highway and Stony Point Road. Photograph by J. Allen, 2001.

explained by known faults and folds, so we interpret the basement relief as pre-existing highs which have since been exhumed by erosion of the overlying Wilson Grove Formation (Plate 2, cross section F-F ; Johnson, 1934; Ely, 1999).

Structurally, outcrops of the Wilson Grove Formation are cut by a series of northwest-trending reverse faults of relatively small displacement, including the Bloomfield fault (Travis, 1952; Hitchcock and Kelson, 1998, Plate 1). These faults strike approximately N 60° W, dip to the east, and typically the northeast block is up-thrown (Travis, 1952; Hitchcock and Kelson, 1998). Hitchcock and Kelson (1998) suggest that the Bloomfield fault has a minimum of 183 m of vertical offset based on restoration of throw using depth to Franciscan Complex basement rocks across the fault. This determination was based on cross section data that depicts a small outcrop of Wilson Grove Formation capping English Hill, north of the Bloomfield fault, and assumes a thin, flat-lying veneer of Wilson Grove Formation south of the fault. Unfortunately, the Wilson Grove Formation outcrops on English Hill do not represent the lowermost part of the formation in that area. Outcrops on English Hill that occur along strike are found at a lower elevations than the base of the formation on English Hill. This indicates that the base of the Wilson Grove Formation is lower than their model shows and supports our contention that English Hill was a pre-existing high, or island, similar to that of Hill 724 east of Bodega (Plates 1 and 2). Using our model, there is at least 1,500 m of Wilson Grove Formation south of the Bloomfield fault with a consistent 6 degree dip to the northeast (Travis 1952) (Plate 2, cross section K-K ). Hitchcock and Kelson (1998) did not evaluate the implications that the 6 degree dip has on basement restoration and overall thickness of the formation. Furthermore, the Wilson Grove Formation is at least 300 m (1,000 ft) thick

immediately south of English Hill based on borehole data, along their cross section line (Cardwell, 1958), while Hitchcock and Kelson (1998) estimated the Wilson Grove Formation was 75 m (250 ft) thick in this area. By taking into account dip, varying depths to basement, and stratigraphy within the Wilson Grove Formation, we suggest the section south of the Bloomfield fault cannot be duplicated by a basement-to-basement throw restoration across the fault (Plate 2).

## Faunal composition, preservation, and paleoecology

**Faunal composition and preservation.** The fauna from the Wilson Grove Formation consists of at least 107 taxa; two brachiopods, 95 mollusks, including 48 bivalves, 46 gastropods, and one scaphopod, at least eight arthropods, and at least two echinoids (Table 7). Preservation varies between localities and ranges from mostly poor, to rarely very good.

Accurate environmental interpretations require a minimum fauna of 15 to 20 extant species, otherwise the ecological interpretations are commonly very broad. Faunas with greater than 15 extant taxa are rare (about 5%) in the Wilson Grove Formation. Therefore, the ecological interpretations presented here are imprecise, but represent our best guess based on the fossils present, the sediments they were collected in, and the stratigraphic succession in which the locality is located.

Fossil localities are placed into the composite stratigraphic section (Figure 6) based on the thickness and structural section presented in Plate 2. A potential problem exists at Salmon Creek where the Roblar tuff of Sarna-Wojcicki (1992) appears to overlie Pliocene fossils based on our regional dip of 6°. We assume and observed structural complications in this area that are beyond the scope of this study. But, keeping this in mind, the stratigraphic succession of fossil localities in Figure 6 is generally correct, but is not assumed to be completely correct in all cases.

**Paleoecology.** Several collections and outcrop areas of the Wilson Grove Formation are not discussed here for one of three reasons: 1) fossils are not in any of the collections examined from these areas (i.e., Petaluma), 2) the collections are not sufficient to give any accurate age or environmental determination (i.e., CAS 31273, CAS 55978, CAS 55981, CAS 55982, CAS 58003, CAS 60461, CAS 60462, CAS 60463, CAS 60464, CAS 60466, CAS 60467, CAS 60471, CAS 60934, CAS 60937, LACMIP 11777, UCMP 7025, UCMP A866, UCMP A867, UCMP A868, UCMP A870, UCMP A873, UCMP A4189, UCMP A4190, UCMP A6890, UCMP A6895, UCMP B4668), or, 3) the locality data are not sufficient to accurately locate the fossil collection (i.e., CAS 425, CAS 439, UCMP 3614, UCMP A6892, UCMP A6893).

Outcrop areas of the Wilson Grove Formation with sufficient fossil collections to discuss paleontology and age include Bennett Valley, Bloomfield Quarry, Ebabias Creek, Meacham Hill and vicinity, River Road, Roblar Road and vicinity, Salmon Creek and vicinity, South Valley Ford, Spring Hill, Steinbeck Ranch, Whittaker Bluff and vicinity, and Wilson Grove. These areas are discussed below and are located on Plate 1. In addition, Burdell Mountain is discussed and excluded from the Wilson Grove Formation.

**Bennett Valley.** Outcrops along Mantazas Creek in Bennett Valley were examined by James Allen during this study and contain a limited fauna of rare indeterminate bivalve fragments, crab remains, and a possible barnacle plate (JA100501A). These fossils suggest marine conditions but are too poorly preserved for a precise environmental interpretation and are not age significant. Associated with the bed containing marine fossils are herringbone-stratified sandstone and conglomerate beds suggesting a nearshore marine environment. In addition, a thin shale bed near the marine bed contains leaf impressions suggesting a nearshore marine or continental environment. Fossil leaves have also been found at Spring Hill associated with marine fossils, so this association is not unique in the Wilson Grove Formation. In addition, collections at UCMP from Mantazas Creek contain well preserved leaves, but their exact locality is not clear. Locality JA1005001A is very close to and underlies a vertebrate fossil locality (UCMP V-5320) that is supposedly Blancan in age,

Taxa/Locality	Bloomfield Quarry	Ebabias Creek	Meancham Hill	River Road	Roblar Road	Salmon Creek (Freestone)	South Valley Ford	Steinbeck Ranch and vicinity	Whittaker Bluff and vicinity	Wilson Grove
<b>Brachiopoda</b>										
<b>Inarticulata</b>										
<i>Discinisca cumingii Broderip</i>	cf.	cf.	-	-	-	-	-	-	-	-
<b>Articulata</b>										
<i>Terebratalia transversa Sowerby</i>	X	? sp. (?)	-	-	-	sp.	-	-	-	-
<b>Mollusca</b>										
<b>Bivalvia</b>										
<i>Acila? sp.</i>	-	-	-	-	-	-	-	-	X	-
<i>Anadara trilineata (Conrad)</i>	sp.	-	-	sp.	sp.	-	-	-	-	X
<i>Arca santamariensis Reinhart</i>	cf.	? (?)	-	-	-	-	-	-	-	-
<i>Axinopsida serricata (Carpenter)</i>	-	-	-	X	-	-	-	-	-	-
Cardiidae, indeterminate	X	-	-	-	X	-	-	X	-	X
<i>Chlamys hastata (Sowerby)</i>	cf.	-	-	-	-	X	-	-	-	-
<i>Chlamys sp.</i>	X	X	-	-	-	?	-	-	-	-
<i>Clinocardium meekianum (Gabb)</i>	? sp.	-	-	? sp.	-	sp.	-	-	sp.	X
<i>Compsomyax? sp.</i>	-	-	-	-	-	X	-	-	-	-
<i>Cryptomya californica (Conrad)</i>	?	-	X	X	X	X	-	? sp.	-	X
<i>Glycymeris sp., cf. G. grewinki Dall</i>	-	-	-	-	-	-	-	-	-	X
<i>Lituyapecten turneri (Arnold)</i>	-	-	-	-	-	-	-	-	X	-
<i>Lucinoma annulatum (Reeve)</i>	X	-	-	-	-	-	-	-	-	-
Lucinidae, indeterminate	-	X	-	X	X	-	-	-	-	-
<i>Macoma addicotti Nikas</i>	sp.	-	-	X	-	sp.	-	-	-	cf.
<i>Macoma nasuta (Conrad)</i>	-	-	?	cf.	-	cf.	-	-	-	X
<i>Macoma sp.</i>	-	-	-	X	?	X	-	-	-	X
Mactridae, indeterminate	X	X	-	X	X	X	-	-	X	X
<i>Macromeris albaria (Conrad)</i>	-	-	-	cf.	-	cf.	-	-	-	X
<i>Macromeris polynyma (Stimpson)</i>	-	-	-	-	-	-	-	-	-	cf.
<i>Modiolus sp.</i>	X	-	X	-	-	-	-	-	X	X
<i>Mya truncata Linnaeus</i>	-	-	-	-	-	X	-	-	-	-
Mytilidae, indeterminate	X	-	-	-	-	-	X	-	X	-
<i>Mytilus coalingensis (Arnold)</i>	cf.	sp.	-	sp.	-	-	-	-	-	-

Taxa/Locality	Bloomfield Quarry	Ebabias Creek	Meancham Hill	River Road	Roblar Road	Salmon Creek (Freestone)	South Valley Ford	Steinbeck Ranch and vicinity	Whittaker Bluff and vicinity	Wilson Grove
<i>Nuttallia jamesii</i> Roth and Naidu	-	-	-	X	-	-	-	-	-	-
<i>Ostrea</i> sp.	-	-	-	-	-	-	-	-	-	X
<i>Pandora</i> sp.	-	-	-	-	-	-	-	-	-	X
<i>Panope abrupta</i> (Conrad)	sp.	? sp.	-	-	-	X	-	-	-	-
<i>Patinopecten healeyi</i> (Arnold)	-	-	-	-	-	X	-	-	-	-
<i>Patinopecten</i> sp.	X	X	-	-	-	-	-	X	?	-
Pectinidae, indeterminate	(?)	X	-	-	X	X	-	-	X	-
<i>Panomya</i> sp.	-	-	-	-	-	-	-	-	X	-
<i>Pododesmus macrochisma</i> (Deshayes)	cf.	-	-	-	-	-	-	-	-	-
<i>Protothaca staleyi</i> (Gabb)	(?)	-	-	X	-	X	-	-	-	X
<i>Protothaca tenerrima</i> (Carpenter)	-	-	-	-	-	-	-	-	-	?
<i>Protothaca</i> sp.	(?)	?	X	X	-	-	-	-	-	X
<i>Saxidomus</i> sp.	-	-	-	-	-	X	-	-	-	-
<i>Securella?</i> sp.	(?)	-	-	?	-	-	-	X	-	-
<i>Siliqua</i> sp.	? sp.	-	X	X	X	-	-	X	-	X
<i>Solen</i> sp.	X	X	X	X	X	X	?	X	X	X
<i>Swiftopecten parmeleei</i> (Dall)	X	-	-	-	-	-	-	-	-	-
<i>Tagelus</i> sp.	-	-	-	-	-	-	-	-	-	X
<i>Tellina</i> sp.	X	-	-	-	-	-	-	X	-	-
<i>Teredo</i> sp.	X	-	-	-	-	-	-	-	X	-
<i>Tresus nuttallii</i> (Conrad)	-	-	-	-	-	sp.	-	-	-	cf.
<i>Tresus pajaroanus</i> (Conrad)	?	?	?	-	-	X	X	?	cf.	X
Veneridae, indeterminate	(?)	-	X	(?)	-	X	-	X	-	X
<i>Yoldia cooperi</i> Gabb	sp.	-	-	aff.	sp.	? sp.	-	-	-	-
<b>Gastropoda</b>										
<i>Acanthinucella?</i> sp.	-	-	-	X	-	-	-	-	-	-
<i>Admete</i> sp.	-	-	-	?	-	-	-	-	-	-
<i>Antiplanes</i> sp.	-	-	-	-	-	-	-	X	-	-
<i>Astyris gausapata</i> (Gould)	-	-	-	X	-	-	-	-	-	X
<i>Aulacofusus?</i> <i>recurva</i> (Gabb)	-	-	-	-	-	?	-	-	-	-
<i>Balcis</i> sp.	-	-	-	X	-	-	-	-	-	-

Taxa/Locality	Bloomfield Quarry	Ebabias Creek	Meancham Hill	River Road	Roblar Road	Salmon Creek (Freestone)	South Valley Ford	Steinbeck Ranch and vicinity	Whittaker Bluff and vicinity	Wilson Grove
<i>Calicantharus fortis</i> (Carpenter)	-	-	-	sp.	-	-	-	-	-	?
<i>Calliostoma?</i> sp.	-	(?)	-	-	-	-	-	-	-	-
<i>Calyptraea</i> sp.	-	-	-	-	-	X	-	-	-	-
<i>Calyptraea (Trochita) n. sp.?</i>	X	? (?)	-	-	-	-	-	-	-	-
<i>Cancellaria?</i> sp.	-	(?)	-	-	-	-	-	-	-	-
<i>Crepidula onyx</i> Sowerby	-	? sp.	-	sp.	-	-	-	-	-	cf.
<i>Crepidula princeps</i> (Conrad)	?	(?)	-	X	-	X	X	-	X	X
<i>Cryptonatica affinis</i> (Gmelin)	-	-	-	X	-	-	-	-	-	X
<i>Cylichna</i> sp.	-	-	-	X	-	-	-	-	-	-
<i>Fusinus</i> sp.	-	-	-	-	-	?	-	-	-	-
<i>Fusitriton oregonensis</i> (Redfield)	-	-	-	-	-	-	-	-	? sp.	cf.
<i>Lirabuccinum portolaensis</i> (Arnold)	? sp.	-	-	X	? sp.	X	? sp.	? sp.	? sp.	-
<i>Littorina petricola</i> Dall	-	-	-	-	-	-	-	-	-	X
<i>Littorina</i> sp.	-	-	-	-	-	-	-	-	-	-
<i>Mediargo mediocris</i> (Dall)	-	-	-	X	-	-	-	-	-	-
<i>Megascurcula carpenteriana</i> (Gabb)	-	-	-	X	-	-	-	-	-	X
<i>Megascurcula remondii</i> (Gabb)	-	-	-	X	-	-	-	-	-	X
<i>Nassarius californicus</i> (Conrad)	? sp.	-	sp.	X	sp.	X	-	sp.	sp.	X
<i>Nassarius grammatus</i> (Dall)	-	-	-	X	-	-	-	-	-	X
<i>Nassarius</i> sp.	-	? (?)	-	-	-	-	-	-	-	X
<i>Natica janthostoma</i> Deshayes	-	-	-	-	-	-	-	-	-	X
Naticidae, indeterminate	X	X	X	X	X	X	X	X	X	X
Neogastropoda, indeterminate	-	(?)	-	-	-	X	-	X	X	-
<i>Neverita reclusiana</i> (Deshayes)	-	-	-	-	-	-	-	-	-	X
<i>Nucella</i> sp., cf. <i>N. emarginata</i> (Deshayes)	-	-	-	-	-	-	-	-	-	X
<i>Nucella n. sp.</i> , aff. <i>N. lamellosa</i> (Gmelin)	X	-	-	-	-	-	-	-	-	-
<i>Nucella transcoana</i> Arnold	-	-	-	X	-	-	-	-	-	X.
<i>Nucella</i> sp.	?	-	X	X	?	?	-	-	-	X
<i>Odostomia</i> sp.	-	-	-	X	-	-	-	-	-	-

Taxa/Locality	Bloomfield Quarry	Ebabias Creek	Meancham Hill	River Road	Roblar Road	Salmon Creek (Freestone)	South Valley Ford	Steinbeck Ranch and vicinity	Whittaker Bluff and vicinity	Wilson Grove
<i>Olivella biplicata</i> (Sowerby)	(?)	-	sp.	X	-	-	-	sp.	-	X
<i>Olivella pycna</i> Berry	-	-	-	X	-	-	-	-	-	sp.
<i>Ophiodermella graciosa</i> Arnold	-	-	-	cf.	-	-	-	-	-	X
<i>Ophiodermella</i> sp.	-	-	-	?	-	-	-	-	-	-
<i>Polinices</i> sp.	-	-	X	-	-	-	-	-	-	X
<i>Sinum scopulosum</i> (Conrad)	-	-	-	X	-	-	-	-	-	-
Trochidae, indeterminate	-	-	-	-	-	X	-	-	-	-
<i>Trophosycon</i> sp.	-	-	-	-	X	-	-	-	-	-
<i>Turbonilla</i> sp.	-	-	-	X	-	-	-	-	-	-
<i>Turcica brevis</i> Stewart	-	-	-	-	-	?	-	-	-	-
<b>Scaphopoda</b>										
<i>Dentalium</i> sp.	-	-	-	-	-	-	-	-	?	-
<b>Arthropoda</b>										
<b>Crustacea</b>										
<i>Balanus</i> sp., aff. <i>B. nubilus</i> Darwin	X	-	-	-	-	-	-	-	-	-
<i>Balanus irradians</i> Zullo & Naidu	X	-	-	-	-	-	-	-	-	-
<i>Balanus</i> sp., cf. <i>B. irradians</i> Zullo & Naidu	X	-	-	-	-	-	-	-	-	-
<i>Balanus?</i> sp.	X	X	-	-	-	X	-	-	-	X
<i>Callianassa</i> sp.	?	-	-	-	-	-	-	-	-	-
<i>Cancer</i> sp.	X	-	X	X	-	-	-	-	-	-
<i>Notomegabalanus(?) insperatus</i> Zullo & Naidu	X	-	-	-	-	-	-	-	-	-
Indeterminate crabs and crab parts	-	-	X	X	-	-	-	-	X	-
<b>Echinodermata</b>										
<b>Echinoidea</b>										
<i>Brisaster?</i> sp.	-	-	-	-	-	-	-	-	X	-
Indeterminate specimens	-	-	X	X	-	-	-	-	X	-

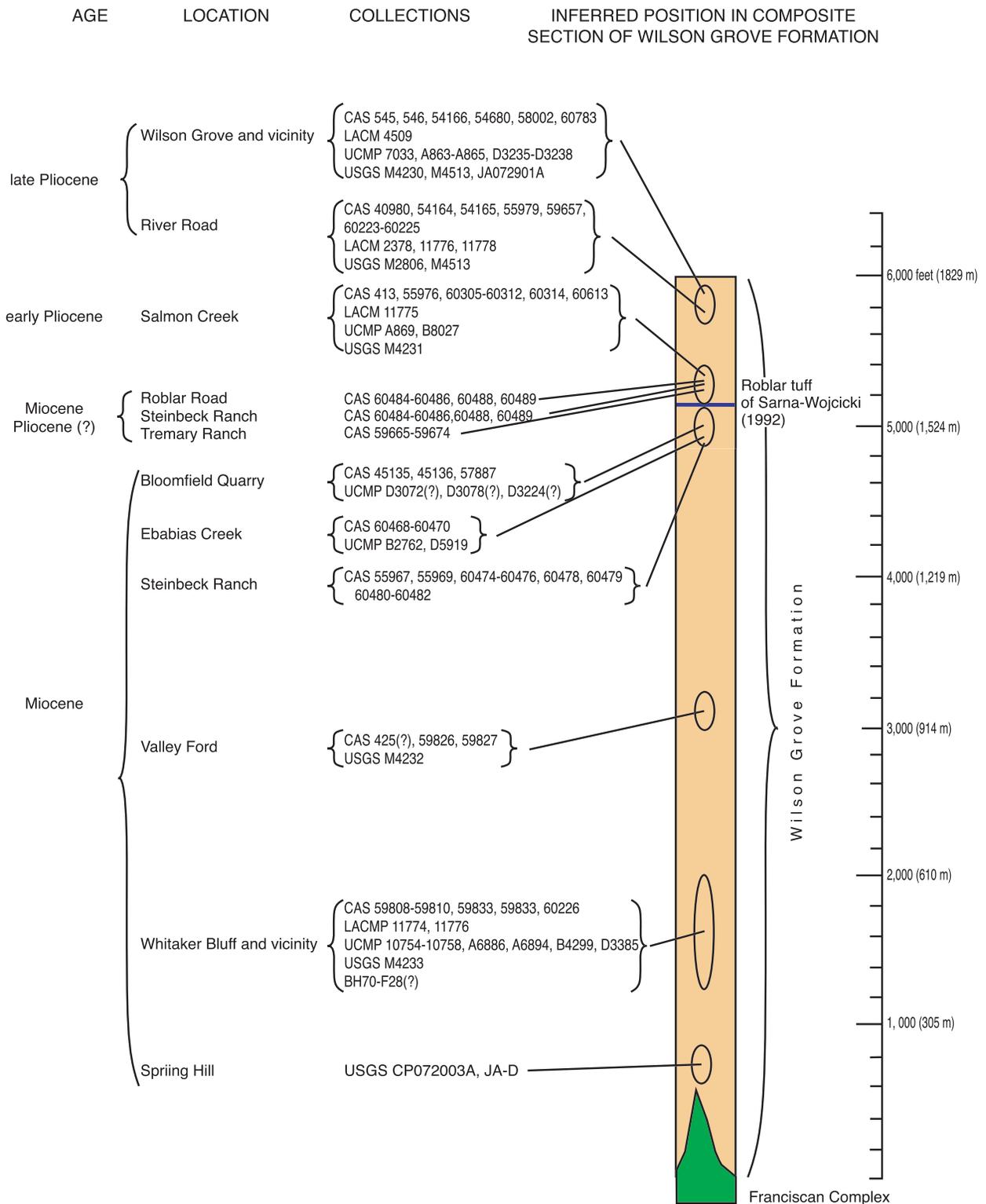


Fig. 6. Composite section of the Wilson Grove Formation with approximate position of major fossil localities and collections.

supporting a Pliocene age call for the Wilson Grove Formation in this area. In addition, Rathbun (1926) described two crabs from an outcrop on the south side of Santa Rosa (UCMP 7025). These crabs are not age diagnostic although Rathbun cites a Pliocene age for them. Fox and others (1985) report a K/Ar age determination from a tuff in the Petaluma Valley northeast of Rohnert Park at 3.95 – 0.32 Ma, again supporting a Pliocene age for the Wilson Grove Formation in the Bennett Valley.

**Bloomfield Quarry.** The Wilson Grove Formation crops out in an inactive rock quarry on the east side of the road from Bloomfield to Valley Ford in Sonoma County (Plate 1) and is here referred to as the Bloomfield quarry. At the Bloomfield quarry the Wilson Grove Formation overlies graywacke and shale of the Franciscan Complex along an angular unconformity and consists of about 0.3 to 0.6 m of a fossiliferous basal conglomerate of pebbles, cobbles, and boulders derived from Franciscan Complex rocks. This is overlain by 4 to 6 m of massive, soft, fine- to medium-grained, fossiliferous sand. The Roblar tuff of Sarna-Wojcicki (1992) crops out on a hill to the north, and is at least 68 m up-section from the basal unit (Plate 2, cross section I-I). Between the basal conglomerate at Bloomfield Quarry and the Roblar tuff of Sarna-Wojcicki (1992) are thickly- to hummocky cross-stratified, medium-grained, well-sorted, sub-angular feldsarenite sandstone beds (Holland and Allen, 1998).

The only report of fossils from the Bloomfield Quarry is a paper by Zullo and Naidu (1982) who described a barnacle fauna of five taxa from the basal conglomerate. Mollusks collected at the same site were analyzed by Barry Roth (*in* Zullo and Naidu, 1982) who interpreted the paleoenvironment as a rocky intertidal or immediately subtidal environment exposed to moderate or heavy surf. The coquina itself, and its relationship to the underlying fining-upwards conglomerate, suggests a time of stillstand after rapid transgression in a shallow depositional basin affected by wave base and (or) current action, in general agreement with our findings. Zullo and Naidu (1982) apparently miss-calculate the stratigraphic position of the Roblar tuff of Sarna-Wojcicki (1992) with relation to the basal fossil beds. They report the tuff is few meters above the base of the formation, while we measured the tuff at least 60 meters above base of the formation (Plate 2). The basal conglomerate contains a fauna of two brachiopods, 23 mollusks (17 bivalves, six gastropods), and seven arthropods. These taxa suggest normal marine salinity (35 ppt; Pearse and Gunter, 1957) at shelfal water depths (here we define shelfal as water depths < about 100 m; the approximate position of the shelf/slope break). Too few extant taxa are present for precise ecological interpretation. The upper sand unit contains a small fauna of two brachiopods, 11 mollusks (six bivalves and five gastropods), and two arthropods. Again too few extant taxa are present for a precise ecological interpretation, though these taxa suggest normal marine salinity and shelfal water depths. A composite fauna for Bloomfield Quarry is presented in Table 8.

Zullo and Naidu (1982) suggest a late Miocene age for the fossils exposed at the Bloomfield Quarry. This is not based on the taxa present, but on the stratigraphic position of the fossil localities below the Roblar tuff of Sarna-Wojcicki (1992). Four mollusks from the basal unit [*Arca santamariensis* Reinhart [questionably identified], *Mytilus coalingensis* (Arnold) [questionably identified], *Swiftopecten parmeleei* (Dall), and *Tresus pajaroanus* (Conrad) (also questionably identified)] and two from the upper sand unit at Bloomfield Quarry [*Tresus pajaroanus* (Conrad) [questionably identified] and *Crepidula princeps* (Conrad) [questionably identified]] are extinct. Unfortunately, these taxa are too broadly ranging to support the late Miocene age but also do not dispute it, as they are known from late Miocene to late Pliocene rocks elsewhere in California.

**Burdell Mountain.** Dickerson (1922) was the first to mention fossils from Burdell Mountain in northern Marin County south of the area studied here, which he attributed to the Merced Formation. This was followed by Weaver (1949) who described the distribution and lithology of the Merced Formation north of San Francisco Bay. In an unpublished report on referred fossils to the U.S. Geological Survey, Warren Addicott (written communication, 1971; USGS E&R PE-70-9M) reports a questionable Temblor provincial molluscan age for fossils collected from the northwest side of Burdell Mountain based on the questionable occurrence of *Tivela* sp., cf. *T. gabbi* Clark. In addition, the sandstone underlies volcanics that have been dated using K-Ar at approximately 12.1 – 0.8 Ma

Table 8. Composite faunal list from outcrops at or near Bloomfield Quarry, Sonoma County (Basal conglomerate: CAS 54135. Upper bed: CAS 54136. Float: CAS 57867; see Appendix 2). \*After Zullo and Naidu (1982).

Taxa/Location	Basal conglomerate	Upper bed	Float
<b>Brachiopoda</b>			
<b>Inarticulata</b>			
<i>Discinisca</i> sp., cf. <i>D. cumingii</i> Broderip	X	X	-
<b>Articulata</b>			
<i>Terebratalia transversa</i> Sowerby	X	X	-
<b>Mollusca</b>			
<b>Bivalvia</b>			
<i>Anadara</i> sp.	X	-	-
<i>Arca</i> sp., cf. <i>A. santamariensis</i> Reinhart	X	-	-
Cardiidae, indeterminate	X	-	-
<i>Chlamys</i> sp., cf. <i>C. hastata</i> (Sowerby)	X	-	-
<i>Chlamys</i> sp.	X	X	-
<i>Clinocardium?</i> sp.	-	-	X
<i>Cryptomya californica</i> (Conrad)?	X	-	-
<i>Lucinoma annulatum</i> (Reeve)	-	X	-
<i>Macoma</i> sp.	X	-	-
Mactridae, indeterminate	-	-	X
<i>Modiolus</i> sp.	X	X	-
Mytilidae, indeterminate	X	-	-
<i>Mytilus</i> sp., cf. <i>M. coalingensis</i> (Arnold)	X	-	-
<i>Panope</i> sp.	-	X	-
<i>Patinopecten</i> sp.	X	-	X
<i>Pododesmus</i> sp., cf. <i>P. macrochisma</i> (Deshayes)	X	sp.	-
<i>Siliqua?</i> sp.	-	-	X
<i>Solen</i> sp.	X	-	-
<i>Swiftopecten parmeleei</i> (Dall)	X	-	-
<i>Tellina</i> sp.	-	-	X
<i>Teredo</i> sp.	X	-	-
<i>Tresus pajaroanus</i> (Conrad)?	X	X	X
<i>Yoldia</i> sp.	X	-	-
<b>Gastropoda</b>			
<i>Calyptraea (Trochita)</i> n. sp.?	X	-	-
<i>Crepidula princeps</i> (Conrad)?	X	-	-
<i>Lirabuccinum?</i> sp.	X	-	-
<i>Nassarius?</i> sp.	X	-	-
Naticidae, indeterminate	X	-	-
<i>Nucella</i> n. sp.? aff. <i>N. lamellosa</i> (Gmelin)	X	-	-
<i>Nucella</i> sp.	-	X	-
<b>Arthropoda</b>			
<b>Crustacea</b>			
<i>Balanus</i> sp., aff. <i>B. nubilus</i> Darwin*	X	-	-
<i>Balanus irradians</i> Zullo & Naidu*	X	-	-
<i>Balanus</i> sp., cf. <i>B. irradians</i> Zullo & Naidu*	X	-	-
<i>Balanus</i> sp.*	X	X	-
<i>Callianassa?</i> sp.	X	X	-
<i>Cancer</i> sp.	X	-	-
<i>Notomegabalanus(?) insperatus</i> Zullo & Naidu*	X	-	-

(Fox et al., 1985) and by Ar-Ar at 12.6 Ma (J. Wakabaishi, written communication, 2001). Graymer and others (2002) suggest a correlation of the unnamed sandstone on Burdell Mountain with the Lone Tree Formation in San Benito County, 175 km to the southwest, based on lithologic,

stratigraphic, and age similarities. Our examination of the sandstone exposed at Burdell Mountain and fossils recently collected from that area, along with the fossil lists of Dickerson (1922) and Weaver (1949), indicate these outcrops are referred to an unnamed, Miocene sandstone (see Graymer and others, 2002). In any case, the rocks and fossils from Burdell Mountain are not similar to the Wilson Grove Formation in Sonoma County, either sedimentologically or faunally, and are not included in the Wilson Grove Formation here.

Ebabis Creek. The Wilson Grove Formation exposed at or around Ebabis Creek is on private land and was not accessible during the present study. The co-occurrence of the inarticulate brachiopod *Discinisca* sp., cf. *D. cumingii* Broderip, and the mollusk genera *Arca* and *Calyptraea* (*Trochita*) at Bloomfield Quarry and Ebabis Creek, suggest correlation between the two sites. It is assumed herein that the two sites are of similar age and environment resulting in the co-occurrence of the taxa above, but there is no independent age control for outcrops at Ebabis Creek.

The fauna from Ebabis Creek consists of 22 invertebrate taxa (two brachiopods, 19 mollusks [11 bivalve, 8 gastropods], and one barnacle) (Table 9). These taxa are broadly ranging both ecologically and stratigraphically, but generally live today in normal marine salinity at shelfal water depths, and, at best, suggest a late Miocene to Pliocene age.

Table 9. Composite faunal list from outcrops at or near Ebabis Creek, Sonoma County, California (CAS 60468, CAS 60469, CAS 60470, UCMP B2762(?), UCMP D5919; see Appendix 2).

**Brachiopoda**

**Inarticulata**

*Discinisca* sp., cf. *D. cumingii* Broderip

**Articulata**

*Terebratalia?* sp.

**Mollusca**

**Bivalvia**

*Arca* sp.

*Chlamys?* sp.

Lucinidae, indeterminate

Mactridae, indeterminate

*Mytilus* sp.

*Panope* sp.

*Patinopecten* sp.

Pectinidae, indeterminate

*Protothaca?* sp.

*Solen* sp.

*Tresus pajaroanus* (Conrad)?

**Gastropoda**

*Calliostoma?* sp.

*Calyptraea* (*Trochita*) sp.

*Cancellaria?* sp.

*Crepidula princeps* Conrad

*Crepidula* sp.

*Nassarius?* sp.

Naticidae, indeterminate

Neogastropoda, indeterminate

**Arthropoda**

**Crustacea**

*Balanus?* sp.

Meacham Hill and vicinity. Outcrops of the Wilson Grove Formation at Meacham Hill along U.S. Highway 101, north of Petaluma and south of Cotati, represent some of the eastern-most outcrops of the Wilson Grove Formation and also show its interfingering relationship with conglomerates of the Petaluma Formation. These outcrops consist of fossiliferous sandstone and several interbedded conglomerate layers with clasts of siliceous, laminated chert of the Monterey Group, Tertiary sandstone, Franciscan Complex rocks, and minor Tertiary volcanics (Allen, 2003). A restricted, but, in places abundant, invertebrate fauna has been recovered here (Table 10). It consists of 12 poorly-preserved mollusks (eight bivalves and four gastropods) and well preserved indeterminate crab chela. Because of the poor preservation, fossil identifications and the resulting ecological interpretations are limited.

Table 10. Composite faunal list from outcrops at and near Meacham Hill, Sonoma County, California (CAS 60750, CAS 60765, CAS 60819, USGS M4511; see Appendix 2)

- Mollusca**  
**Bivalvia**  
*Cryptomya californica* (Conrad)  
*Macoma nasuta* (Conrad)  
*Macoma?* sp.  
*Modiolus rectus* (Conrad)  
*Siliqua* sp.  
*Solen* sp.  
*Tresus pajaroanus* (Conrad)  
Veneridae, indeterminate  
**Mollusca**  
**Gastropoda**  
*Nassarius* sp.  
Naticidae, indeterminate  
*Nucella* sp.  
*Olivella* sp.  
**Arthropoda**  
**Crustacea**  
Indeterminate crab parts

Four species of bivalve were identifiable to species: *Cryptomya californica* (Conrad), *Macoma nasuta* (Conrad), *Modiolus rectus* (Conrad), and *Tresus pajaroanus* (Conrad). With the exception of *Tresus pajaroanus* (Conrad), all are extant and occur off the adjacent California coast today at intertidal to shallow subtidal water depths. The limited number of species, but abundant individuals, suggests marginal marine conditions such as a tidal flat or bay (Hedgpeth, 1957). *Tresus pajaroanus* (Conrad) ranges in age from late Miocene to middle Pleistocene (Powell, 1998). Addicott (written communication, 1971; USGS Report on referred fossils PE-71-6M) identified *Nassarius grammatus* (Dall) from this locality, which would indicate a Pliocene age for the outcrops at Meacham Hill. Although we favor this age call, all the specimens examined during the present study (including Addicott's specimens) are too poorly preserved to be identified to species, and too small to be assigned with confidence to *Nassarius grammatus* (Dall).

Limited outcrops here attributed to the Wilson Grove Formation were recently exposed along Stony Point Road west of Meacham Hill (Figure 7). These rocks consist of up to 3.5 m of sandstone and conglomerate (Allen and others, 2000). The lower 1.5 meters consists of fine-grained sandstone contains abundant marine fossils. Conglomerate beds consisting of well-rounded Franciscan Complex, laminated chert of the Monterey, and Tertiary sandstone clast types conformably overlies the fossil bed (Allen and others, 2000). Fossil preservation is very poor, but a fauna of about four molluscan taxa have been identified [3 bivalves (*Cryptomya?* sp., Mactridae? indeterminate, Tellinidae?



Figure 7. Outcrop of the Wilson Grove Formation at the intersection of Pepper and Stony Point roads. Fossiliferous (near coquina) sandstone conformably overlain by well rounded, cobble conglomerate. Section dips to the west, away from the main reverse fault at Meacham Hill. Photograph by G. Yip, 1999.

indeterminate) and 1 gastropod (Naticidae, indeterminate)]. Because of the poor preservation and limited number of taxa present, ecologic interpretation is limited to marine, although the interbedded relationship of the marine beds with continental beds suggests very close proximity to shore, probably in a bay or estuarine environment.

Petaluma. Dickerson (1922) and Weaver (1949) mention outcrops of the Wilson Grove Formation (Merced Formation) from the Petaluma area, mostly on the northern side of Walker Creek and Chileno Valley. In Reservoir Hill about 3 miles west of Petaluma, in some street cuts in Petaluma, The ridge between Tolay and Petaluma valleys. The ridge between Tolay and Petaluma valleys has been mapped as Petaluma Formation and marine fossils were not found here during recent extensive field mapping along the Tolay fault. The only fossils found near the ridgeline between the Tolay and Petaluma valleys are a Proboscidian scapula fragment (Repenning, written communication, 2002) and marine-transitional and lacustrine microfauna in the Petaluma Formation (D. Peterson *in* Allen, 2003).

River Road. Northwest of Santa Rosa, on the north side of River Road and adjacent to the Trenton thrust-fault, are several outcrops of sandstone which dip away from the Trenton thrust-fault and are attributed to the Wilson Grove Formation. This area has seen extensive collection in recent years and most of the outcrop area today is simply float. The Roblar tuff of Sarna-Wojcicki (1992) crops out in several places nearby; most prominently in a road cut on the eastside of the Trenton-Healdsburg Road at its intersection with River Road. North of Trenton fault, the Roblar tuff of

Sarna-Wojcicki (1992) crops out again and dips to the north and below the outcrops at Wilson Grove (Plate 2 & Figure 8).

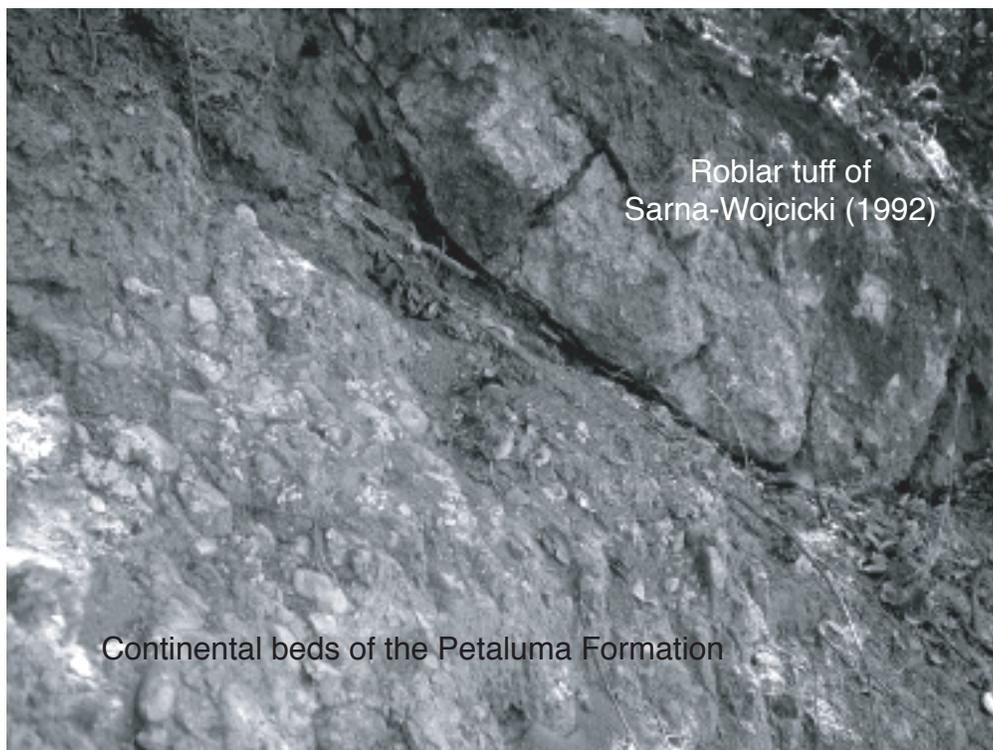


Figure 8. Outcrop of the Roblar tuff of Sarna-Wojcicki (1992) underlain by continental conglomeratic beds of the Petaluma Formation. This exposure is near the intersection of Trenton-Healdsburg Road and River Road and across the corner from the River Road outcrops which contain fossils of late Pliocene age. The occurrence of the Roblar tuff of Sarna-Wojcicki (1992) adjacent to the late Pliocene fossils suggests that thrusting has exposed older portions of the Wilson Grove Formation in this area. The strata pictured here dips 37° to the southwest, away from the Trenton fault. Photograph by J. Allen, 2002.

Travis (1952) appears to have been the first to report fossils from the Wilson Grove Formation in this area. He lists a small fauna of three taxa [the bivalves *Protothaca staleyi* (Gabb), and indeterminate Mactridae (as *Spisula* sp.), and the gastropod *Nassarius californicus* (Conrad)]. Roth and Naidu (1974) describe *Nuttallia jamesi*, a psammobiid bivalve, from the outcrops along River Road. They suggest the fauna was deposited on a silty sand bottom between 15 and 40 m deep, along with several taxa transported from intertidal and shallow subtidal depths. This ecologic interpretation is in general agreement with our interpretation, presented below.

The River Road area contains the largest fauna from the Wilson Grove Formation. This fauna is dominated by mollusks, but also include vertebrates, echinoids, and arthropods. The fauna consists of 41 mollusks (17 bivalves and 24 gastropods), at least two decapods (Arthropoda) (represented by numerous chela, free fingers and other indeterminate parts), and two echinoids (Table 11). There are also vertebrate fossils from this site in collections at UCMP, but these are beyond the

Table 11. Composite faunal list from outcrops at or near River Road, Sonoma County, California (CAS 40980, CAS 54164, CAS 54165, CAS 55979, CAS 59657, CAS 60223, CAS 60224, CAS 60225, LACMIP 2378, LACMIP 11778, UCD 281a, USGS M2806, USGS M4512, USGS M4513; Appendix 2).

**Mollusca**

**Bivalvia**

*Axinopsida serricata* (Carpenter)  
*Clinocardium?* sp.  
*Cryptomya californica* (Conrad)  
 Lucinidae, indeterminate  
*Macoma addicotti* Nikas  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
 Mactridae, indeterminate  
*Mytilus* sp.  
*Nuttallia jamesii* Roth and Naidu  
*Protothaca staleyi* (Gabb)  
*Protothaca* sp.  
*Securella?* sp.

**Mollusca**

**Bivalvia (continued)**

*Siliqua* sp.  
*Solen* sp.  
*Yoldia* sp., aff. *Y. cooperi* Gabb

**Gastropoda**

*Acanthinucella?* sp.  
*Admete?* sp.  
*Astyris gausapata* (Gould)  
*Balcis* sp.  
*Calicantharus* sp.  
*Crepidula princeps* Conrad  
*Crepidula* sp.  
*Cryptonatica affinis* (Gmelin)  
*Cylichna* sp.  
*Lirabuccinum portolaensis* (Arnold)  
*Mediargo mediocris* (Dall)  
*Megasurcula carpenteriana* (Gabb)  
*Megasurcula remondii* (Gabb)  
*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
 Naticidae, indeterminate  
*Nucella transcoana* Arnold  
*Nucella* sp.  
*Odostomia* sp. (large)  
*Olivella biplicata* (Sowerby)  
*Olivella pycna* Berry  
*Ophiidermella graciosa* Arnold  
*Sinum scopulosum* (Conrad)  
*Turbonilla* sp.

**Arthropoda**

**Crustacea**

*Cancer* sp.  
 Indeterminate crab parts

**Echinodermata**

**Echinoidea**

Indeterminate echinoid

scope of this study. Extant taxa from this locality indicate normal marine salinities, probably at water depths between about 40 and 50 m, on a sandy bottom. Water temperatures slightly warmer than along the adjacent coast today are suggested by the occurrence of the gastropods *Megascurcula remondi* (Gabb) and *Sinum scopulosum* (Conrad) that have modern ranges entirely south of the fossil locality.

Abundant extinct molluscan taxa are also present at this locality, including the bivalves *Macoma addicotti* Nikas, *Mactromeris* sp., cf. *M. albaria* (Conrad), *Nuttallia jamesii* Roth and Naidu, *Protothaca staleyi* (Gabb), and the gastropods *Mediargo mediocris* (Dall), *Nassarius californicus* (Conrad), *Nassarius grammatus* (Dall), *Ophiodermella* sp., cf. *O. graciosa* Arnold, and *Lirabuccinum portolaensis* (Arnold). Together these taxa suggest a late Pliocene age for the River Road outcrops (Table 12). Interestingly, *Nuttallia jamesii* Roth and Naidu is known only from River Road in Sonoma County and from the Purisima Formation exposed in the sea cliffs south of Capitola, Santa Cruz County, which is also late Pliocene in age (Powell, 1998).

Roblar Road and vicinity. In this area a small section of approximately five meters of tan to gray, coarse to fine grained sandstone is described. This area has been extensively collected over the years so we only refer to the literature discussed previously; no new collections were made during this study.

Travis (1952) reports a small fauna of four taxa from this area. This includes the bivalve mollusks *Cryptomya californica* Conrad and an indeterminate *Macoma*, a questionably identified

Table 12. Stratigraphic ranges of extinct taxa reported from outcrops at River Road, Sonoma County.

Taxa/Age	late Miocene	early Pliocene	late Pliocene	early Pleistocene
<b>Mollusca</b>				
<b>Bivalvia</b>				
<i>Macoma addicotti</i> Nikas	-	-	X	-
<i>Mactromeris albaria</i> (Conrad)	X	X	X	X
<i>Nuttallia jamesii</i> Roth and Naidu	-	-	X	-
<i>Protothaca staleyi</i> (Gabb)	X	X	X	?
<b>Gastropoda</b>				
<i>Lirabuccinum portolaensis</i> (Arnold)	X	X	X	-
<i>Mediargo mediocris</i> (Dall)	X	X	X	-
<i>Nassarius californicus</i> (Conrad)	-	X	X	-
<i>Nassarius grammatus</i> (Dall)	-	X	X	?
<i>Ophiodermella</i> sp., cf. <i>O. graciosa</i> Arnold	-	?	X	?

whale barnacle, and a possible coral. These taxa are not age or environmentally significant. Bedrossian (1974) lists of fauna of 35 taxa (one indeterminate bryozoan, 32 mollusks, and two arthropods) from three sites in this general area of Roblar Road (UCD 271a, UCD 271b, UCD 271c). These specimens are too poorly preserved to allow precise identification. Several of Bedrossian's collections were found at UCD and her fauna is re-identified here (Table 13) to bring the taxonomy up to date and to eliminate names that appear to be in error (some of these name changes are discussed in Appendix 1). The updated faunal list includes one bryozoan, 25 mollusks (16 bivalves, nine gastropods), and two arthropods.

Addicott, in an unpublished report on referred fossils (written communication, 1971; USGS E&R PE-70-12M) from this area, reports the questionable occurrence of *Nassarius californianus* (Conrad), although we have not found any specimens from the Roblar Road area that could not be identified as this species. Specimens examined during this study are internal molds and, while they could be *N. californianus* (Conrad), are not well enough preserved to identify to species, so are here

listed as indeterminate *Nassarius*. If the specimens are referable to *Nassarius californianus* (Conrad), then this would suggest a Pliocene age south of Steinbeck Ranch where the late Miocene Roblar tuff of Sarna-Wojcicki (1992) occurs. But based on the local faulting, low dips in this area, and the adjacent Bloomfield fault, the section at Roblar Road probably lies above the tuff (Plate 2). Unfortunately the specimens examined during this study do not resolve this problem as they cannot be attributed to *N. californianus* (Conrad) with any confidence.

Collections from the Roblar Road area (Table 14) examined during the present study contain a small composite fauna of 21 mollusks (12 bivalves, nine gastropods). Because of poor preservation, these taxa are not age or environmentally significant except to say marine, probably from the continental shelf.

Salmon Creek and vicinity. Perhaps as much as 10 m of medium- to fine-grained, tan sandstone is poorly exposed along Salmon Creek north and south of the Freestone Flat Road bridge along the road from Freestone to Occidental. Fossils are found within 10 intervals in this section, but slumps and overgrown vegetation make an accurate description of the section impossible. The number of taxa collected from each interval is small and not ecologically significant; therefore, the entire stratigraphic interval is treated as a whole.

Dickerson (1922) is the first to mention outcrops of the Wilson Grove Formation at Salmon Creek and around Freestone. He does not report any taxa from this area but mentions a serpentine mass underlying the Wilson Grove Formation here.

The fauna reported here, from collections examined during this study, is poorly preserved and consists of 33 invertebrate taxa, one brachiopod, 31 mollusks (20 bivalves and 11 gastropods), and one arthropod (Table 15). The occurrence of *Mya truncata* Linnaeus suggests cooler water temperatures than exist along the adjacent coast today. *Mya truncata* Linnaeus has a modern range from Hood Canal, Washington, north to the Chukchi Sea, Alaska (Coan and others, 2000). Extant taxa from this area suggest shelfal water depths. Eight extinct taxa are present from this section: the bivalve mollusks *Patinopecten healeyi* (Arnold), *Protothaca staleyi* (Gabb), *Tresus pajaroanus* (Conrad), the gastropods *Aulacofusus? recurva* (Gabb) (questionably identified here), *Crepidula princeps* Conrad, *Nassarius californianus* (Conrad), *Lirabuccinum portolaensis* (Arnold), and *Turcica brevis* Stewart (questionably identified here). *Aulacofusus? recurva* (Gabb) (questionably identified here), *Lirabuccinum portolaensis* (Arnold), and *Turcica brevis* Stewart (questionably identified here), are restricted to the Pliocene, suggesting an early Pliocene age for outcrops at Salmon Creek (see discussion under the individual species in Appendix 1).

South Valley Ford. Scattered outcrops containing a small molluscan fauna are exposed south of the town of Valley Ford on the Valley Ford - Estero Road, just north of the Marin - Sonoma County line, in Sonoma County. Here about 2 to 3 m of yellowish brown, fine-grained, sandstone containing large, rounded, bluish-gray concretions containing fossils are exposed in a road cut on the west side of the road. Similar fossils have also been reported on a small hill just east of the road (CAS425(?), CAS 59826, CAS 59827; USGS M4232), but no section is presently exposed there.

A small fauna of six molluscan taxa, three bivalves and three gastropods, have been collected from this area. These taxa are poorly preserved and the identification of many is questionable, but they suggest normal marine salinities, probably at shelfal water depths. Only one extinct species occurs here, the gastropod *Crepidula princeps* (Conrad). This species is wide ranging in the later Tertiary of California, occurring from the middle Miocene to middle Pleistocene (Powell, 1998), so does not help refine the age of the Wilson Grove Formation at Valley Ford.

Spring Hill. A section of Franciscan Complex greenstone and metagraywackes, overlain by a volcanic flow, and interbedded conglomerate and sandstone beds of the Wilson Grove Formation are exposed on the south side of Spring Hill. Approximately 20 meters of the Wilson Grove Formation is exposed in a creek bottom here and these beds dip slightly (6°) to the northeast. An approximate 1 m-thick coarse conglomerate bed is present at the base of the Wilson Grove section. Interbedded conglomerate and sandstone beds above the basal conglomerate are 25 to 50 cm thick and composed

of calcite and argillaceous cemented, thin- to thickly-bedded, medium- to coarse-grained, subangular sandstone. The conglomerate beds are generally poorly cemented, clast supported, and show rare

Table 13. Annotated faunal list of taxa reported by Bedrossian (1974) from outcrops along Roblar Road, Sonoma County

Taxa/Locality	UCD 271a	UCD 271b	UCD 271c
<b>Bryozoa</b>			
Indeterminate bryozoan remains	X	-	X
<b>Mollusca</b>			
<b>Bivalvia</b>			
<i>Anadara trilineata</i> (Conrad) [as <i>Arca trilineata</i> Conrad]	X	-	-
Cardiidae, indeterminate [as <i>Pseudocardium</i> sp.]	-	X	X
<i>Clinocardium meekianum</i> (Gabb) [as <i>Laevicardium meekianum</i> (Gabb)]	X	-	-
<i>Cryptomya californica</i> (Conrad)	X	X	X
<i>Luciniscia annulatum</i> (Reeve) [as <i>Lucina acutilineata</i> (Conrad)]	-	X	-
<i>Macoma</i> sp. [as <i>M. nasuta</i> (Conrad)]	-	X	X
Mactridae, indeterminate [as <i>Spisula hemphilli</i> (Dall) and <i>Spisula</i> sp.]	-	X	X
<i>Patinopecten?</i> sp. [as <i>P. caurinus</i> (Gabb) and <i>Patinopecten purismansis</i> (Arnold)]	X	-	-
Pectinidae, indeterminate [as <i>Pecten</i> sp.]	X	-	-
<i>Protothaca</i> sp. [as <i>P. staminea</i> (Conrad)]	-	X	X
<i>Siliqua</i> sp. [as <i>S. lucida</i> (Conrad), <i>S. media</i> (Sowerby), and <i>S. patula</i> (Dixon)]	X	X	-
<i>Solen</i> sp. [as <i>S. sicarius</i> Gould]	X	X	X
<i>Tagelus?</i> sp. [as <i>Tagelus californianus</i> (Conrad)]	X	X	X
<i>Tresus pajaroanus</i> (Conrad) [as <i>T. nuttallii</i> (Conrad)]	X	X	-
Veneridae? and Tellinidae?, indeterminate [as <i>Dosinia</i> sp.]	X	X	-
<i>Yoldia</i> sp. [in part as <i>Yoldia cooperi</i> (Gabb)]	X	-	X
<b>Gastropoda</b>			
<i>Calyptraea</i> sp. [as <i>C. mammillaris</i> Broderip]	X	-	-
<i>Crepidula onyx</i> (Sowerby)	X	X	-
<i>Crepidula</i> sp.	-	-	X
<i>Diodora</i> sp., cf. <i>D. aspera</i> (Rathke)	X	-	-
<i>Megasurcula carpenteriana</i> (Gabb)	-	X	-
<i>Mitrella?</i> sp.	X	-	-
<i>Nassarius</i> sp. [as <i>Nassarius californicus</i> (Conrad) and <i>N. grammatus</i> (Dall)]	X	X	-
Naticidae, indeterminate [as <i>Polinices lewisii</i> (Gould) and <i>Polinices reclusianus</i> (Deshayes) and <i>Polinices</i> sp.]	X	X	X
<i>Trophosycon</i> sp.	-	X	-
<b>Arthropoda</b>			
<b>Crustacea</b>			
<i>Balanus?</i> sp.	X	X	X
Indeterminate crab parts	X	-	-

planar to trough cross-stratification. Clasts types include foliated graywacke with muscovite, red chert, green chert, vein quartz, porphyritic volcanics, and minor weathered Tertiary volcanics. The graywacke, red chert, green chert, and vein quartz are derived from the underlying Franciscan

Complex (Allen, 2003). The prophyritic volcanics are felsic with plagioclase phenocrysts and are derived from the Great Valley sequence. The Tertiary volcanics are derived from the underlying Miocene volcanic flow that has been dated by K-Ar by Fox and others (1985) at  $11.76 \pm 0.44$  Ma, giving a maximum age for the basal Wilson Grove Formation in this area. Marine fossils were collected from this area during the present study. Six bivalve mollusks have been identified from the

Table 14. Composite faunal list from outcrops at or near Roblar Road area, Sonoma County (CAS 54138, CAS 55970, CAS 55973, CAS 60472, CAS 60484 – CAS 60487, CAS 60489, UCD A271a, UCD A271b, USGS M4287, USGS M5845; Appendix 2).

**Mollusca**

**Bivalvia**

*Anadara* sp.  
 Cardiidae, indeterminate  
*Cryptomya californica* (Conrad)  
 Lucinidae, indeterminate  
*Macoma* sp.  
 Mactridae, indeterminate  
 Pectinidae, indeterminate  
*Pseudocardium?* sp.  
*Siliqua* sp.  
*Solen* sp.  
*Tagelus?* sp.  
*Yoldia* sp.

**Gastropoda**

*Calyptraea* sp.  
 Columbelloidea, indeterminate  
*Crepidula* sp.  
*Diodora* sp., cf. *D. aspera* (Rathke)  
*Lirabuccinum?* sp.  
*Nassarius* sp.  
 Naticidae, indeterminate  
*Nucella?* sp.  
*Trophosycon* sp.

poorly preserved, internal molds collected: *Clinocardium?* sp., *Cryptomya?* sp., indeterminate Lucinidae, and questionably Mactridae, *Siliqua* sp. and indeterminate Veneridae. These taxa indicate a marine setting, but are so widespread ecologically that they do not allow a more detailed determination. Well preserved sanddollars have also been recently collected from near Spring Hill by Steve Bezore (California Geological Survey) from an interval 5 to 10 m above the base of the formation. These specimens were examined by Rich Mooi (CAS) and questionably identified as *Scutellaster* sp., cf. *S. oregonensis* (Clark), which is restricted to the late Miocene from central California through Oregon (R. Mooi, personal communication, 2002).

Steinbeck Ranch. The section at Steinbeck Ranch is at least 105 m thick with the Roblar tuff of Sarna-Wojcicki (1992) overlying about 100 m of thickly bedded, hummocky-cross stratified, medium- to fine-grained, feldsarenite sandstone (Allen and Holland, 1999; Plate 2). The Roblar tuff of Sarna-Wojcicki (1992) has been dated at approximately 6.25 Ma (Sarna-Wojcicki, oral communication, 2001) and suggests that most, if not the entire Steinbeck Ranch section, is late Miocene in age. Present at the base of the tuff is a 5 to 15 cm-thick angular gravel bed with clasts of red and gray mafic volcanics up to 1 cm in diameter. The tuff bed varies in thickness laterally from one to five meters and contains large pumice lapilli (up to 7 cm), and dish structures locally. The dish structures associated are up to 10-cm in diameter, and are recognized as fine-grained ash

laminations and may represent deposition from a rapid and highly-concentrated flow (i.e., Boggs, 1992). This is overlain by a maximum of 4 m of thick-bedded to, rare hummocky cross-stratified, medium- to fine-grained, sandstone.

Table 15. Composite faunal list from the Wilson Grove Formation around Salmon Creek, Sonoma County (CAS 413, CAS 55976, CAS 60305 - CAS 60312, CAS 60314, CAS 60613, LACMIP 11775, UCMP A869, UCMP B4608, UCMP B8027, USGS M4231; Appendix 2).

**Brachiopoda**

**Articulata**

*Terebratalia* sp.

**Mollusca**

**Bivalvia**

*Chlamys hastata* (Sowerby)

*Chlamys* sp.

*Clinocardium?* sp.

*Compsomyax?* sp.

*Cryptomya californica* (Conrad)

*Macoma* sp., aff. *M. calcarea* (Gmelin)

*Macoma* sp., cf. *M. nasuta* (Conrad)

*Macoma?* sp.

*Mactromeris* sp., cf. *M. albaria* (Conrad)

*Mya truncata* Linnaeus

*Panope abrupta* (Conrad)

*Patinopecten healeyi* (Arnold)

Pectinidae, indeterminate

*Protothaca staleyi* (Gabb)

*Saxidomus nuttalli* Conrad

*Solen* sp.

*Tresus pajaroanus* (Conrad)

Veneridae, indeterminate

*Yoldia* sp.

Indeterminate bivalves

**Gastropod**

*Aulacofusus? recurva* (Gabb)?

*Calyptraea* sp.

*Crepidula princeps* (Conrad)

*Fusinus* sp.

*Lirabuccinum portolaensis* (Arnold)

*Nassarius californianus* (Conrad)

Naticidae, indeterminate

Neogastropoda, indeterminate

*Nucella* sp.

Trochidae, indeterminate

*Turcica brevis* Stewart?

**Arthropoda**

**Crustacea**

*Balanus?* sp.

Fossil beds crop out both above and below the tuff and are up to 45 cm-thick. They are generally well cemented and contain scattered, broken, and disarticulated shell fragments suggesting transport of the shells. Based on the sediments, sedimentary structures, and fossils, we believe this section was deposited at outer shelf to upper slope depths, and that most of the mollusk fossils were transported from shallower depths, probably as storm lag deposits.

The fossil beds from Steinbeck Ranch contain a fauna of 14 mollusks (10 bivalves and four gastropod) (Table 16) and the skull of a primitive balaenopterid whale, which was collected approximately 1 m below the tuff (Figure 9; Allen and others, 1999). *Tresus pajaroanus* (Conrad) (questionably identified here) is the only age restricted species from this area and it has been reported in rocks of Miocene to middle Pleistocene age (Powell, 1998).

Table 16. Composite faunal list from outcrops at or near Steinbeck Ranch, Sonoma County (CAS 55967, CAS 55969, CAS 60472, CAS 60474 – CAS 60479, CAS 60480 - CAS 60482; Appendix 2).

**Mollusca**

**Bivalvia**

Cardiidae, indeterminate

*Cryptomya* sp.

Macluridae, indeterminate

*Patinopecten?* sp.

*Securella?* sp.

*Siliqua* sp.

*Solen* sp.

Tellinidae, indeterminate

*Tresus pajaroanus* (Conrad)?

Veneridae?, indeterminate

**Gastropoda**

*Lirabuccinum?* sp.

*Nassarius* sp.

Neogastropoda, indeterminate

*Olivella* sp.

Tomales Bay. Outcrops of the Merced Formation have been reported from the head of Tomales Bay (Lawson, 1908; Martin, 1914, 1916; Weaver, 1949; Galloway, 1977). These outcrops are the Merced Formation *s.s.* and are not part of the Wilson Grove Formation.

Whittaker Bluff and vicinity. This area includes both sides of the Estero San Antonio centered on Whittaker Bluff and extending up to three kilometers to the east, west, and south. As shown in Plate 2, a section of approximately 360 m is present in the area including Whittaker Bluff and southwest to the base of the formation at an area, of bold outcrops of sandstone, locally known as The Elephants. A fauna of 24 invertebrate taxa including 20 mollusks (13 bivalve, six gastropods, and one scaphopod), at least two arthropods, and at least two echinoids have been collected in this area (Table 17).

At Whittaker Bluff proper, a section of over 20-m of fine-to medium-grained, wavy-parallel to hummocky-cross stratified sandstone with scattered concretionary beds is present. Travis (1952) reports the Pliocene Pectinid *Patinopecten healeyi* Arnold from this general area. These specimens could not be located during the present study, but are probably referable to *Lituyapekten turneri*

(Arnold) which is common in the road cut at Whittaker Bluff. *Lituyapekten turneri* (Arnold) is well known from Whittaker Bluff and has been considered Pliocene in age (see Moore, 1984). The work done here suggests the age of this species should be revised and restricted to the late Miocene, since Whittaker Bluff is located stratigraphically well below the late Miocene Roblar tuff of Sarna-Wojcicki (1992) exposed at Steinbeck Ranch. Other extinct taxa from this area are not helpful, ranging from late Miocene to Pliocene in age.

The base of the Wilson Grove Formation is exposed to the west of the Whittaker Bluff (Allen and Holland, 1999; Plates 1, 2, & Figure 10) along the Estero San Antonio. Here the basal Wilson Grove Formation is marked by an undulating, 1 to 5 m-thick, poorly-sorted, clast-supported, angular conglomerate with clasts up to 120 cm in maximum diameter. The basal conglomerate is overlain by

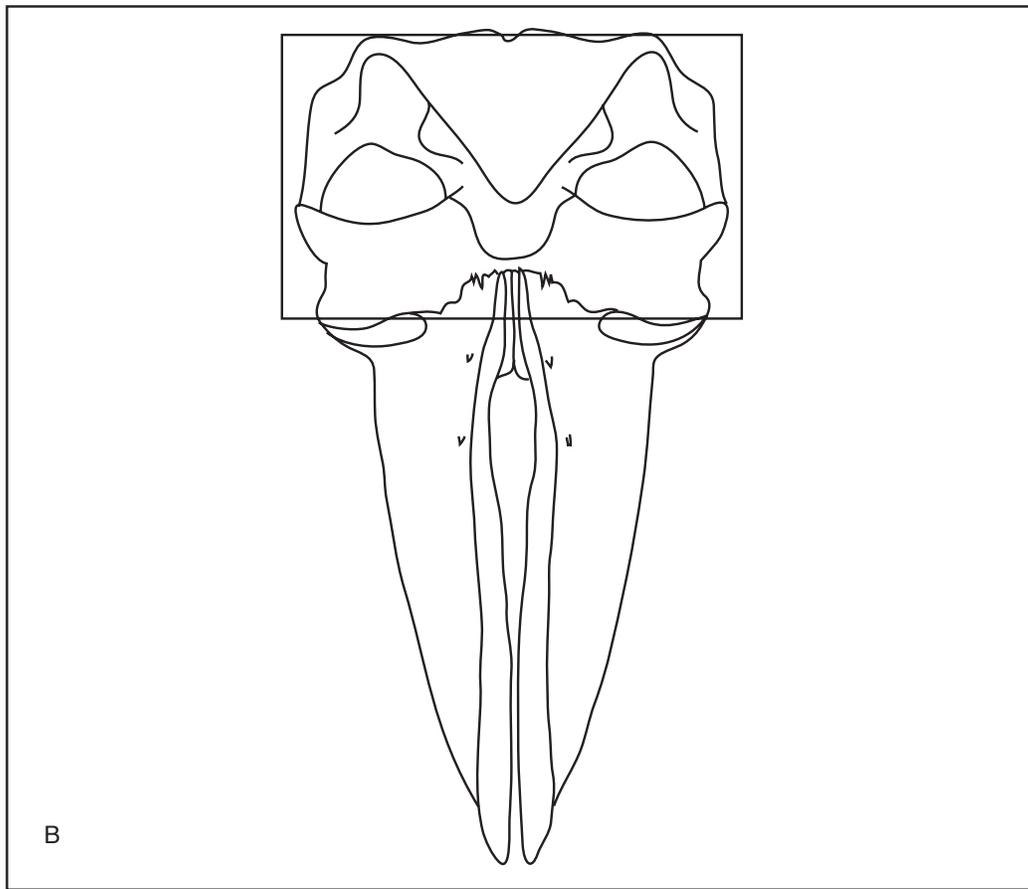
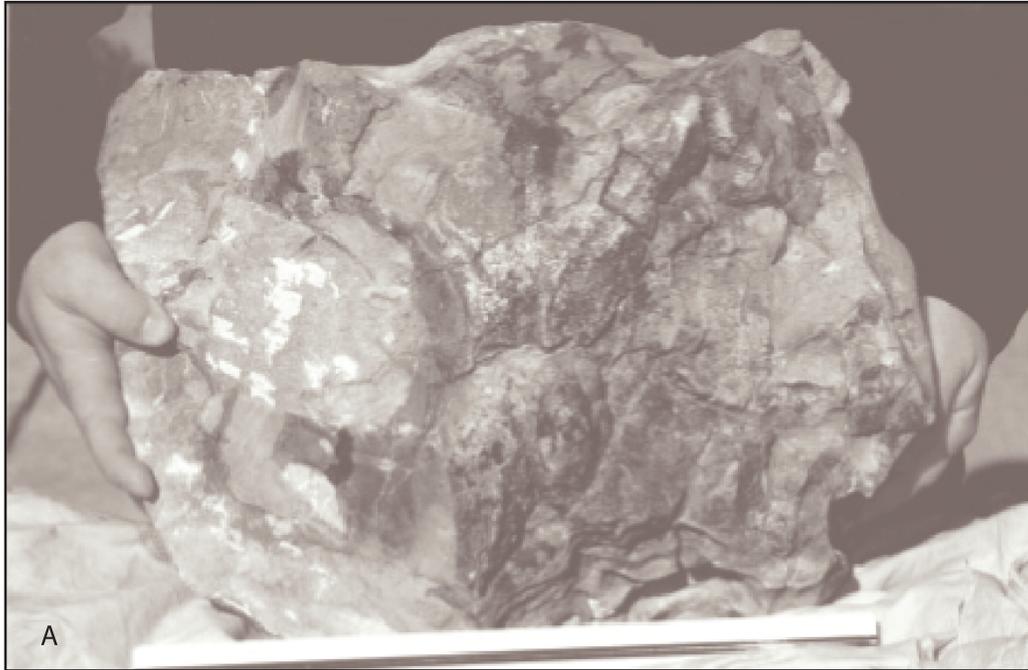


Figure 9. Skull of primitive balanopterid whale from Steinbeck Ranch (Allen and others, 1999). Photograph by J. Allen, 2001. A. Specimen in rock. B. generalized balanopterid whale skull with box showing portion of specimen in 9A.

Table 17. Composite faunal list from outcrops at and near Whittaker Bluff, Sonoma County (Whittaker Bluff proper: CAS 59808-59810, UCMP 10755, UCMP A6886, UCMP A6894, UCMP D3385, USGS M4233; Arroyo San Antonio: CAS 59832, CAS 60226, UCMP 10756, UCMP 10757; The Elephants: UCMP B4299, field observations; Middle Road: LACMIP 11774, UCMP 10754, UCMP 10758; Appendix 2). fo = field observation.

Taxa/Location	Whittaker Bluff	Arroyo San Antonio	The Elephants	Middle Road
<b>Mollusca</b>				
<b>Bivalvia</b>				
<i>Acila?</i> sp.	X	-	-	-
<i>Clinocardium</i> sp.	-	-	-	X
<i>Lituyapecten turneri</i> (Arnold)	X	-	cf.	cf.
Mactridae, indeterminate	-	X	-	X
<i>Modiolus</i> sp.	-	X	-	-
Mytilidae?, indeterminate	X	X	-	-
<i>Panomya</i> sp.	-	X	-	-
<i>Patinopecten?</i> sp.	?	X	fo	X
Pectinidae, indeterminate	-	X	-	X
<i>Solen</i> sp.	-	X	-	-
<i>Teredo</i> sp.	X	-	-	-
<i>Tresus</i> sp., cf. <i>T. pajaroanus</i> (Conrad)	X	X	-	-
Indeterminate bivalve	X	X	-	-
<b>Gastropoda</b>				
<i>Crepidula princeps</i> (Conrad)	X	-	-	-
<i>Fusitriton?</i> sp.	-	X	-	-
<i>Lirabuccinum?</i> sp.	X	-	-	-
<i>Nassarius?</i> sp.	X	-	-	X
Naticidae, indeterminate	X	-	-	-
Neogastropoda, indeterminate	X	X	-	-
<b>Scaphopoda</b>				
<i>Dentalium?</i> sp.	X	-	-	-
<b>Arthropoda</b>				
<b>Crustacea</b>				
Indeterminate crab parts (two taxa)	-	X	-	-
<b>Echinodermata</b>				
<b>Echinoidea</b>				
<i>Brisaster?</i> sp. (locality uncertain)	-	-	-	-
Indeterminate echinoid	-	X	-	-

a fining-upward sandstone sequence. Clasts from the basal conglomerate are Franciscan Complex-derived, but the basal conglomerate does not appear to be present everywhere at the contact. The Franciscan Complex below the basal contact consists of interbedded shale and graywacke.

South of Whittaker Bluff the coarse-grained sandstone previously described as The Elephants was first examined by Travis (1952). Here the Wilson Grove Formation consists of planar stratified, channelized, gray, coarse sandstone with scattered poorly preserved indeterminate Pectinids and Cetacean(?) bone fragments, some as large as one meter. Thickness of these channels changes laterally from a few meters to approximately 20 meters thick. The base of the Wilson Grove Formation is also exposed in this area, but good outcrops are lacking and the distance between the channels and the base of the Wilson Grove Formation is greater than 10 m. Distance from the base of the channel to the underlying Franciscan Complex depends on how deep the individual channel cut. These channels have been correlated with the Delgada Fan off northern California by Allen and Holland (1999) based on the Roblar tuff of Sarna-Wojcicki (1992) in both areas, and to the southeast in the East Bay (Issacson, 1990). The thick- to hummocky-cross-stratified sandstone and coarse-grained channels are inferred to have been deposited in a fan system on the continental shelf (Allen, 2003).



Figure 10. Basal conglomerate exposed west of Whittaker Bluff on the north side of the Estero San Antonio. Rock hammer for scale. Photograph by J. Allen, 2002.

Wilson Grove. No measured section of the Wilson Grove Formation at Wilson Grove is present in the literature. One of us (JA) measured a section consisting of about 3.5 m of thick-bedded, tan to light brown, medium-grained, fossiliferous sandstone on the west side of a small hill on the west side of Eastside Road across from Wilson Grove (Figure 11). On the east side of the same hills, small fossiliferous outcrops are exposed in road cuts and much of the fauna referred to Wilson Grove was collected here. These outcrops consist of perhaps 3-4 m of tan to yellowish tan, iron stained, massive to thickly bedded medium- to fine-grained sandstone with rare pebbles. Casts and molds of fossil mollusks along with some original shell material are preserved in scattered beds within this section. South of this hill a stratigraphic section of sandstone, sandy conglomeratic beds, and the Roblar tuff of Sarna-Wojcicki (1992) is intermittently exposed in road cuts and stream

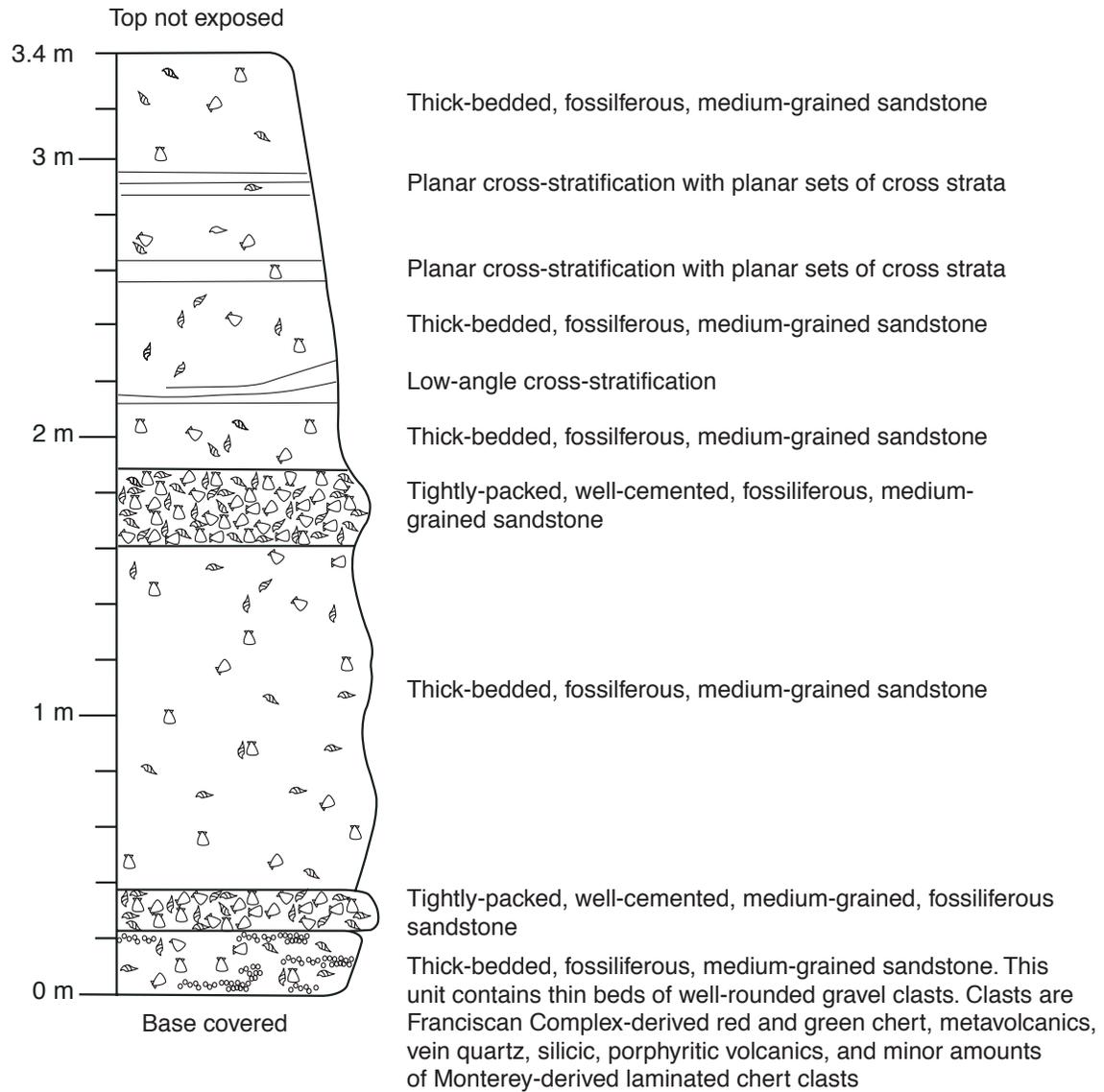


Figure 11. Measured section of the uppermost Wilson Grove Formation on the west side of the hill on west side of Eastside Road at Wilson Grove, Sonoma County, California. Shell in section (clams and snails) represent the occurrence of fossils; small circles represent clasts. Measured by J. Allen, 2003. □

gullies. Bedding attitudes taken in this section strike pervasively to the northwest with a north dip (Plate 1).

From these observations a section about 390 m (1,280 ft.) was graphically determined in cross section (Plate 2, cross section G-G). This is the only section that shows the Roblar tuff of Sarna-Wojcicki (1992) stratigraphically below the Pliocene outcrops of the type Wilson Grove Formation. Elsewhere in the area the Roblar tuff of Sarna-Wojcicki (1992) outcrops are in fault contact with the younger beds of the Wilson Grove Formation (i.e., River Road).

Osmons (1905) appears to have made the earliest record of marine beds at Wilson Grove. He stated that the beds are made up of soft, friable yellow sandstone and fine volcanic conglomerates of a thickness probably exceeding 2,000 feet, and carrying typical Merced fossils.

His thickness is significantly greater than we show (Plate 2), but may include rocks now attributed to the Glen Ellen Formation. The Glen Ellen Formation consists of continental beds that overlie and interfinger with the Wilson Grove Formation to the east. The beds north of Mark West Creek and east of the Wilson Grove Formation at Wilson Grove have been referred to the Glen Ellen Formation (Blake and others, 1974).

Dickerson (1922) refers to the marine beds at Wilson Ranch (= Wilson Grove) and lists a fauna of 21 molluscan taxa (11 bivalves and 10 gastropods) here revised to 20 molluscan taxa (10 bivalves and 10 gastropods) (Table 18). Weaver (1949) lists 35 taxa (23 bivalves and 12 gastropods) from Wilson Grove, but unfortunately these specimens could not be located during the present study. In Table 19 we revise Weaver's taxa to 28 species (18 bivalves and 10 gastropods). Of these taxa only the bivalves *Corbicula* sp., and *Tellina bodegensis* (Hinds) have not been recognized in other collections from the same area. Therefore these two taxa are not included in the list of taxa from Wilson Grove until such time as Weaver's specimens can be examined.

Table 18. Annotated fauna list from the Wilson Grove Formation at Wilson Grove reported by Dickerson (1922) (CAS 545A, CAS 546).

### **Mollusca**

#### **Bivalvia**

*Anadara trilineata* (Conrad) [as *Arca trilineata* Conrad]  
*Clinocardium?* sp. [as *Cardium* sp.]  
*Cryptomya californica* Conrad [as *C. ovalis* Conrad]  
*Glycymeris* sp., cf. *G. grewingki* Dall [as *G. gabbi* Dall]  
*Macoma addicotti* Nikas [? as *M. eduntula*(?) Broderip & Sowerby]  
*Mactromeris* sp., cf. *M. polynyma* (Stimpson) [? as *Spisula* cf. *falcata* (Gould), *Spisula voyi* Gabb and *S. cf. voyi* Gabb]  
*Mactromeris albaria* Conrad [as *Spisula albaria* Conrad]  
Mactridae, indeterminate [as *Spisula*(?) sp.]  
*Protothaca staleyi* (Gabb) [as *Paphia staleyi* Gabb]  
*Solen sicarius* Conrad

#### **Gastropoda**

*Crepidula princeps* (Conrad) [? as *C. adunca* Sowerby]  
*Cryptonatica affinis* Broderip [as *Natica consors* Dall]  
*Mediargo mediocris* (Dall) [as *Trophon*(?) sp.]  
*Megasurcula carpenteriana* (Gabb)  
*Megasurcula remondii* (Gabb) [as *Bathytoma carpenteriana fernandoana* Arnold]  
*Nassarius californicus* (Conrad) [as *Nassa californiana* Conrad]  
*Nassarius grammatus* (Dall) [as *Nassa moraniana* Martyn]  
*Nucella transcoana* Arnold [? as *Thais papillus* (Linnaeus)]  
*Olivella biplicata* (Sowerby)  
*Ophiodermella mercedensis* (Martyn) [as *Drilla mercedensis* Martyn]

A composite fauna of 41 molluscan taxa are in collections from Wilson Grove; 20 bivalves and 21 gastropods (Table 20). These taxa suggest normal marine salinity at shallow, shelfal water depths and all extant taxa live along the adjacent coast today. Eleven extinct taxa are known from collections at Wilson Grove (Table 21), five are questionable. Together they suggest a Pliocene, probably late Pliocene, age for this area. The late Pliocene age is supported by the occurrences of the bivalve *Macoma addicotti* Nikas and the gastropods *Littorina petricola* Dall, and *Nucella transcoana* (Arnold). Unfortunately the precise age ranges of these taxa are not well documented and they are all represented by few individuals. Therefore the age of the outcrops at Wilson Grove are only questionably referred to the late Pliocene.

Osmont (1905) suggests that the Wilson Grove beds correlate with the Purisima Formation at Capitola, California, based on the abundant specimens of *Anadara trilineata* (Conrad) at both

Table 19. Annotated faunal list from the Wilson Grove Formation at Wilson Grove by reported Weaver (1949).

**Mollusca**

**Bivalvia**

*Anadara trilineata* (Conrad) [also as *Anadara trilineata* (Conrad) var. *canalis* Conrad and ? as *Cunearaca* n. sp.]  
*Clinocardium meekianum* (Gabb) [as *Cerastoderma meekianum* (Gabb)]  
*Clinocardium nuttallii* Conrad [as *Cerastoderma corbis* (Martyn)]  
*Compsomyax subdiaphana* (Carpenter) [as *Venerella (Compsomyax) subdiaphana* (Conrad)]  
*Corbicula* sp.  
*Cryptomya californica* Conrad  
*Glycymeris grewingki* Dall [? as *G. gabbi* Dall]  
*M. addicotti* Nikas and (or) *Macoma nasuta* (Conrad) [? as *Macoma brota* Dall and *Macoma inquinata* (Deshayes)]  
*Mactromeris albaria* (Conrad) [as *Spisula albaria* (Conrad), ? as *Spisula albaria* (Conrad) var. *coosensis* Howe]  
*Macromeris* sp., cf. *S. polynyma* (Stimpson) [? as *Spisula voyi* (Gabb)]  
*Mytilus* sp.  
*Pandora punctata* Conrad  
*Protothaca staleyii* (Gabb) [as *Venerupis staleyii* (Gabb)]  
*Siliqua patula* (Dixon)  
*Solen sicarius* (Gould) [as *Solena sicarius* (Gould)]  
*Tagelus californianus* (Conrad)  
*Tellina bodegensis* (Hinds)  
*Tresus pajaroanus* (Conrad) [as *Schizothaerus pajaroensis* (Conrad)]

**Gastropoda**

*Astyris* sp  
*Crepidula princeps* Conrad [? as *Crepidula adunca* Sowerby, *Crepidula onyx* Sowerby, and *Crepidula* sp.]  
*Cryptonatica affinis* Broderip [as *Natica (Tectonatica) clausa* Broderip and Sowerby]  
*Megasurcula remondii* (Gabb)  
*Nassarius californianus* (Conrad)  
*Nassarius grammatus* (Dall) [as *N. moranianus* (Martyn)]  
*Nucella transcoana* Arnold [? as *Thais imperialis* (Dall)]  
*Odostomia* sp.

**Gastropoda (continued)**

*Olivella biplicata* (Sowerby)  
*Ophiodermella* sp., cf. *O. graciosa* (Arnold) [as *Moniliopsis graciosa* (Arnold) var. *mercedensis* (Martyn)]

locations. However, *Anadara trilineata* (Conrad) is common in many late Miocene to late Pliocene deposits so his correlation does not necessarily hold true. But the questionable late Pliocene age suggested by the fauna at Wilson Grove, supports a correlation between Capitola and Wilson Grove, as well as from the River Road locality (this study).

Other miscellaneous outcrops. Other fossil occurrences in the Wilson Grove Formation are scattered around Sonoma County and are illustrated on Plate 1. These localities include: CAS 425, CAS 31273, CAS 55978, CAS 55981, CAS 55982, CAS 59826, CAS 59827, CAS 60461-60464, CAS 60467-60471, LACM 11777, UCMP 6892, UCMP 7052, UCMP 60466, UCMP A870, UCMP A873, UCMP A4189, UCMP A6895, UCMP B2762, UCMP D5919, USGS M4232, USGS E-14, USGS JA-C, USGS JA072901A, USGS JA100501A, USGS P-4. Fossils from these localities are 1) generally poorly preserved; 2) few taxa are present; and/or 3) do not add any significant data to our understanding of the age and (or) paleoenvironment of the Wilson Grove Formation, so are excluded from further discussion, but are presented in Appendix 2.

Table 20. Composite faunal list from outcrops at or near Wilson Grove, Sonoma County (CAS 545, CAS 546, CAS 54166, CAS 54680, CAS 58002, CAS 60783, LACM 4509, LACM 15341, UCMP 7033, UCMP A863, UCMP A864, UCMP A865, UCMP D3235(?), UCMP 3236, UCMP 3237, UCMP 3238, USGS M4230; see Appendix 2)

**Mollusca**

**Bivalvia**

*Anadara trilineata* (Conrad)  
 Cardiidae, indeterminate  
*Clinocardium* sp., cf. *C. meekianum* (Gabb) s.l.  
*Cryptomya californica* (Conrad)  
*Glycymeris* sp., cf. *G. grewingki* Dall  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Macoma nasuta* (Conrad)  
 Mactridae, indeterminate  
*Mactromeris albaria* (Conrad)  
*Mactromeris* sp., cf. *M. polynyma* (Stimpson)  
*Modiolus* sp.  
 Ostreidae, indeterminate  
*Pandora* sp.  
*Protothaca staley* (Gabb)  
*Protothaca* sp.  
*Siliqua lucida* Conrad  
*Solen* sp., cf. *S. sicarius* Gould  
*Tresus* sp., cf. *T. nuttallii* (Conrad)  
*Tresus pajaroanus* (Conrad)?  
 Veneridae, indeterminate

**Gastropoda**

*Astyris gausapata* (Gould)  
*Calicantharus?* sp.  
*Crepidula* sp., cf. *C. onyx* Sowerby  
*Crepidula princeps* Conrad  
*Cryptonatica affinis* (Gmelin)  
*Fusitriton* sp., cf. *F. oregonensis* (Redfield)  
*Littorina petricola* Dall  
*Megascurcula* sp., cf. *M. carpenteriana* (Gabb)  
*Megascurcula remondi* (Gabb)  
*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
*Nucella* sp., cf. *N. emarginata* (Deshayes)  
*Nassarius* sp.  
*Natica janthostoma* Deshayes  
 Naticidae, indeterminate  
*Neverita reclusiana* (Deshayes)  
*Neptunea tabulata* (Baird)?  
*Nucella transcoana* Arnold  
*Olivella biplicata* (Sowerby)  
*Ophiodermella* sp., cf. *O. graciosana* Arnold  
 Turridae, indeterminate

**Age**

The age of the Wilson Grove Formation differs in different parts of the study area, ranging from late Miocene to late Pliocene. The oldest age determinations are from the lower part of the formation at Spring Hill, whereas the youngest ages occur in the northeast at Wilson Grove. The section around the Estero San Antonio is stratigraphically well below the Roblar tuff of Sarna-Wojcicki (1992) at

Steinbeck Ranch and certainly older, but we have not been able to date these rocks or fossils. In general, we infer that older rocks are present to the southwest and younger rocks to the northeast.

Table 21. Stratigraphic ranges of extinct taxa reported from outcrops of the Wilson Grove Formation at Wilson Grove, Sonoma County, California.

Taxa/Age	late Miocene	early Pliocene	late Pliocene	early Pleistocene
<b>Mollusca</b>				
<b>Bivalvia</b>				
<i>Anadara trilineata</i> (Conrad)	X	X	X	X
<i>Clinocardium</i> sp., cf. <i>C. meekianum</i> (Gabb) s.l.	-	X	X	-
<i>Macoma addicotti</i> Nikas	-	-	X	-
<i>Mactromeris albaria</i> (Conrad)	X	X	X	X
<i>Protothaca staleyi</i> (Gabb)	X	X	X	?
<i>Tresus pajaroanus</i> (Conrad)	X	X	X	X
<i>Crepidula princeps</i> Conrad	X	X	X	X
<i>Littorina petricola</i> Dall	-	-	X	-
<i>Nassarius californicus</i> (Conrad)	-	X	X	-
<i>Nassarius grammatus</i> (Dall)	-	X	X	?
<i>Nucella transcoana</i> (Arnold)	-	-	X	?
<i>Ophiodermella</i> sp., cf. <i>O. graciosa</i> Arnold	-	?	X	?

The strongest evidence for a late Pliocene age comes from late Pliocene-restricted taxa that occur at River Road and Wilson Grove [i.e., *Macoma addicotti* Nikas, *Littorina petricola* Dall, *Nucella transcoana* Arnold (questionably reported), *Nuttallia jamesii* Roth and Naidu, and *Ophiodermella graciosa* Arnold (questionably reported)], even though these taxa are all rare and their stratigraphic ranges are not well documented (see Appendix 2). This age determination is further supported by the occurrence of *Nuttallia jamesii* Roth and Naidu (described from River Road) from the New Brighton-Seacliff Beach section of the Purisima Formation south of Capitola, Santa Cruz County (CAS collections). The New Brighton-Seacliff section of the Purisima Formation has been dated as late Pliocene by high resolution diatom biostratigraphy and magnetic polarity zonation (Dumont and Madrid, 1987), supported by molluscan biostratigraphy (Addicott and other, 1978; Powell, 1998), suggesting a similar age for the River Road outcrops of the Wilson Grove Formation.

#### Numerical age

The only numerical age determined for the Wilson Grove Formation is from the informal Roblar tuff of Sarna-Wojcicki (1992) which has been dated at about 6.25 Ma. The Roblar tuff of Sarna-Wojcicki (1992) occurs in the middle of the outcrop area of the Wilson Grove Formation around Bloomfield Quarry and Steinbeck Ranch, and in isolated, fault-block near River Road to the north. As discussed above outcrops of the Roblar tuff of Sarna-Wojcicki (1992) near River Road and Wilson Grove are either surrounded by faults (River Road), or a significant stratigraphic section occurs between them and rocks assigned to the late Pliocene (Wilson Grove).

#### Paleontologic age

Specimens of the sand dollar *Scutellaster* sp., cf. *S. oregonensis* (Clark) (identified by R. Mooi, CAS) have recently been collected south of Spring Hill (CP072003A). According to Rich Mooi (oral communication, 2002) this species is restricted to the late Miocene and occurs from central

California north through Oregon. Although questionably identified, this species further supports the late Miocene age for the middle to lower part of the Wilson Grove Formation. Fossils from Whittaker Bluff which, based on stratigraphic position, should be late Miocene in age, are not age diagnostic. Based on work here, *Lituyapecten turneri* (Arnold), formerly considered Pliocene in age, is now considered late Miocene. Unfortunately, fossils from Whittaker Bluff do not help resolve the age of the lower part of the Wilson Grove Formation. Thin sections of sandstone matrix collected from the basal conglomerate along the Estero San Antonio and examined by Ken Finger (written communication, 2001) contain a couple of partial whorls resembling those of the benthic foraminifer *Anomalinoidea salinasensis* Kleinpell (Figure 12). This species ranges in age from early to middle Miocene (Saucian to Mohnian). Unfortunately, the specimens are not well enough preserved to allow a confident early or middle Miocene age call for the base of the Wilson Grove Formation, and there is no supporting data for an early or middle Miocene age. Therefore, the Wilson Grove Formation is reported as no older than late Miocene.

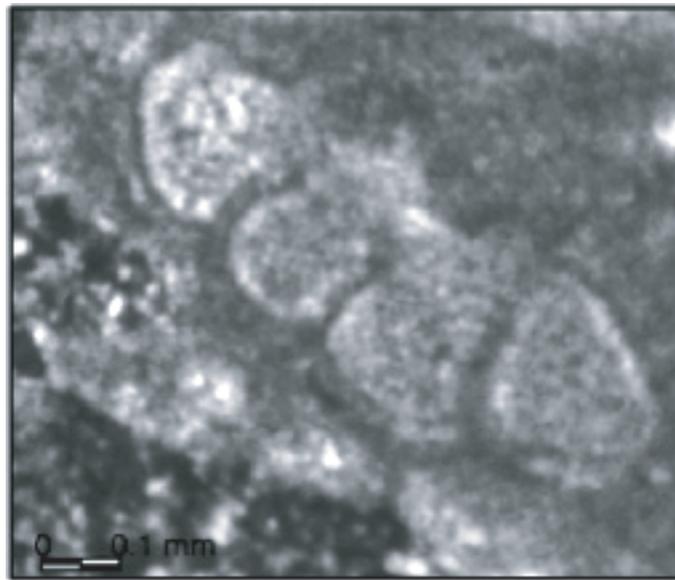


Figure 12. Partial whorl resembling those of the benthic foraminifera *Anomalinoidea salinasensis* Kleinpell (K. Finger, written communication, 2001). Photograph by J. Allen, 1999.

#### Age controls from units associated with the Wilson Grove Formation

Further supporting age data comes from the Petaluma Formation, which is in part the lateral equivalent to the Wilson Grove Formation. Age determinations, and the relationships between the Wilson Grove and Petaluma Formations are outlined in Figure 13.

An understanding of the age control in the Petaluma Formation and associated rocks aid in our understanding of the age of the Wilson Grove Formation. To the southeast at Sears Point, the base of the Petaluma Formation contains an 9.9 to 8.5 Ma Donnell Ranch Volcanics (Youngman, 1989). Near the Stony Point rock quarry thin volcanic flows have been dated by K-Ar between  $6.32 \pm 0.66$  Ma and  $4.26 \pm 0.27$  Ma (Fox and others, 1985). Atop these flows are interbedded conglomerates and sandstone, that contain poorly preserved mollusks molds and casts, referred here to the Wilson Grove Formation. Mid-way between Stony Point and Bloomfield a K/Ar date from a

basalt in the Andesite of Rodgers Creek, underlying the Wilson Grove Formation, has been dated at  $7.83 \pm 0.29$  Ma (Fox and others, 1985). In addition, the fossil horse *Neohipparion gidleyi* Merriam, which is considered Hemphillian ( $8.41 - 5.03 \pm 0.72$  Ma; J. Alroy, web page, 2002) in the North American mammalian time scale (Repenning, oral communication, 2002), has been collected at the Stony Point Quarry by E. Boudreau (oral communication, 2001).

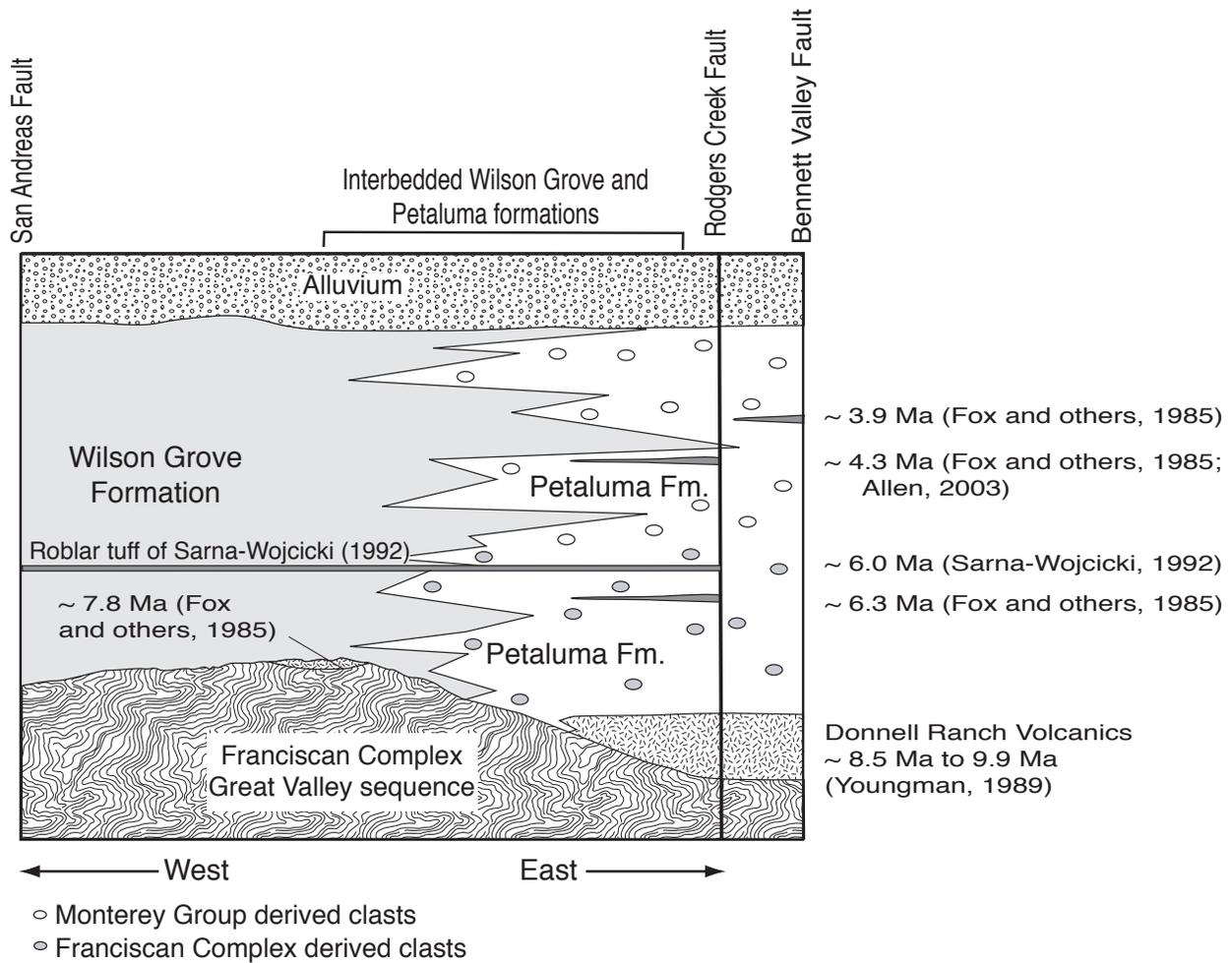


Figure 13. Schematic cross-section showing age determinations and stratigraphic relationship of the Wilson Grove, Cotati, and Petaluma formations in northern Marin and southern Sonoma Counties, California after restoration of about 35 km right-lateral offset on the Petaluma Valley Fault of Graymer and others (2002). Vertical scale reflects time.

## Summary

The Wilson Grove Formation represents a sequence of marine rocks of late Miocene to late Pliocene age. It is composed of friable to well lithified sandstone, siltstone, and conglomerate with exposures extending from the Pacific Ocean on the west to the Bennett Valley on the east, north of Santa Rosa, and south to Petaluma. Structurally, the outcrop area is cut by a series of northwest trending fault of relatively small displacement. Over the outcrop area bedding attitudes are

remarkably consistent, usually between six and 10; to the northeast. A maximum thickness of about 820 m (2,700 ft) has been reported in the literature for the formation, but the actual thickness is probably at least twice that. If vertical displacement along these faults is minimal, and we expect it is, then a section nearly 1,800 m (over 6,000 ft) thick is present in Sonoma County.

The Wilson Grove Formation outcrops are divided into four areas here for the purpose of a general discussion of trends in the formation. These areas are: 1) the northern outcrops around Wilson Grove and River Road, 2) the central outcrops around Steinbeck Ranch, 3) the eastern outcrops around Meacham Hill and Bennett Valley, and 4) the southern outcrops around Whittaker Bluff and the Arroyo del San Antonio.

The northern outcrops (1 above) of the Wilson Grove Formation at Wilson Grove and River Road contain a fauna that is late Pliocene in age, and represents shallow water with water temperatures possibly slightly warmer than along the adjacent coast today. These are the youngest rocks attributed to the Wilson Grove Formation. The late Miocene Roblar tuff of Sarna-Wojcicki (1992), which has been dated at about 6.25 Ma (Sarna-Wojcicki, 1992), outcrops in this area but it is separated from the late Pliocene beds by about 300 m as determined from our cross sections. Unfortunately, direct field observation of the relationship between the Wilson Grove and outcrops of the Roblar tuff of Sarna-Wojcicki (1992) are obscured by younger rocks and lack of outcrops.

In the central part of the outcrop area at Bloomfield Quarry and Steinbeck Ranch (2 above), the Roblar tuff of Sarna-Wojcicki (1992) is exposed near the top of the Wilson Grove Formation, indicating a late Miocene age for most, if not all, of the formation here. Fossils from Steinbeck Ranch are generally poorly preserved and are to broadly ranging to be ecologically or chronologically significant, although the bedded nature of the rocks suggest deposition below wave base. At Bloomfield Quarry an intertidal to shallow subtidal environment is interpreted from the mollusks. Slightly to the northwest around Salmon Creek, fossils of possibly early Pliocene age are found. The Roblar tuff of Sarna-Wojcicki (1992) is also found in this area, but because of structural complications, it is unclear where the early Pliocene age fossils occur in relation to the tuff. We presume the ash underlies the fossils, but outcrops are not adequate to confirm this assumption.

Fossils from marine beds on the eastern margin of the outcrop area at Meacham Hill and Bennett Valley (3 above) interfinger with continental deposits, suggesting a shallow, marginal marine environment. Identified species from the eastern margin are not age diagnostic, although adjacent formations suggest a late Miocene to early Pliocene age (Hemphillian to Blancan land mammal ages) age for these rocks.

The southern part of the outcrop area (4 above) is stratigraphically well below the late Miocene rocks of the Steinbeck Ranch. Fossils in this area are mostly rare and poorly preserved, so no significant age or depth determinations have been made. However, a few new localities have stratification suggesting possibly outer shelf and (or) slope depths.

In general the fossils and rocks from the Wilson Grove Formation show the shallowest water depths to the north and east, and deeper water to the southwest. This is coupled with a late Pliocene age to the northeast and a late Miocene age in the central part of the outcrop area around Steinbeck Ranch and Spring Hill. Presumably, older rocks occur to the southwest around Whittaker Bluff, but fossils in this area do not allow precise age determinations. The Wilson Grove Formation is separate from the contemporary Ohlson Ranch Formation to the north, and Purisima Formation to the south.

Three possible new gastropods (Mollusca) taxa are reported here: *Calyptraea (Trochita)* n. sp. and *Nucella* sp., aff. *N. lamellosa* (Gmelin) from the Bloomfield Quarry area, and *Acanthinucella?* n. sp. from the River Road area. In addition, the age range of the Pectinid *Lituyapecten turneri* (Arnold) is restricted to the late Miocene based on the stratigraphic succession within the Wilson Grove Formation, not Pliocene as reported by earlier authors.

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## Appendix 1. Faunal notes

The taxonomic arrangement of families and higher classifications presented here follows Vaught (1989). All taxa are not discussed, only species deemed ecologically and (or) chronologically significant, or for which some confusion exists. The comments presented are from the literature and from specimens examined during this study. In several cases names applied in the literature are probably incorrect as the taxa cited are outside their known geographic and (or) stratigraphic range, and (or) the ecological ranges of the species are not in keeping with the paleoecologic interpretation of the Wilson Grove Formation. This work attempts to resolve some of these problems, but many are just a best guess until such time as all related specimens can be found and examined, or new specimens come to light.

The following abbreviations are used below:

CAS	California Academy of Sciences, Golden Gate Park, San Francisco, California.
LACM(IP)	Invertebrate Paleontology section, Los Angeles County Museum of Natural History, Los Angeles, California.
SU	Stanford University (now housed at CAS).
UCMP	Museum of Paleontology, University of California, Berkeley, California.

### Phylum Brachiopoda

#### Class Inarticulata

#### Family Discinidae

Powell (2001) first reported the genus *Discinisca* from the Wilson Grove Formation. These specimens are questionably referred to *D. cumingii* Broderip and occur at Broomfield Quarry (Powell, 2001) but additional specimens have been found from Ebabias Creek (CAS 60470). *Discinisca cumingii* Broderip has also been reported or questionably reported from the Merced Formation at Felt Lake (Hertlein and Grant, 1944), the Purisima Formation (Perry, 1993; Powell, 1998), the San Joaquin Formation (Hertlein and Grant, 1944), and the Santa Margarita Formation (Clark, 1981), all in northern California. All these occurrences are late Miocene to late Pliocene in age.

Peck (1960) reports discinid brachiopods from the Ebabias Creek area. These specimens could not be located during the present study, but are probably referable to the same species that occurs at Bloomfield Quarry. Until Peck's (1960) specimens can be located, they are referred to as discinid brachiopods.

#### Class Articulata

#### Family Terebratulidae

Specimens attributed to *Terebratalia transversa* Sowerby have been found at Bloomfield Quarry (CAS 54135). Smooth forms dominate, but some with moderate radial ribs are present in the same fauna. The smaller, wider, coarse-ribbed *Terebratalia transversa caurina* Gould is not present. *Terebratalia transversa* Sowerby has a modern range from Alaska south to Baja California Norte, Mexico, in water depths from intertidal to about 170 m (Hertlein and Grant, 1944). It has also been reported in rocks as old as Miocene in the eastern Pacific (Hertlein and Grant, 1944).

### Phylum Mollusca

#### Class Bivalvia

#### Family Arcidae

An indeterminate *Arca* has been reported from the Ebabias Creek area associated with discinid brachiopods (Peck, 1960), but was not found in the collections from that area. The faunal association of *Arca* sp. and discinid brachiopods is similar to, and possibly the same as, at Bloomfield

Quarry, where *A. sp.*, cf. *A. santamariensis* Reinhart has been recognized in association with *Discinisca sp.*, cf. *D. cumingii* Broderip. The *Arca sp.* reported from Ebabias Creek (Peck, 1960) has not been verified, but if true, its occurrence suggests that these two areas, separated by about 5.5 km, may represent the same stratigraphic interval, as these two taxa are not known elsewhere in the Wilson Grove Formation.

*Arca santamariensis* Reinhart has been previously recognized in the Miocene to Pliocene Capistrano Formation in southern California (Kern and Wicander, 1974), although Groves (1991) refers these collections to the Niguel Formation of late Pliocene age. This species also occurs in the Cebada Member of the Careaga Sandstone in the Santa Maria area of central California (Woodring and Bramblette, 1950). If Groves (1991) is correct about the occurrence of these specimens from the late Pliocene Niguel Formation, then the occurrence here below the Roblar tuff of Sarna-Wojcicki (1992) would mark its oldest occurrence, in the late Miocene.

*Anadara trilineata* (Conrad) is well known from late Miocene to Pleistocene rocks from British Columbia, Canada, to southern California (Moore, 1983). *Arca sulcicosta* Gabb was described from Wilson Grove and along Mark West Creek in Sonoma County, and is synonymous with *A. trilineata* (Hertlein and Grant, 1972; Moore, 1983).

#### Family Mytilidae

*Mytilus coalingensis* (Arnold) is reported here only from the Bloomfield Quarry and occurs in Miocene to Pleistocene age rocks elsewhere in central and southern California (Moore, 1983). Moore's (1983) citation of a Pleistocene age is based on its occurrence in the Fernando Formation (Zinsmeister, 1970) in Orange County, southern California and the Merced Formation in San Mateo County (Martin, 1916; Yancey, 1978). These younger age calls are based on the U.S. Geological Survey's use of broad age ranges for its formal internal publications. For example even though Zinsmeister (1970) restricts his fauna to the late Pliocene, someone else has stated that the Fernando Formation can be as young as Pleistocene, so Moore (1983) had to include the Pleistocene age for this species. Both the Fernando Formation and Merced Formation occurrences of this species are restricted to the Pliocene, by Zinsmeister (1970) and Yancey (1978). Other *Mytilus* from the Wilson Grove Formation are not well enough preserved to determine species.

#### Family Glycymeridae

Dickerson (1922) reports *Glycymeris sp.*, cf. *G. gabbi* Dall from the Wilson Grove Formation. His specimen (CAS 545) are here referred to *Glycymeris sp.*, cf. *G. grewingki* Dall. Travis (1952) reports unidentified *Glycymeris* from the Wilson Grove Formation from the southwest part of the Sebastopol quadrangle, but his specimens could not be located during the present study.

#### Family Pectinidae

Five Pectinids have been reported from the Wilson Grove Formation (Dickerson, 1922; Keen and Bentson, 1944; Johnson, 1934; Peck, 1960; Bedrossian, 1974), *Lituyapecten purisimaensis* (Arnold), *L. turneri* (Arnold), *Patinopecten caurinus* (Gould), *Swiftopecten parmeleei* (Dall), and *Pecten sp.* A sixth and seventh, *Chlamys hastata* (Sowerby) and *Patinopecten healeyi* (Arnold), are recognized during the present study. *Chlamys hastata* (Sowerby) and *S. parmeleei* (Dall) will not be discussed below because their presence in the Wilson Grove Formation is expected in rocks of this age.

*Lituyapecten turneri* (Arnold) is well known from the Whittaker Bluffs outcrops of the Wilson Grove Formation. It has been reported elsewhere from the late Miocene to late Pliocene Purisima Formation (Durham and Morgan, 1978; Powell, 1998), but occurrences are likely from the late Miocene part of the formation. Reports of this species from the Merced Formation (Dickerson, 1922; Keen and Bentson, 1944) are referred to the Wilson Grove Formation and most likely to outcrops at Whittaker Bluff, Sonoma County. Here we consider outcrops of the Wilson Grove Formation containing *Lituyapecten turneri* (Arnold) late Miocene in age and we suggest that the age range of this species should be restricted to the late Miocene.

*Patinopecten caurinus* (Gould) has been questionably reported from the Wilson Grove Formation by Peck (1960) and Bedrossian (1974). It has also been reported from the Purisima Formation (Ashley, 1895; Arnold, 1906; Moore, 1984) on the San Francisco Peninsula, but is now thought not to be present in that formation (Powell, 1998). No specimens of *P. caurinus* (Gould) from the Wilson Grove Formation were observed during the present study, although one specimen is in a collection from northwest of Healdsburg (CAS 34401). This specimen was collected well north of the known outcrops of the Wilson Grove Formation and may come from an outlying outcrop of the Ohlson Ranch Formation where *P. caurinus* (Gould) is known to occur (Peck, 1960). Likewise, *Lituyapecten purisimaensis* (Arnold) has been reported from the Wilson Grove Formation but has not been found in collections during the present study. Therefore, its occurrence in the Wilson Grove Formation, like *P. caurinus* (Gould), is questioned until specimens are found.

One *Patinopecten* from Salmon Creek has been identified by Warren Addicott (USGS) and confirmed by one of us (CP) as *Patinopecten healeyi* (Arnold). This is the only confirmed record of this species from the Wilson Grove Formation. Moore (1984) cites the age range of this species as late Miocene to early Pleistocene.

Bedrossian (1974) reports the genus *Pecten* from the Wilson Grove Formation. Examination of specimens collected by her and labeled *Pecten* sp. at UCD are referable to indeterminate Pectinidae.

#### Family Cardiidae

Two species of *Clinocardium* have been reported from the Wilson Grove Formation (Johnson, 1934; Osmont, 1905; Weaver, 1949). Species in the genus *Clinocardium* are difficult to distinguish from one another without well preserved material, which is generally lacking in the Wilson Grove Formation. Osmont (1905) and Weaver (1949) report *C. nuttallii* (Conrad) from the Wilson Grove Formation, but it has not been recognized from the collections studied here. While it is entirely possible that *C. nuttallii* (Conrad) has been recovered in the Wilson Grove Formation, the species is not included on the faunal list for the formation until reliably identified specimens can be found. *Clinocardium meekianum* (Gabb) has also been reported from the Wilson Grove Formation (Johnson, 1934; Weaver, 1949) and has been found in collections examined during this study. It is an extinct species reported from the Pliocene of southern Oregon and northern to central California (Grant and Gale, 1931; Roth, 1979; Powell, 1998).

Bedrossian (1974) cites *Pseudocardium* sp. from the Roblar Road area and its identification is questionably confirmed here from examination of collections at UCD.

#### Family Tellinidae

Four species of *Macoma* have been reported from the Wilson Grove Formation: *M. brota* Dall [also as *M. eduntula*(?) Broderip & Sowerby], *M. inquinata* (Deshayes), and *M. nasuta* (Conrad). In addition, indeterminate *Macoma* specimens have also been reported. *Macoma brota* Dall and *M. inquinata* (Deshayes) are not included in the fauna from the Wilson Grove Formation because they were not recognized during the present study.

Specimens of *Macoma addicotti* Nikas occur at the River Road and Wilson Grove localities. The occurrence of *M. addicotti* Nikas at these two sites suggests a correlation and a similar age for the River Road and Wilson Grove outcrops. In addition, both *Macoma addicotti* Nikas and *Nuttallia jamesii* Roth and Naidu (discussed below) co-occur at the Capitola-New Brighton-Sea Cliff section of the Purisima Formation south of Capitola, Santa Cruz County (Perry, 1993; Powell, 1998) and at the River Road locality, suggesting an age correlation between these two sites. *Macoma addicotti* Nikas also has been collected from the Merced Formation at Felt Lake, San Mateo County (Nikas, 1977). Outcrops outside of Sonoma County containing this *M. addicotti* Nikas have been referred to the late Pliocene (Addicott, 1969; Perry, 1993; Powell, 1998), complementing the late Pliocene age suggested here for the northern outcrops of the Wilson Grove Formation.

Weaver (1949) reported *Tellina bodegensis* Hinds from the Wilson Grove Formation. No specimens of this species were recognized during the present study. While its fossil record includes the age and geographic area covered by the Wilson Grove Formation, it is not included here until specimens can be located and examined.

#### Family Psammobiidae

*Nuttallia jamesii* Roth and Naidu was described from the River Road outcrops of the Wilson Grove Formation (Roth and Naidu, 1974). As discussed above under *Macoma addicotti* Nikas, it is also known from the Capitola-New Brighton-Sea Cliff section of the Purisima Formation south of Capitola, Santa Cruz County (Perry, 1993; Powell, 1998). Both these occurrences appear to be restricted to the late Pliocene.

#### Family Veneridae

Johnson (1934) reports *Securella securis* (Shumard) from the Wilson Grove Formation. Examination of collections at UCB show Johnson's (1934) specimens are probably from UCB 870, and should be referred to indeterminate *Securella*? Other specimens referred to indeterminate *Securella*? sp. have been collected at Bloomfield Quarry, River Road, and Steinbeck Ranch.

The genera *Chione* and *Securella* are very similar and easily confused. *Chione* is predominately a tropical genus, while *Securella* a predominately temperate to cool water taxon (Parker, 1949). The distinguishing features between the two genera are internal to the shells (Parker, 1949) and specimens from the Wilson Grove Formation are not well enough preserved to show these features. Therefore, they are questionably referred to the genus *Securella* based on the temperate water temperatures suggested by the associated fauna.

*Protothaca staleyi* (Gabb) is an extinct species ranging in age from late Miocene to late Pliocene, or possibly early Pleistocene, and geographically from Coos Bay, Oregon, south to the Santa Maria District in central California (Addicott and others, 1978; Powell, 1998; Woodring and Bramlette, 1950). It was described as *Dosinia staleyi* Gabb from the Pliocene on Mark West Creek, a branch of Russian River (Gabb, 1869). This location is here referred to the Wilson Grove area.

Travis (1952) reports *Katherinella angusifrons* (Conrad) [as *Marcia angustifrons* (Conrad)] as common in [the] southwestern part of [the Healdsburg] quadrangle. No specimens attributed to this species have been recognized during the present study and Travis (1952) specimens could not be located. Also, preservation in the southern and western outcrops of the Wilson Grove Formation is commonly poor. Therefore, Travis (1952) report of *Katherinella angusifrons* (Conrad) are here attributed questionably to indeterminate Veneridae until such time as his specimens can be examined.

#### Family Mactridae

The family Mactridae has nine taxa reported from the Wilson Grove Formation: *Macromeris albaria* (Conrad), *Macromeris albaria* v. *coosensis* (Howe), *Macromeris polynyma* (Stimpson) [as *Spisula polynyma* (Stimpson) and *Spisula voyi* (Gabb)], questionably *Mactromeris brevirostrata* (Packard), *Mactromeris hemphilli* (Dall), *Mactrotoma nasuta* (Gould), *Simomactra falcata* (Gould), and indeterminate *Spisula* sp. Mactridae are very difficult to identify without well-preserved material, and well-preserved material is generally lacking from the Wilson Grove Formation. During the present study only *M. albaria* (Conrad), *M. polynyma* (Stimpson), and indeterminate Mactrids (probably = *Spisula* sp., above) are recognized from the Wilson Grove Formation. *M. albaria* v. *coosensis* (Howe) was described from the Pliocene Empire Formation in Oregon and is known from the Purisima Formation (Roth, 1979; Perry, 1988) and Merced Formation (Weaver, 1949; Yancey, 1978; Roth, 1979) in central California. Its occurrence is likely in the Wilson Grove Formation, but it was not recognized during the present study because preservation of the Wilson Grove fauna is not adequate. The same holds true for *M. brevirostrata* (Packard), which is known from the Pliocene to Pleistocene "Merced" Formation (Roth, 1979), Rio Dell Formation (Faustman, 1964), and the Wildcat Group (Packard, 1916), all in northern California. In the modern eastern Pacific, *M. nasuta* (Gould) does not occur north of Santa Barbara, southern California. Therefore its occurrence in the Wilson Grove Formation is doubtful as it would not be in keeping with the paleo-temperatures suggested by other taxa for the formation. Similarly, *M. hemphilli* (Dall) does not occur as far north as the San Francisco Bay area and, therefore, its occurrence is also doubtful in the Wilson Grove Formation. The modern occurrence of *S. falcata*

(Gould) includes northern California so the occurrence of this species from the Wilson Grove Formation is possible, but specimens attributed to this species were not found during the present study, possibly because of poor preservation. Therefore, *S. falcata* (Gould) is not included in the fauna from the Wilson Grove Formation until such time as specimens referable to this species are found.

*Tresus pajaroanus* (Conrad) has been reported from the Miocene to middle Pleistocene (Powell, 1998).

#### Family Pandoridae

Weaver (1949) reports *Pandora punctata* Conrad from the Wilson Grove area. Specimens attributed to *Pandora* are present in several collections from Wilson Grove, but none of the material is well enough preserved to identify to species. Therefore, *P. punctata* Conrad is not included in the fauna from the Wilson Grove Formation until distinct specimens can be found.

### Class Gastropoda

#### Family Fissurellidae

Bedrossian (1974) illustrates *Diodora aspera* (Rathke) from the Wilson Grove Formation near Roblar Road. Although additional specimens could not be located during the present study, Bedrossian's specimen was located at UCD and is questionably referred to this species.

#### Family Trochidae

A single specimen questionably identified as *Turcica brevis* Stewart by Warren Addicott is in the USGS collections from Salmon Creek (USGS M4231). This species was described from the *Acila* and *Pecten* zones of the San Joaquin Formation in the Kettleman Hills (Woodring and others, 1946). Woodring and Bramlette (1950) later reported it from the Cebada Member of the Carega Sandstone, probably from the Foxen Mudstone, and the San Diego Formation. These occurrences suggest a Pliocene age for this species.

#### Family Turbiniidae

Dickerson (1922) reported the genus *Astralium* from Salmon Creek. Woodring (1928) pointed out that the genus *Astralium* should be used for West Indian *Astraeas* which have a narrow umbilicus or are entirely imperforate (Grant and Gale, 1931). Therefore, its use in California is probably incorrect. Dickerson's (1922) specimens are here assigned to indeterminate Trochidae (Appendix 2, CAS 413).

#### Family Littorinidae

*Littorina petricola* Dall is reported from the Pliocene of central California by Addicott (1969) and questionably by Woodring and Bramlette (1950). Specimens from the Wilson Grove Formation at Wilson Grove match well with specimens illustrated by Dall (1909) and Addicott (1969) and are attributed to that species. All occurrences of this species are from the Pliocene (Dall, 1909; Arnold and Hannibal, 1913; Howe, 1922; Woodring and Bramlette, 1950; Addicott, 1969).

#### Family Calyptraidae

Smooth Tertiary *Calyptraea* from California are poorly defined, commonly poorly preserved, and difficult to identify. *Calyptraea inornata* Gabb has been reported from the Wilson Grove Formation by Dickerson (1922), and *C. mamillaris* Broderip has been reported by Bedrossian (1974). *Calyptraea fastigiata* Gould and *C. filosa* (Gabb) are also names applied to smooth Neogene *Calyptraea* occurring in central California. Distinguishing characteristics, if any, between these taxa and their range of variability is not known and is beyond the scope of this study. Therefore, smooth specimens of *Calyptraea* from the Wilson Grove Formation lacking radial sculpture are all referred to *C. sp. indeterminate*.

Specimens of a *Calyptraea* with well developed oblique spiral ribs are present from Bloomfield Quarry and probably represents a new species. The best preserved example is a latex mold from CAS 54135. The following description is from this mold, supplemented by many internal molds from the same collection. This new species is wider than long, with an offset apex towards the apertural margin. It has two to three rapidly expanding whorls with well developed oblique spiral ribs similar to that of the modern *Calyptraea (Trochita) trochiformis* (Born) and *C. (T.) spirata* (Forbes) from tropical western America. At a maximum diameter of about 49 mm, this new species only has two or three body whorls, compared to three plus in slightly smaller specimens of the modern species (CAS collections). The spire is lower than similar-sized specimens of the modern eastern Pacific *Calyptraea (Trochita)*. Tertiary fossil taxa from California have previously been assigned to the modern species above, but, at least some, likely represent new taxa. It is beyond the scope of this paper to review all fossil *Calyptraea (Trochita)* from California so the description of this new taxon will have to wait until that to be accomplished.

Four species of *Crepidula* have been reported from the Wilson Grove Formation: *C. adunca* Sowerby, *C. grandis* Middendorff, *C. onyx* Sowerby, *C. princeps* (Conrad), as well as indeterminate *Crepidula* (Osmont, 1905; Dickerson, 1922, Weaver, 1949, Bedrossian, 1974). Only *C. onyx* Sowerby, *C. princeps* (Conrad), and indeterminate *Crepidula* were found during the present study. Based on our examination of the collections, it seems likely that specimens previously referred to *C. adunca* Sowerby are actually juvenile *C. princeps* (Conrad), and specimens of *C. grandis* Middendorff are also *C. princeps* (Conrad). *Crepidula onyx* (Sowerby) ranges in age from late Miocene to Holocene (Grant and Gale, 1931), while *C. princeps* ranges in age from Miocene to middle Pleistocene (Grant and Gale, 1931; Powell and Stevens, 2000).

#### Family Naticidae

Dickerson (1922) reports *Natica cansors* Dall from Wilson Grove (CAS 546) and questionably from near Salmon Creek (CAS 413). Specimens examined by Marincovich (1977) as *Natica cansors* Dall from throughout the northeastern Pacific, were attributed by him to *Cryptonatica affinis* Broderip (as *C. clausa* Broderip and Sowerby) and *Natica janthostoma* Deshayes. Our examination of CAS 546 found both *Natica janthostoma* Deshayes and *Neverita reclusiana* (Deshayes). Therefore, it appears that *Natica cansors* Dall of Dickerson (1922) refers, at least in part, to *Neverita reclusiana* (Deshayes). Dickerson's specimens from CAS 413 are here referred to indeterminate Naticidae.

Bedrossian (1974) reports *Polinices lewisii* (Gould), *Neverita reclusiana* (Deshayes) [as *P. reclusianus* (Deshayes)] and indeterminate *Polinices* from the Wilson Grove Formation. In most cases Naticids from the Wilson Grove Formation are too poorly preserved to allow precise identification and Bedrossian's specimens at CAS are generally referred to indeterminate Naticidae. *Polinices lewisii* (Gould) has also been reported from near Santa Rosa (CAS) (Marincovich, 1977). The species has not been observed during the present study and, therefore, is not included in the fauna from the Wilson Grove Formation. In addition, Marincovich (1977) reported both *Natica janthostoma* Deshayes and *Cryptonatica affinis* Broderip (as *C. clausa* Broderip & Sowerby) from the Wilson Grove Formation, and their occurrence is confirmed here (CAS 546).

Recently a crushed specimen questionably identified as *Polinices draconis* (Dall) (L. Marincovich, Jr., oral communication, 2002) was collected by the junior author southeast of Meacham Hill. The oldest stratigraphic occurrence of this species is unclear. Marincovich (1977) questionably reports this species from the middle Pliocene Etchegoin Formation in central California. It is unclear if this reference refers to early or late Pliocene in modern usage. *Polinices draconis* (Dall) is generally considered a deeper water species from 15 to over 400 m (Marincovich, 1977), but the specimen found was collected in beds that are very shallow marine at best which interfinger with continental deposits. It was also the only shell collected from this mainly continental exposure.

#### Family Ranellidae

*Mediargo mediocris* (Dall) is represented by a single immature, worn specimen collected from Wilson Ranch and previously identified by Dickerson (1922) as *Trophon*(?) sp. It has been reported

in rocks of possibly middle, but definitely late Miocene to late Pliocene from the Olympic Peninsula, Washington to San Diego, California (Smith, 1970).

A single, small, poorly preserved, mold identified as an indeterminate *Trophosycon* is in collections from Roblar Road (CAS 60489). It is represented by a small mold, perhaps two cm long, which shows faint radial threads on the body whorl and nodes on the shoulder. Unfortunately, it is too poorly preserved for precise identification. Grant and Gale (1931) cite an age range of late Miocene to early Pliocene for this genus, but they also cite its occurrence in the San Diego Formation, which suggests the genus lived to the late Pliocene.

#### Family Muricidae

Five Muricidae have been found or reported from the Wilson Grove Formation. Of these five, two are possibly new. These new taxa include *Acanthinucella?* n. sp., and *Nucella* sp., aff. *N. lamellosa* (Gmelin) and both are represented by few individuals. Both are discussed below along with other Muricids from the Wilson Grove Formation, but are not formally described.

An apparent new species of *Acanthinucella?* is present in collections from River Road (CAS 54164). This species is represented by a single broken specimen (CAS 54164.06) measuring 37.4 mm and missing most of the spire and penultimate whorl. The body whorl has five, broad, well rounded, concentric ridges and no secondary ribs. Not enough of the penultimate whorl is present for an accurate count of concentric ridges, but it appears to have two. The outer lip is moderately thin with a small labial tooth projecting from the margin. The tooth matches with a spiral depression on the exterior of the ultimate whorl similar to that seen in the modern *Acanthinucella punctulata* (Sowerby) (Marko and Vermeij, 1999, fig. 5-9).

Specimens of *Nucella* sp., aff. *N. lamellosa* (Gould) from CAS 54135 at Bloomfield Quarry do not show much variability. Only two are well enough preserved for adequate description and they have five, regular, coarse concentric ridges on the ultimate whorl and two on the penultimate. These specimens measure 36.9 mm and 38.1 mm and both specimens appear to be missing the tip of the spire. They possess a thickened, flaring lip, and the best preserved specimen shows two, large, round denticles (apertural teeth) on the inside of the lip removed from the lip margin. These specimens are similar to some forms of *N. lamellosa* (Gmelin) as illustrated by Kincaid (1957) (e.g., pl. XIX), but the spiral cords are more regular and lack secondary cords. In addition, the apertural teeth are larger and fewer in number than *N. lamellosa* (Gmelin). Therefore, the specimens from the Wilson Grove Formation are very questionably referred to *N. lamellosa* (Gmelin) and may represent a new species.

*Nucella transcoana* (Arnold) is reported here from Wilson Grove and River Road. Other occurrences of *N. transcoana* (Arnold) in California and Baja California Norte, Mexico seem to suggest a Pliocene age for this species. It has been reported from the Purisima Formation at Capitola (Perry, 1993) and the Purisima Formation in the Sargent's oil field (Allen, 1945), from the Merced Formation at Felt Lake, San Mateo County (Addicott, 1969), the type Merced Formation (Hertlein and Allison, 1959), and the Cantil Costero Formation in northwestern Baja California, Mexico (Hertlein and Allison, 1959). Most of these occurrences are also restricted to the Pliocene (Capitola, Felt Lake, and the Cantil Costero Formation). The other two, the Purisima Formation at Sargent's oil field and the type Merced Formation, are mostly Pliocene, but the former may extend into the Miocene (Powell, 1998) and the latter into the Pleistocene (Ingram and Ingle, 1998). It seems reasonable to assume this species is restricted to the Pliocene, and possibly the late Pliocene, judging from the well dated occurrences above.

Dickerson (1922) reports *Nucella? imperialis* (Dall) from near Salmon Creek. Weaver (1949) also reported it from Wilson Grove, but we have not been able to examine his specimens. However, since *N. transcoana* Arnold is common at Wilson Grove and was not reported there by Weaver, it is possible that his specimens should be attributed to *N. transcoana* Arnold instead. Because specimens of *N? imperialis* (Dall) could not be located during the present study, its occurrence in the Wilson Grove Formation still needs confirmation.

#### Family Buccinidae

*Aulacofusus? recurvus* (Gabb) was originally described from the Estero San Antonio area (Gabb, 1866), but has not been recognized in collections from that area. It seems possible that this species does not occur at Estero San Antonio and that the type locality is in error. However, it has been questionably recognized in modern collections at Salmon Creek. Other occurrences of this species are from the Ohlson Ranch Formation in northwestern Sonoma County (Peck, 1960), the Falor Formation in Humboldt County (Manning and Ogle, 1950), and Glen (1959) reports a single, crushed specimen questionably referred to *A.? recuva* (Gabb) from the Purisima Formation at Moss Beach. Discounting the reported type locality from which specimens can not be verified, these occurrences suggest a Pliocene age for this species.

#### Family Columbelloidea

*Columbella richthofeni* Gabb was described from the Wilson Grove Formation from the Pliocene, on the Russian River (Gabb, 1866). Unfortunately, the type has been lost (Stewart, 1927) and the type illustration alone seems insufficient to differentiate this species from the several modern eastern Pacific Columbelloidea. Specimens attributed to this species are common at the River Road locality which is on the Russian River and are here attributed to *Astyris gausapata* (Gould) as suggested by Addicott (1969). This species is well known from the Pliocene of central California (Woodring and Bramlette, 1950; Addicott, 1969; Powell, 1998), but not the Miocene, with the exception of Loel and Corey's (1932) *Mitrella* cf. *M. richthofeni* (Gabb). Their specimen, which is incomplete and poorly preserved, is probably referable to another species. *Astyris gausapata* (Gould) has a modern occurrence in the modern eastern Pacific, from the Alaska Peninsula, Alaska, to Punta San Pablo, Baja California Sur, Mexico, on soft bottoms between 30 and 200 m (McLean and Groslinger, 1996).

#### Family Photinidae

Vermeij (1991) recently placed *Chrysodomus portolaensis* Arnold, 1908 in his new genus *Lirabuccinum*. From occurrences reported in the literature (Arnold, 1908; Martin, 1916; Allen, 1945; Adegoke, 1969; Addicott and others, 1978; Perry, 1993) Powell (1998) suggested a late Miocene to late Pliocene age range for *Lirabuccinum portolaensis* (Arnold). Most, if not all, of the occurrences of *L. portolaensis* (Arnold) appear to be restricted to the Pliocene part of their respective formations.

#### Family Nassariidae

Bedrossian (1974) reports both *Nassarius californicus* (Conrad) and *N. grammatus* (Dall) from the Roblar Road area. Unfortunately, her specimens could not be located in collections from this area. Other *Nassarius* from Roblar Road are internal molds and not identifiable to species. Therefore, Bedrossian's (1974) specimens are here referred to indeterminate *Nassarius* sp. until such time as the specimens can be located. Both taxa are known elsewhere in the Wilson Grove Formation, at River Road and at Wilson Grove, suggesting a Pliocene age for part of the formation.

#### Family Volutidae

Travis (1952) reports the genus *Mioleione* (as *Mioleione*) from southwestern part of [the Sebastopol] quadrangle. This species has not been reported elsewhere in the Wilson Grove Formation and is not present in any of the examined collections. Therefore, it is excluded from the Wilson Grove fauna until such time as Travis' (1952) specimens can be located or other specimens collected.

#### Family Turriculinae

The type of *Megascurla remondii* (Gabb) was described from the Estero San Antonio area along with the earlier mentioned *Aulacofusus? recurvus* (Gabb). Neither of these taxa have been found in the Estero San Antonio area since their description and the only confirmed specimens of *M.*

*remondii* (Gabb) in the Wilson Grove Formation are from the River Road, while *A.? recurvus* (Gabb) has been questionably reported only from Salmon Creek. As discussed under *A.? recurvus* (Gabb), the type locality of these species may be incorrect. Addicott (1969) suggested this species was restricted to the Pliocene assuming that the Wilson Grove Formation occurrence was Pliocene in age. Some confusion exists between *Megascurula remondii* (Gabb) and *M. stearnsiana* (Raymond). Grant and Gale (1931) synonymize these taxa along with *M. carpenteriana fernandoana* Arnold, and *M. gabbiana* Dall. But McLean (1978) seems to believe they are separate, as he lists *M. remondii*, of authors, as a synonym of *M. stearnsiana* (Raymond), but does not include *M. remondii* (Gabb). It is beyond the scope of this paper to resolve this problem and here we use the name *M. remondii* (Gabb) which was described from the Wilson Grove Formation.

*Megascurula carpenteriana* (Gabb) has also been reported from the Wilson Grove Formation (Dickerson, 1922) and is found at River Road and Wilson Grove. These occurrences and Grant and Gale (1931) indicate the oldest occurrence as Pliocene, but a collection (UCMP B-2102) at the Museum of Paleontology, University of California at Berkeley from the Santa Margarita Formation in San Benito County, central California, contains a worn specimen of this species indicating its range extends back to the late Miocene.

#### Family Borsoniinae

Some confusion exists between *Ophiodermella graciosa* (Arnold) and *O. mercedensis* (Martin). According to Yancey (1978) the two species are separate and form a stratigraphic succession in the Merced Formation of coastal San Mateo County. He states: *O. graciosa* can be distinguished from *O. mercedensis* by its stronger and less numerous spiral ribs, presence of a weak keel, and radial ribs across the upper half of the whorl. Based on this distinction specimens from the Wilson Grove Formation are attributed to *O. sp.*, cf. *O. graciosa* (Arnold).

### Phylum Arthropoda Class Crustacea

#### Order Decapoda, section Brachyura (true crabs)

Bedrossian (1974) illustrates a specimen of the genus *Cancer*, but it could not be located during the present study. The photograph is sufficient to allow identification to genus and it is included in the faunal list from the Wilson Grove Formation.

Several species of crabs appear to be present in the Wilson Grove Formation, but they are represented by poorly preserved material. We make no attempt to identify these specimens because we are not familiar with the Eastern Pacific Brachyura fauna. These specimens must await identification by a qualified individual.

#### Family Coronulidae

Travis (1952) questionably reports the whale barnacle *Coronula* from Road cut, 2 1/8 miles west of Durham school. This would be in the vicinity of the Steinbeck Ranch/Roblar Road outcrops of the present study. No barnacles have been reported from this area and whale barnacles have not been reported elsewhere from the Wilson Grove Formation. However, as mentioned earlier, a whale fossil has been found at Steinbeck Ranch (Allen and others, 1999), so associated barnacle fossils would not be unexpected from this area. Until such time as Travis (1952) specimen comes to light or new specimens are collected, *Coronula* is not included in the fauna from the Wilson Grove Formation.

## Appendix 2. Fossil localities and occurrences

Several collections at the California Academy of Sciences appear to be from the Wilson Grove Formation and are filed with collections from that area, but have incorrect locality data (CAS 31772, CAS 36447, CAS 54709, CAS 60233), or are thought to be represent other contemporary formations (CAS 34401). All these collections are identified and listed below but are not used in any interpretations. These collections are also printed in red on non-print copies of this report.

When a number of collections can be grouped in a small area, a location name (i.e., Steinbeck Ranch) is give for those collection so they can be easily recognized as coming from the same general area. Scattered samples, collections not precisely located, or those from areas where few collections occur, lack these locality names.

All geologic units identified in the following locality descriptions are from the original description and may not conform to our current understanding of these units.

All specimens were identified by C. Powell, II, unless otherwise noted.

### California Academy of Sciences

Schenck 413. Locality: Salmon Creek. One-half mile north of Freestone and 200 ft east of trestle in stream. Shaly sandstone and soft sandstone with a east-west strike and a dip of 5<sub>i</sub> to the south. Collected by J.B. Kerr, 7/24/1916 (cited as 7/22/1916 by Dickerson, 1922).

#### Mollusca

##### Bivalvia

*Clinocardium* sp.  
*Cryptomya californica* (Conrad)?  
*Macoma* sp., cf. *M. nasuta* (Conrad)  
*Panope* sp., cf. *P. abrupta* (Conrad)  
Pectinidae, indeterminate  
*Protothaca?* sp.  
*Solen* sp.  
*Tresus* sp.

##### Gastropoda

*Calyptraea* sp. (high and smooth)  
*Crepidula princeps* (Conrad)  
Naticidae, indeterminate  
Neogastropoda, indeterminate  
Trochidae, indeterminate

#### Arthropoda

##### Crustacea

*Balanus?* sp.

Schenck 425. From Miss Burns Hill at Valley Ford, Sonoma County, California. Collected by J.B. Kerr, 7/23/1916.

#### Mollusca

##### Bivalvia

*Tresus pajaroanus* (Conrad)?

Schenck 439. Collected at the bottom of a 30-foot well at an elevation of 1,400 ft on Mrs. McKenna s Ranch near Plantation, Sonoma County, California. Donated by Mrs. T. McKenna.

#### Mollusca

##### Gastropoda

*Crepidula* sp.

CAS 545. Locality: Wilson Grove. Fossils collected 0.25 mile southeast of CAS 546, which is described in the CAS locality book only as Wilson Ranch, Sonoma County, California. Collected by R.E. Dickerson.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)  
*Glycymeris* sp., cf. *G. grewingki* Dall  
*Macoma* sp., cf. *M. addicotti* Nikas  
Mactridae, indeterminate  
*Protothaca staley* (Gabb)

Gastropoda

*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
*Nucella* sp., cf. *N. transcoana* Arnold  
*Ophiidermella* sp.

CAS 546. Locality: Wilson Grove. Merced fossils from Wilson Ranch, Sonoma Co. California. Collected by R.E. Dickerson.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)  
Cardiidae, indeterminate  
*Cryptomya californica* (Conrad)  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Macromeris albaria* (Conrad)  
*Macromeris* sp., cf. *M. polynyma* (Stimpson)  
Mactridae, indeterminate  
*Protothaca* sp., cf. *P. staley* (Gabb)  
*Solen* sp.  
*Tresus* sp., cf. *T. pajaroanus* (Conrad)

Gastropoda

*Astyris* sp., cf. *A. gausapata* (Gould)  
*Crepidula* sp., cf. *C. onyx* Sowerby  
*Cryptonatica affinis* (Gmelin)  
*Cymatidium?* sp.  
*Littorina* sp., cf. *L. petricola* Dall  
*Megascurcula stearnsiana* (Raymond)  
*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
*Natica janthostoma* Deshayes  
*Neverita reclusiana* (Deshayes)  
*Nucella* sp., cf. *N. transcoana* Arnold  
*Olivella biplicata* (Sowerby)  
*Ophiidermella* sp., cf. *O. graciosa* Arnold

CAS 31273. 2.8 km (1.75 miles) west of Occidental, Sonoma County, California. Collected by N. Dinba, received from O.P. Jenkins, October 1940.

Mollusca

Bivalvia

*Patinopecten* sp.

CAS 34313. Locality: vicinity of Wilson Ranch. Fossils from bed of blue-gray, fine to very fine-grained sandstone overlain by gravels of the Glen Ellen Formation exposed on Decrner (?) Ranch in artificial cut for Mark West Creek diversion channel about 50 south of bridge on private access road

in NE/4, NE/4, section 10, T. 7 N., R. 9 W., Sebastopol 15 quadrangle, Sonoma County, California. Collected by G. T. Carlwell, USGS Ground water Branch, circa. mid-1950 s (judging from other locality in this section of the locality book).

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)  
*Clinocardium* sp.  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Protothaca staleyi* (Gabb)  
*Siliqua* sp.

Gastropoda

*Calicantharus fortis* (Carpenter)?  
*Nassarius grammatus* (Dall)  
*Nucella* sp.  
*Polinices* sp.

CAS 34401. About 7.2 km (4.5 miles) northwest of Healdsburg on P. D. Austin Ranch, Sonoma County, California. Obtained in the fall of 1953 by G. T. Cardwell from Mr. P. D. Austrin who collected the fossil from a presumable erosional remnant of soft sandstone (= Merced Formation) in a gully approximately 150 m (500 ) southeast of intersection of West Dry Creek Road and road crossing Dry Creek from Dry Creek Store, approximately 60 m (200 ) southwest of West Dry Creek Road, in the SE1/4, section 2, T. 9 N., R. 10 W., Healdsburg 15 quadrangle.

Note: This locality may not be attributed to the Wilson Grove Formation (see discussion under Pectinidae in Appendix 1).

Mollusca

Bivalvia

*Patinopecten* sp., cf. *P. caurinus* (Gould)

CAS 36447. The locality number on the specimen in this collection is different from other CAS or SU collections. Also the specimens do not appear to be from the locality cited in either the CAS or SU locality catalogs for this number (i.e., Wilson Grove looking fossils from the Cretaceous of Utah). They are included here because they are in drawers associated with other collections from the Wilson Grove Formation and appear to be from the Wilson Grove Formation.

Mollusca

Bivalvia

*Modiolus* sp.

CAS 40980. Locality: River Road. Grayish white, fine-grained sandstone containing abundant marine fossils in road cut on north side of River Road, 5.6 miles west of Fulton exit from U.S. Highway 101 north of Santa Rosa. About 0.35 mile east of first intersection of River Road and Trenton Road, Sonoma County, California. Sebastopol quadrangle. Collected by V.A. Zullo and J.E. Zullo, 7/20/1968. = CAS 54164, CAS 55979, CAS 59657; UCD A280

Mollusca

Bivalvia

*Macoma* sp., cf. *M. addicotti* Nikas  
*Protothaca staleyi* (Gabb)  
*Yoldia* sp.

Gastropoda

*Astyris gausapata* (Gould)  
*Cryptonatica affinis* (Gmelin)  
*Nassarius grammatus* (Dall)  
*Nucella* sp.  
*Odostomia* sp.  
*Olivella pycna* Berry

*Ophiidermella* sp., cf. *O. graciosa* Arnold

Arthropoda

Crustacea

Indeterminate crab parts

CAS 54135. Location: Bloomfield Quarry. The lower part of quarry is in Franciscan Formation; the upper part is in Merced Formation. The lower 0.3-0.6 m (1-2 ) of the Merced Formation is a basal conglomerate with pebbles, cobbles, and boulders of Franciscan rocks in a matrix of weakly to strongly cemented, fine- to medium-grained sandstone (CAS 54135). This basal conglomerate contains abundant fossils; mostly mollusks and brachiopods. Overlying the basal conglomerate is about 4-6 m (15-20 ) of soft, tan, fine- to medium-grained sandstone containing scattered fossils (mostly internal molds of mollusks) (CAS 54136). This site is located on the south side of Bloomfield Road 3.1 km (1.9 miles) N 12; E of the junction of Bloomfield Road and the road that leads from the town of Bloomfield to Valley Ford, Sonoma County, California. Two Rock 7.5 quadrangle. Collected by W. F. Barbat, R. Naidu, P. U. Rodda, and B. Roth, 18 October 1973.

Brachiopoda

Inarticulata

*Discinisca* sp., cf. *D. cumingii* Broderip

Articulata

*Terebratalia transversa* Sowerby

Mollusca

Bivalvia

*Anadara* sp.

*Arca* sp., cf. *A. santamariensis* Reinhart

Cardiidae, indeterminate

*Chlamys* sp., cf. *C. hastata* (Sowerby)

*Chlamys* sp.

*Cryptomya californica* (Conrad)?

*Macoma* sp.

*Modiolus* sp.

Mytilidae, indeterminate

*Mytilus* sp., cf. *M. coalingensis* (Arnold)

*Patinopecten* sp.

*Pododesmus* sp., cf. *P. macrochisma* (Deshayes)

*Solen* sp.

*Swiftopecten parmeleei* (Dall)

*Teredo* sp.

*Tresus pajaroanus* (Conrad)?

*Yoldia* sp.

Gastropoda

*Calyptraea (Trochita)* n. sp.?

*Crepidula princeps* (Conrad)?

*Lirabuccinum?* sp.

*Nassarius?* sp.

Naticidae, indeterminate

*Nucella* n. sp., aff. *N. lamellosa* (Gmelin)

Arthropoda

Crustacea

*Balanus?* sp.

*Callianassa?* sp.

*Cancer* sp.

CAS 54136. Location: Bloomfield Quarry. The lower part of quarry is in Franciscan Formation; the upper part is in Merced Formation. The lower 0.3-0.6 m (1-2 ) of the Merced Formation is

a basal conglomerate with pebbles, cobbles, and boulders of Franciscan rocks in a matrix of weakly to strongly cemented, fine- to medium-grained sandstone (CAS 54135). This basal conglomerate contains abundant fossils; mostly mollusks and brachiopods. Overlying the basal conglomerate is about 4-6 m (15-20 ) of soft, tan, fine- to medium-grained sandstone containing scattered fossils (mostly internal molds of mollusks) (CAS 54136). This site is located on the south side of Bloomfield Road 3.1 km (1.9 miles) N 12; E of the junction of Bloomfield Road and the road that leads from the town of Bloomfield to Valley Ford, Sonoma County, California. Healdsburg 7.5 quadrangle. Collected by W. F. Barbat, R. Naidu, P. U. Rodda, and B. Roth, 18 October 1973.

Brachiopoda

Inarticulata

*Discinisca* sp., cf. *D. cumingii* Broderip

Articulata

*Terebratalia* sp.

Mollusca

Bivalvia

*Chlamys* sp.

*Lucinoma annulatum* (Reeve)

*Modiolus* sp.

*Panope* sp.

*Pododesmus* sp.

*Tresus pajaroanus* (Conrad)?

Gastropoda

*Crepidula princeps* (Conrad)?

*Lirabuccinum?* sp.

Naticidae, indeterminate

*Nucella?* sp.

Arthropoda

Crustacea

*Balanus?* sp.

*Callianassa?* sp.

CAS 54138. Locality: Roblar Road. Yellow to grayish white tuff-breccia in sanitary landfill cuts and terraces exposed on the south side of Roblar Road, 0.4 mile east of intersection with Canfield Road and circa. 2.7 miles E of town of Bloomfield, Sonoma County, California. Collected by B. Roth, 10/21/1973.

Mollusca

Bivalvia

Cardiidae?, indeterminate

*Siliqua* sp.

CAS 54164. Locality: River Road. In road cut on north side of River Road about 0.3 km (0.2 miles) north of Trenton and about 0.5 km (0.3 mile) east of intersection of River Road and Trenton-Healdsburg Road. In grayish-white, poorly indurated, highly fossiliferous sandstone, Sonoma County, CA. Sebastopol 7.5 quadrangle; latitude  $\sim 38;20$  , longitude  $\sim 122;51$  . Collected by J. Nikas, R. Naidu, and B. Roth, 5 July 1973. = CAS 40980, CAS 55979, CAS 59857; UCD A280

Mollusca

Bivalvia

*Clinocardium?* sp.

*Cryptomya californica* (Conrad)

Lucinidae, indeterminate

*Macoma addicotti* Nikas

*Macoma* sp., cf. *M. nasuta* (Conrad)

*Macoma* sp.

*Mactromeris* sp., cf. *M. albaria* (Conrad)

Mactridae, indeterminate  
*Mytilus* sp.  
*Nuttallia jamesii* Roth and Naidu  
*Protothaca staleyi* (Gabb)  
*Protothaca* sp.  
*Siliqua* sp.  
*Solen?* sp.  
*Yoldia* sp., aff. *Y. cooperi* Gabb

Gastropoda

*Acanthinucella?* sp.  
*Admete?* sp.  
*Astyris gausapata* (Gould)  
*Balcis* sp.  
*Calicantharus* sp.  
*Crepidula* sp.  
*Cryptonatica affinis* (Gmelin)  
*Cylichna* sp.  
*Lirabuccinum portolaensis* (Arnold)  
*Mediargo mediocris* (Dall)  
*Megascurcula carpenteriana* (Gabb)  
*Megascurcula remondii* (Gabb)  
*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
*Odostomia* sp. (large)  
*Olivella pycna* Berry  
*Ophiodermella* sp., cf. *O. graciosa* Arnold  
*Ophiodermella?* sp.  
*Sinum scopulosum* (Conrad)  
*Turbonilla* sp.

Arthropoda

Crustacea

*Cancer* sp.  
Indeterminate crab parts

Echinodermata

Echinoidea

Indeterminate echinoid

CAS 54165. Locality: River Road. Road cut on the north side of River Road about 180 m (200 yd.) west of CAS 54164 in hard, gray, brown stained sandstone with abundant *Protothaca* and *Macoma*, Sonoma Co., California. Collected by J. Nikas, R. Naidu, and B. Roth, 5 July 1973.

Mollusca

Bivalvia

*Macoma* sp., cf. *M. addicotti* Nikas  
*Macoma* sp.  
Mactridae, indeterminate?  
*Nuttallia* sp., cf. *N. jamesi* Roth and Naidu  
*Protothaca* sp.  
*Yoldia* sp.

CAS 54166. Locality: Wilson Grove. Low road cut in tan to gray silty sandstone on the west side of Trenton-Healdsburg Road (= Eastside Road of USGS Healdsburg 7.5 quadrangle), circa 0.8 km (0.5 mile) north of intersection with Mark West Station Road, in NW1/4, SE1/4, section 28 (projected), T. 8 N., R. 9 W., Healdsburg 7.5 quadrangle, Sonoma Co., California. Collected by J. Nikas, R. Naidu, and B. Roth, 5 July 1973.

Mollusca

Bivalvia

*Anadara* sp.  
*Macromeris* sp., cf. *M. albaria* (Conrad)  
*Protothaca* sp., cf. *P. staley* (Gabb)

Gastropoda

*Crepidula* sp.  
*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
Naticidae, indeterminate  
*Nucella* sp., cf. *N. transcoana* Arnold  
*Olivella biplicata* (Sowerby)  
*Ophiidermella* sp., cf. *O. graciosa* Arnold

CAS 54680. Locality: Wilson Grove. Tan, friable, highly fossiliferous sandstone outcropping on the east bank of Russian River at Wilson s Grove in NE1/4, NE1/4, section 28, T. 8 N., R. 9 W. Healdsburg 7.5 quadrangle, Sonoma Co., California. Collected by B. Roth, W. Haggat, 9 February 1974.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)  
*Cryptomya californica* (Conrad)  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Macoma* sp.  
Mactridae, indeterminate  
*Protothaca staley* (Gabb)  
*Solen* sp.

Gastropoda

*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
Naticidae, indeterminate  
*Nucella* sp.  
*Olivella biplicata* (Sowerby)  
*Ophiidermella* sp., cf. *O. graciosa* Arnold

CAS 54709. The locality number on the specimen in this collection is different from other CAS or SU collections. Also the specimens do not appear to be from the locality cited in either the CAS or SU locality catalogs for this number (i.e., Wilson Grove looking fossils from the Cretaceous of Utah). They are included here because they are in drawers associated with other collections from the Wilson Grove Formation and appear to be from the Wilson Grove Formation.

Mollusca

Gastropoda

*Ophiidermella* sp.

CAS 55967. Locality: Steinbeck Ranch. Continuation of fine, well-cemented, gray sandstone (continuation of CAS 55969) on east side of large sea stack directly across street from Sonoma County Refuse Disposal area about 2.5 miles east of intersection of Roblar Road and US101, Sonoma County, California. Collected by T. L. Bedrossian, 1970. = UCD A273B.

Mollusca

Bivalvia

*Securella?* sp.  
Mactridae, indeterminate

CAS 55969. Locality: Steinbeck Ranch. Fine, well-cemented, gray sandstone with abundant shell fragments exposed on east side of large sea stack about 0.125 mile northeast of farmhouse, about 2.5 miles east of intersection of Roblar Road and U.S. Highway 101, Sonoma County, California. Collected by T. L. Bedrossian, 1970. = UCD A273A.

Mollusca

Bivalvia

*Securella?* sp.

CAS 55970. Locality: Roblar Road. Cryptomya community fossils from approximately 90 m from curve at top of the paved road in a moderately well sorted, gray silt overlain by brown sandstone, Refuse Disposal area on Roblar Road approximately 2.8 miles from its intersection with U.S. Highway 101, Sonoma County, California. Collected by T. L. Bedrossian, 1970. = UCD A271B.

Mollusca

Bivalvia

Mactridae, indeterminate

Gastropoda

*Calyptraea?* sp.

CAS 55973. Locality: Roblar Road. In filled road cut east of CAS 55970-CAS 55972 in gray, silty sandstone with beds of tuffaceous conglomerate, Refuse Disposal area on Roblar Road approximately 2.8 miles from its intersection with US101, Sonoma County, California. Collected by T. L. Bedrossian, 1970. = UCD A272.

Mollusca

Bivalvia

*Macoma?* sp.

Mactridae, indeterminate

*Solen* sp.

Gastropoda

*Lirabuccinum?* sp.

*Nassarius* sp.

CAS 55976. Locality: Salmon Creek. Poorly sorted, yellowish-brown sandstone containing molds and casts located in stream bed about 0.8 km (0.5 mile) north of Freestone, 180 m (200 ) east of railroad trestle (T. 6 N., R. 10 W.), Camp Meeker 7.5 quadrangle, Sonoma Co., California. Collected by T. L. Bedrossian, 1970. Said to be equivalent to Dickerson (1922), loc. 413; = UCD A277.

Mollusca

Bivalvia

*Chlamys?* sp.

CAS 55978. Poorly sorted gray to yellow-brown sandstone about 2 above road in road cut at the Thorn residence on Lewis Road, 200 m (0.125 mile) south of its intersection with Vine Hill Road (T. 7 N., R. 9 W.), Sebastopol 7.5 quadrangle, Sonoma Co., California. Collected by T. L. Bedrossian, 1970. = UCD A279.

Mollusca

Bivalvia

*Securella?* sp.

*Macoma* sp.

CAS 55979. Locality: River Road. At top of hill about 6 m (20 ) above base of the road in very well sorted, loosely consolidated, gray sandstone underlain by a 0.3 m (1 ) thick hard shell layer on River Road about 160 m (0.1 mile) east of its intersection with Vine Hill Road (T. 7 N., R. 9 W.), Sebastopol 7.5 quadrangle, Sonoma Co., California. Collected by T. L. Bedrossian, 1970. = CAS 40980, CAS 54164; UCD A280.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)  
Lucinidae, indeterminate  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Macromeris* sp., cf. *M. albaria* (Conrad)  
Mactridae, indeterminate  
*Protothaca* sp., cf. *P. staley* (Gabb)  
*Siliqua* sp.  
*Yoldia* sp.

Gastropoda

*Astyris gausapata* (Gould)  
*Cryptonatica affinis* (Gmelin)  
*Nassarius grammatus* (Dall)  
Naticidae, indeterminate  
*Nucella* sp.  
*Odostomia* sp.  
*Olivella pycna* Berry  
*Ophiidermella* sp., cf. *O. graciosa* Arnold  
*Turbonilla* sp.

Arthropoda

Crustacea

Indeterminate crab parts

CAS 55981. About 0.3 m (1 ) of exposed section on the side of a shallow drainage in soft, tan to orange and red-brown sandstone with abundant molds of bivalves in 2.5 cm (1 ) thick layer in the lower part of the exposure. Exposed in small southwest flowing tributary of Green Valley Creek on a 10-acre plot of the parents of Mrs. Alison Close (3350 Oakes Dr., Hayward, CA), northwest of house, 900 m (3,000 ) east and 180 m (600 ) north of the southeast corner of section 1, T. 7 N., R. 10 W., Camp Meeker 7.5 quadrangle, 0.4 mile west-west-northwest of Forestville, Sonoma Co., California. Collected by P. Rodda and B. Roth, 13 August 1975.

Mollusca

Bivalvia

*Protothaca?* sp.  
Indeterminate bivalve

CAS 55982. About 1.2 m (4 ) of section exposed in bottom and sides of small drainage, just upstream from junction with a south-flowing branch. Beds are 7.6 cm (3 ) to 15 cm (6 ) thick of moderately hard, dark gray sandstone with abundant shells and shell fragments (mostly bivalves), interbedded with equally thick beds of softer, gray, muddy and silty sandstone without conspicuous fossils. In same small tributary of Green Valley Creek and about 90 m (100 yd.) downstream from CAS 55981, about 640 m (0.4 mile) west-west-northwest of Forestville and 850 m (2,800 ) east and 120 m (400 ) north of the southeast corner of section 1, T. 7 N., R. 10 W., Camp Meeker 7.5 quadrangle, Sonoma Co., California. Collected by P. Rodda and B. Roth, 13 August 1975.

Mollusca

Bivalvia

*Clinocardium* sp.

Gastropoda

Indeterminate gastropod

CAS 57867. Locality: Bloomfield Quarry. Fossils (mostly external molds) collected from outcrop and loose blocks of tuffaceous sandstone exposed in a recently made, roughly scraped road upslope and behind the quarry face in Bloomfield Quarry. Tuffaceous sandstone is 0.9 to 1.2 m (3 to 4 ) thick, contains tuff fragments to 13 mm (0.5 ) across and is 4.5 m (15 ) above the base of the

Wilson Grove ( Merced ) Formation. Quarry face has been moved back (south) about 55 m (60 yd.) since October, 1973. South side of Bloomfield Road about 3.1 km (1.9 mile) (map distance) N. 12; E., of the junction of Bloomfield Road and the road from Bloomfield to Valley Ford, Two Rocks 7.5 quadrangle, Sonoma Co., California. Collected by P. Rodda and B. Roth, 15 March 1976. - CAS 54135.

Mollusca

Bivalvia

*Clinocardium?* sp.  
Mactridae, indeterminate  
*Patinopecten* sp.  
*Siliqua?* sp.  
*Tellina* sp.  
*Tresus pajaroanus* (Conrad)?

CAS 58002. Locality: Wilson Grove. On Eastside Rd about 1.6 km (1 mile) north of the fork of the Trenton-Healdsburg Road in the Healdsburg 7.5 quadrangle, Sonoma Co., California. Collected by J. D. Otis, August 1975.

Mollusca

Bivalvia

*Anadara* sp.  
*Cryptomya californica* (Conrad)  
*Macoma?* sp.  
Mactridae, indeterminate  
*Mactromeris albaria* (Conrad)  
*Protothaca staleyi* (Gabb)?  
*Solen* sp.  
*Tresus pajaroanus* (Conrad)?  
Veneridae, indeterminate

Gastropoda

*Megascurcula* sp., cf. *M. carpenteriana* (Gabb)  
*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)  
Naticidae, indeterminate  
*Nucella* sp., cf. *N. transcoana* Arnold  
*Olivella biplicata* (Sowerby)  
*Ophiodermella* sp., cf. *O. graciosa* Arnold

CAS 58003. Rock dredged from artificial lake at depth of 40 m in Kaiser Sand and Gravel Company quarry. North of UCD A-281 about 0.8 km (0.5 mile) west on privately owned road off Eastside Road, 3.2 km (2 mile) north of the fork of Trenton-Healdsburg Road, Healdsburg, Sonoma Co., CA. Collected by J. D. Otis, August 1975, ex. J. T. Carlton, UCD.

Mollusca

Bivalvia

*Protothaca?* sp.  
Indeterminate bivalves

CAS 59657. Locality: River Road. 0.3 km (0.2 mile) north of Trenton and 0.1 mile east of intersection of River Road and Trenton-Healdsburg Road on north side in road cut about 40 above road base, Sonoma Co., California. Collected by R. Naidu, 3/10/1978. Equivalent to CAS 40980, CAS 54164, CAS 55979; UCD A280.

Mollusca

Bivalvia

Indeterminate bivalves

Gastropoda

Naticidae, indeterminate?

CAS 59665 to CAS 59674 are located on Tremary Ranch about 1.5 to 2 mile northeast of Bloomfield. They are at elevations between about 330 and 410 on grassy slopes on east and west sides of southwest flowing branch of Americano Creek, Sonoma County, California. Localities are 9,500 to 10,000 N35;E to N43;E from intersection of Bloomfield Road and Valley Ford Road on Valley Ford 7.5 quadrangle. Collected by R. Naidu, P. Rodda, B. Roth, E. Levine, E. Hart, and S. Gardner, 3/17&21/1978. Note: Some of these collections could not be located at CAS.

CAS 59666. Locality: Tremary Ranch. Sample from 1 thick hard concretionary sandstone the top of which is located about 196 below top of section measured down from the top of east ridge.

Mollusca

Bivalvia

Cardiidae, indeterminate

*Siliqua* sp.

*Tellina* sp.

Gastropoda

Naticidae, indeterminate

CAS 59667. Locality: Tremary Ranch. Sample from 6 to 8 thick hard sandstone the top of which is located about 204 below top of section measured down from top of east ridge.

Mollusca

Bivalvia

Veneridae, indeterminate

CAS 59668. Locality: Tremary Ranch. Sample from 5 thick soft, tan sandstone, the upper part with shells and the lower part with shelly concretions, the top of which is located about 207 below top of section measured down from top of east ridge.

Mollusca

Bivalvia

Pectinidae, indeterminate

CAS 59671. Locality: Tremary Ranch. Sample from middle of 27 thick, thickly bedded, tan to brown sandstone with hard shelly concretions, the top of which is about 156 below top of section measured down from the top of the west ridge. Possibly correlates with CAS 59666.

Mollusca

Bivalvia

Pectinidae, indeterminate

*Protothaca?* sp.

Veneridae, indeterminate

Indeterminate bivalve

Gastropoda

Indeterminate gastropod

Scaphopoda

Indeterminate scaphopod?

CAS 59808 to CAS 59810 are from the north side of Whitaker Bluff Road and stream cut at Whitaker Bluff on the north side of Estero de San Antonio about 2.3 miles (map distance) north-northeast of Dillon Beach and about 0.2 mile east of Whitaker Bluff Road and Dillon Beach-Valley Ford Road, Sonoma County, California. Section begins about 6 above level of field on north side of Estero de San Antonio. Rocks are mainly poorly bedded, gray to tan, fine- to medium-grained sandstone, extensively burrowed. Locally thin-bedded with few burrows. Numerous, commonly fossiliferous, hard, weathered to dark brown, dense concretions and concretionary lenses and beds up

to 2 thick are present. Total section is 94 thick. Collected by P.U. Rodda, B. Roth, and R. Naidu, 6/9/1978.

CAS 59808. Locality: Whitaker Bluff. 18 thick scattered Pecten bed, the top of which is about 20 below top of measured section. This bed is, in part, located in road cut on north side Whitaker Bluff Road at top of hill about 0.2 mile east of Dillon Beach-Valley Ford Road.

Mollusca

Bivalvia

*Patinopecten?* sp.

CAS 59809. Locality: Whitaker Bluff. Sample from large dark brown concretion about 12 above base of measured section which starts about 6 above alluvial field on the north side of Estero de San Antonio.

Mollusca

Bivalvia

*Teredo* sp. (Teredo bored wood)

CAS 59810. Locality: Whitaker Bluff. Samples from hard concretionary layer about 14 above base of measured section which starts about 6 above alluvial field on the north side of Estero de San Antonio.

Mollusca

Bivalvia

*Acila?* sp.

*Patinopecten?* sp.

Gastropoda

*Crepidula princeps* (Conrad)

Naticidae, indeterminate

Neogastropoda, indeterminate

CAS 59826. Locality: South Valley Ford. Yellowish-gray coarse grained sandstone about 0.8 km (0.5 mile) south on Franklin School Road from its intersection with US Highway 1 on the south side of a flat topped hill in back of Bodega Burl factory and approximately 1.5 m (5 ) below the top of the hill [elevation ~ 14 m (45 )]. West side of Valley Ford, Valley Ford 7.5 quadrangle, Sonoma Co., California. Collected by R. Naidu, 31 May 1978.

Mollusca

Bivalvia

*Solen?* sp.

Indeterminate bivalve

Gastropoda

*Crepidula princeps* (Conrad)

*Lirabuccinum?* sp.

Naticidae, indeterminate

CAS 59827. Locality: South Valley Ford. Concretionary layer about 15 m (50 ) stratigraphically below CAS 59826 and approximately 1.5 m (5 ) above in road base. Located about 61 m (200 ) south of Bodega Burl factory on the west side of Valley Ford, Valley Ford 7.5 quadrangle, Sonoma Co., California. Collected by P. Rodda, B. Roth, and R. Naidu, 9 June 1978.

Mollusca

Bivalvia

Mytilidae, indeterminate

Indeterminate bivalve

Gastropoda

Naticidae, indeterminate

CAS 59832. Locality: Whittaker Bluff and vicinity (Arroyo San Antonio). Medium-grained, tan, moderately soft, fossiliferous sandstone located about 1/2 to 2/3 up from mouth of north-northwest heading canyon on the north side of Estero de San Antonio on Posey Ranch about 0.8 mile west-southwest of Estero bridge on Valley Ford-Franklin School Road, Sonoma County, California. 11,000 N and 11,000 E of SW corner of Valley Ford 7.5 quadrangle. Collected by R. Naidu, 16 June 1978.

Mollusca

Bivalvia

*Patinopecten?* sp.

CAS 59833. Whittaker Bluff and vicinity (Arroyo San Antonio). Medium- to coarse-grained, soft, tan to gray sandstone with burrows filled with coarse sandstone located at mouth of small canyon (next canyon east of CAS 59862) on the north side of Estero de San Antonio on Posey Ranch about 0.5 mile west-southwest of Estero bridge on Valley Ford-Franklin School Road, Sonoma County, California. 9,200 N and 12,600 E of SW corner of Valley Ford 7.5 quadrangle. Collected by P. Rodda, 16 June 1978.

Mollusca

Bivalvia

*Patinopecten?* sp.

CAS 60223. Locality: River Road. 1.5 m (5 ) thick bed dipping about 10<sub>i</sub> east-northeast consisting of gray to tan, fine-grained, soft, poorly bedded sandstone with obscure thin layers of pumice fragments and scattered molds of bivalves about 3.5 m (11.5 ) above base of measured section on slope of hill on the north side of River Road about 560 m (0.35 mile) east of its intersection with Trenton Road and about 1.65 km (5,400 ) south and 2.3 km (7,600 ) east of the northwest corner of Sebastopol 7.5 quadrangle. North of Trenton, Sonoma Co., California. Collected by P. U. Rodda, B. Roth, and R. Naidu, 9 February 1979.

Mollusca

Gastropoda

*Nassarius* sp.

*Olivella* sp.

CAS 60224. Locality: River Road. At top of 0.5 m (1.5 ) thick bed dipping about 10<sub>i</sub> east-northeast consisting of hard, shelly, fine grained sandstone with abundant disarticulated bivalves about 1.8 m (6 ) above base of measured section on slope of hill on the north side of River Road about 560 m (0.35 mile) east of its intersection with Trenton Road and about 1.65 km (5,400 ) S and 2.3 km (7,600 ) east of the northwest corner of Sebastopol 7.5 quadrangle. North. of Trenton, Sonoma Co., California. Collected by P. U. Rodda, B. Roth, and R. Naidu, 9 February 1979.

Mollusca

Bivalvia

*Protothaca?* sp.

*Solen?* sp.

Indeterminate bivalves

CAS 60225. Locality: River Road. 0.5 m (1.5 ) thick bed dipping about 10<sub>i</sub> east-northeast consisting of hard, shelly, fine grained sandstone with abundant disarticulated bivalves about 1.8 m (6 ) above base of measured section on slope of hill on the north side of River Road about 560 m (0.35 mile) east of its intersection with Trenton Road and about 1.65 km (5,400 ) south and 2.3 km (7,600 ) east of the northwest corner of Sebastopol 7.5 quadrangle. North of Trenton, Sonoma Co., California. Collected by P. U. Rodda, B. Roth, and R. Naidu, 9 February 1979.

Mollusca

Bivalvia

*Protothaca staley* (Gabb)?

Gastropoda

*Nassarius* sp.

CAS 60226. Whittaker Bluff and vicinity (Arroyo San Antonio). Gray-tan to yellow-brown sandstone just above the basal conglomerate in low bluff on the north side of Estero de San Antonio about 0.7 mile west of Valley Ford-Franklin School Road, Sonoma County, California.

Approximately 9,000 N and 11,500 E of the southwest corner of the Valley Ford 7.5 quadrangle.

Collected by R. Sullivan, 1974.

Mollusca

Bivalvia

Mytilidae?, indeterminate

*Patinopecten?* sp.

Echinodermata

Echinoidea

Indeterminate echinoid

CAS 60233. The locality number on the specimens in this collection are different from other CAS or SU collections. Also the specimens do not appear to be from the locality cited in either the CAS or SU locality catalogs for this number (i.e., Wilson Grove looking fossils from the Cretaceous of Utah). They are included here because they are in drawers associated with other collections from the Wilson Grove Formation and appear to be from the Wilson Grove Formation.

Arthropoda

Crustacea

Indeterminate crab fragments

CAS 60305 to CAS 60312, CAS 60314 are from sandstone exposures in Salmon Creek from 18 m (20 yd.) upstream (west) to 146 m (160 yd.) downstream (east) of bridge on Freestone Flat Road crossing Salmon Creek. General location is about 910 m (3,000 ) northwest of Freestone, in S1/2, SE1/4, NW1/4, section 12 (projected), T. 6 N., R. 10 W. 4.1 km (13,500 ) west and 0.46 km (1,500 ) north of southeast corner of Camp Meeker 7.5 quadrangle. Collected by P. Rodda, B. Roth, R. Naidu, and F. Perry, May 1979.

CAS 60305. Locality: Salmon Creek. Dark gray to brown, soft, fine- to medium-grained sandstone with scattered coarse black grains and mud-filled burrows in Salmon Creek and on north bank about 18 m (20 yd.) upstream (west) of bridge over Salmon Creek. Field No.: SA-1.

Mollusca

Bivalvia

*Yoldia?* sp.

CAS 60306. Locality: Salmon Creek. Gray-tan, moderately hard, fine- to medium-grained, concretionary sandstone with shells immediately overlying CAS 60305. Field No.: SA-2.

Mollusca

Bivalvia

Indeterminate bivalve

Gastropoda

*Crepidula princeps* (Conrad)

CAS 60307. Locality: Salmon Creek. Collection from upper 15 cm (6 ) of exposure in dark gray, medium- to fine-grained, muddy sandstone with abundant *Crepidula*. Outcrop in creek and on north bank immediately beneath the west side of the bridge. Field No.: SA-3.

Mollusca

Bivalvia

*Yoldia* sp.

Gastropoda

*Crepidula princeps* (Conrad)

CAS 60308. Locality: Salmon Creek. Shell molds in soft, yellow-brown weathering, fine- to medium-grained sandstone exposed in low north bank of Salmon River about 11 m (12 yd.) downstream (east) of bridge. Field No.: SA-4.

Mollusca

Bivalvia

*Solen?* sp.

CAS 60309. Locality: Salmon Creek. Shell molds in soft, yellow-brown weathering, fine- to medium-grained sandstone exposed in low north bank of Salmon River about 22 m (24 yd.) downstream (east) of bridge. Field No.: SA-5.

Mollusca

Bivalvia

*Macoma?* sp.

*Solen?* sp.

Gastropoda

Naticidae, indeterminate

CAS 60310. Locality: Salmon Creek. Shelly, fine- to medium-grained sandstone bed, 7.5 to 20 cm (3 to 8 ) thick which forms a weak ledge and is exposed for about 9.1 m (10 yd.) along the south bank of Salmon Creek beginning about 48.5 m (53 yd.) downstream (east) from bridge. Field No.: SA-6.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

*Panope* sp.

Gastropoda

*Lirabuccinum?* sp.

CAS 60311. Locality: Salmon Creek. Shells scattered in muddy, fine- to medium-grained sandstone and granule conglomerate exposed in steep, 3 m (10 ) high bank along the north side of Salmon Creek starting just east of CAS 60310 and extending for about 68.5 m (75 yd.) downstream (east).

Field No.: SA-7.

Brachiopoda

Articulata

*Terebratalia* sp.

Mollusca

Bivalvia

*Compsomyax?* sp.

*Solen?* sp.

*Yoldia?* sp.

Gastropoda

*Nucella* sp.

Arthropoda

Crustacea

*Balanus?* sp.

CAS 60312. Locality: Salmon Creek. Same shelly, fine- to medium-grained sandstone bed as exposed at CAS 60310, but located 43 m (47 yd.) downstream (east) of upstream end of CAS 60310 on the south bank of Salmon River; intervening area mostly covered with slopewash. Field No.: SA-8.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

*Macoma* sp.  
*Panope?* sp.  
Veneridae, indeterminate  
Gastropoda  
*Lirabuccinum?* sp.  
Naticidae, indeterminate

CAS 60314. Locality: Salmon Creek. 3 m (10 ) thick sequence of dark gray, muddy, fine- to medium-grained, bioturbated sandstone beginning 0.9 m (3 ) stratigraphically above CAS 60613. Section contains 8-10 thin, *Crepidula*-rich beds that extend for about 27 m (30 yd.) along the northeast bank of Salmon Creek, Sonoma County, California. Field No.: SA-10.

Mollusca

Gastropoda

*Crepidula princeps* (Conrad)

CAS 60461. Cut on SW side of Coffee Lane about 150 yd. north of its intersection with Occidental Road in lower 14 of tan, fine-grained, poorly bedded sandstone with scattered shell molds, Sonoma County, California. Collected by Peter Rodda and Raj Naidu, 7/18-20/1979, field number: CL-1.

Camp Meeker 7.5 quadrangle.

Mollusca

Bivalvia

*Anadara* sp.

*Patinopecten?* sp.

Veneridae, indeterminate

CAS 60462. Cut on southwest side of Coffee Lane about 150 yd. north of its intersection with Occidental Road in upper 4 of tan, fine-grained, poorly bedded sandstone with scattered shell molds, Sonoma County, California. Collected by Peter Rodda and Raj Naidu, 7/18-20/1979, field number: CL-2. Camp Meeker 7.5 quadrangle.

Mollusca

Bivalvia

Cardiidae?, indeterminate

Lucinidae, indeterminate

*Patinopecten?* sp.

*Tresus pajaroanus* (Conrad)?

Veneridae, indeterminate

CAS 60463. Specimens from fine-grained, tan to gray sandstone with shell molds in the lower 0.9 m (3 ) of 5.5 m (18 ) high road cut on the northwest side of Occidental Road about 0.5 km (1,700 ) west (by road) of Coffee Lane and 0.4 km (1,300 ) east (by road) of Green Hills Road 4.3 km (14,000 ) north and 1 km (3,300 ) west of southeast corner of Camp Meeker 7.5 quadrangle, Sonoma Co., California. Collected by P. Rodda and R. Naidu, 18-20 July 1979; field no. OR-1.

Mollusca

Bivalvia

*Securella?* sp.

Mactridae, indeterminate

CAS 60464. Road cut on the east side of Coleman Valley Road from 0.17 to 0.3 km (550 to 1,000 ) north of its intersection with Joy Road. Exposed section about 15 m (50 ) thick and consists mostly of fine-grained, gray to tan sandstone. The fossils were collected as molds from about 210 m (700 ) north of Joy Road in a 0.3 m (1 ) thick interval about 5.5 m (18 ) above the base of the road cut, Sonoma Co., California. Collected by P. Rodda and R. Naidu, 18-20 July 1979; field no. CV-1.

Mollusca

Bivalvia

Mactridae, indeterminate  
Veneridae, indeterminate

CAS 60466. Fossils from poorly bedded, fine-grained, tan to gray, extensively burrowed sandstone which starts about 1.2 m (4 ) above road level and extends to a heights of about 4.5 m (15 ) in road cut on east side of Estero Lane 18 m (60 ) southeast of its intersection with Bay Highway (=US 1). 4.3 km (14,200 ) south and 1.1 km (3,600 ) east of northwest corner of Valley Ford 7.5 quadrangle, Sonoma Co., California. Collected by P. Rodda and R. Naidu, 18-20 July 1979; field no EL-1.

Mollusca

Bivalvia

*Patinopecten* sp.

CAS 60467. Small shells weathering in relief from huge sandstone concretions (to 8 diameter, mostly 3 to 5 ) beside ranch gate on Estero Lane and in field about 500 NW and 1.4 mile (by road) south of junction of Estero Lane and Bay Highway (U.S. Highway 1). The concretions are from an excavation for a waste-water pond (for Bodega Harbor Development) on top of hill 515, 20,000 south and 1,600 east of northwest corner of Valley Ford 7.5 quadrangle, Sonoma County, California. Collected by P. Rodda and R. Naidu (?). Field No.: EL-2

Mollusca

Gastropoda

*Cryptonatica* sp., cf. *C. affinis* (Gmelin)

CAS 60468. Locality: Ebabias Creek. Exposure extends for about 90 m (100 yd.) in bottom and bank of a branch of Ebabias Creek in lower 1.2 m (4 ) of gray-tan, fine-grained sandstone with concretions containing shells. Located about 0.55 km (1,800 ) north-northeast of Furlong ranch house, and 1.3 km (4,400 ) east of intersection of Valley Ford-Freestone Road with Bodega Highway. 2.6 km (8,400 ) west and 2 km (6,400 ) south of northeast corner of Valley Ford 7.5 quadrangle in SW1/4, section 18, T. 6 N., R. 9 W, Sonoma Co., California. Collected by P. Rodda and R. Naidu, 18-20 July 1979; field no: EB-1.

Mollusca

Bivalvia

Lucinidae, indeterminate

Mactridae, indeterminate

*Patinopecten* sp.

*Protothaca?* sp.

Gastropoda

Naticidae, indeterminate

CAS 60469. Locality: Ebabias Creek. Exposure extends for about 46 m (50 yd.) in bottom and bank of a branch of Ebabias Creek in 0.9 m (3 ) of thick gray-tan, tuffaceous sandstone overlying CAS 60468. Located about 0.55 km (1,800 ) north-northeast of Furlong ranch house, and 1.3 km (4,400 ) east of intersection of Valley Ford-Freestone Road with Bodega Highway. 2.6 km (8,400 ) west and 2 km (6,400 ) south of northeast corner of Valley Ford 7.5 quadrangle in SW1/4, section 18, T. 6 N., R. 9 W, Sonoma Co., California. Collected by P. Rodda and R. Naidu, 18-20 July 1979; field no. EB-2.

Mollusca

Bivalvia

Mactridae, indeterminate

*Solen?* sp.

CAS 60470. Locality: Ebabias Creek. Three foot thick basal conglomerate containing boulders of Franciscan schist overlain by 12 to 15 of coarse- to fine-grained, gray, poorly bedded sandstone with shells exposed in waterfall and steep banks of Ebabias Creek immediately downstream from bridge on Furlong Ranch Road about 1,000 south-southwest of ranch house and 4,300 southeast of

intersection of Valley Ford-Freestone Road with Bodega Highway, Sonoma County, California. Collected by P. Rodda and R. Naidu (?). Field No. EB-3.

Brachiopoda

Inarticulata

*Discinisca* sp., cf. *D. cumingii* Broderip

Mollusca

Bivalvia

*Chlamys?* sp.

*Mytilus* sp.

*Panope?* sp.

Pectinidae, indeterminate

*Tresus pajaroanus* (Conrad)?

Gastropoda

*Crepidula?* sp.

Arthropoda

Crustacea

*Balanus?* sp.

CAS 60471. Exposure of tan to gray, fine-grained, poorly bedded sandstone in low road cut and ditch on east side of Valley Ford-Franklin School Road about 0.75 mile south of intersection with Dillon Beach Road (map measured), Marin County, California. 16,800 E and 3,400 north of southeast corner of Two Rocks 7.5 quadrangle in SE1/4, section 22, T. 5 N., R. 10 W. Collected by P. Rodda and R. Naidu, 7/18-20/1979; field no.: DB-1.

Mollusca

Bivalvia

*Patinopecten?* sp.

CAS 60472. Locality: Roblar Road. Low cut on south side of Roblar Road beginning 450 east of its intersection with Canfield Road and extending east for about 900 . First 300 exposes tan, fine grained sandstone with abundant shell molds, Sonoma County, California. Locality is 19,000 south and 12,400 west of northeast corner of Two Rocks 7.5 quadrangle. Collected by P. Rodda and R. Naidu, 7/18-20/1979; field no. RR-2.

Mollusca

Bivalvia

*Cryptomya?* sp.

*Siliqua* sp.

Gastropoda

*Nassarius* sp.

CAS localities 60474 to 60479 are from Steinbeck Ranch, NW side of Roblar Road about 1.4 km (0.9 mile) southwest of Canfield Road Fossils collected from two overlapping sections. Section 1 was measured up the first northwest-trending gully north of the ranch house; beginning 550 m (1,800 ) N14<sub>1</sub>W of the ranch house at the 380 contour and proceeding up the gully to the 510 elevation. This section begins 5.9 km (19,500 ) south and 5.4 km (17,600 ) west of northeast corner of the Two Rocks 7.5 quadrangle. Fossils were collected from 4 horizons in highest exposed unit, a concretionary, fine-grained, gray to tan sandstone, with shells generally abundant in concretions and scattered in the softer sandstone (SR-2; SR-3; SR-4, SR-5). Section 2 was measured up the west side of the third northwest-heading gully, beginning 0.9 km (2,900 ) N27<sub>1</sub>E of the ranch house from an elevation of 210 up to the top of a large crag (elevation 405 ). The top of the crag is located 5.6 km (18,300 ) south and 4.9 km (16,200 ) west of the northeast corner of the Two Rocks 7.5 quadrangle. Fossils were collected from hard sandstone concretions between 12.5 m (41 ) and 14.0 m (46 ) above the base of the section (SR-1) and from a moderately hard, gray, burrowed sandstone 8.2 m (27 ) below top of crag (SR-6). Sonoma Co. California. Collected by P. Rodda and R. Naidu, 18-20 July 1979.

CAS 60474. Locality: Steinbeck Ranch. Samples from 12 thick fine-grained, gray to tan, poorly bedded, concretionary layer with abundant shells the top of which is about 130 below top of section 2. Field no. SR-1

Mollusca

Bivalvia

*Patinopecten?* sp.

*Securella?* sp.

Veneridae?, indeterminate

Gastropoda

*Antiplanes* sp.

CAS 60475. Locality: Steinbeck Ranch. Sample from near base of a 16 thick, fine-grained sandstone with abundant concretions the base of which is about 6 below top of section 1.

Mollusca

Bivalvia

Veneridae, indeterminate

CAS 60476. Locality: Steinbeck Ranch. Sample from near the middle of a 16 thick, fine-grained sandstone with abundant concretions the base of which is about 6 below top of section 1. Field no. SR-3.

Mollusca

Bivalvia

*Siliqua?* sp.

CAS 60478. Locality: Steinbeck Ranch. Sample from near the base (below CAS 60475) of a 16 thick, fine-grained sandstone with abundant concretions the base of which is about 6 below top of section 1. Field no. SR-5

Mollusca

Bivalvia

Veneridae?, indeterminate

CAS 60479. Locality: Steinbeck Ranch. Sample from about 10 above the base of a 37 thick, isolated, craggy knob of fine-grained, poorly bedded, gray sandstone with burrows to 1 diameter and 1 in length. The top of this unit marks the top of section 2. Field no. SR-6.

Mollusca

Bivalvia

Cardiidae, indeterminate

Veneridae, indeterminate

CAS 60480 to CAS 60483 are from Steinbeck Ranch on the northwest side of Roblar Road. Thin section exposed in low cut (about 55 m long and 3 m high) on west side of turkey brooder about 300 N of the ranch house and about 21,000 south and 16,900 west of northeast corner of the Two Rocks 7.5 quadrangle, Sonoma County, California. Beds dip about 5° northeast. Collected by Raj Naidu, Frank Perry, Mike Mullen, Barry Roth, and Peter Rodda, 8/1/1979.

CAS 60480. Locality: Steinbeck Ranch. Fossils from 3 thick, tan, medium- to coarse-grained, granular, tuffaceous sandstone with scattered shell molds which starts about 6 above base of section.

Mollusca

Bivalvia

*Cryptomya?* sp.

*Solen?* sp.

*Tresus pajaroanus* (Conrad)?

Gastropoda

*Nassarius* sp.

CAS 60481. Locality: Steinbeck Ranch. Fossils from 6 thick, tan to gray, fine-grained, poorly-bedded sandstone with scattered shell molds which starts about 9 above base of section.

Mollusca

Bivalvia

*Cryptomya?* sp.

*Siliqua* sp.

*Solen* sp.

*Tellina?* sp.

Gastropoda

Naticidae, indeterminate

CAS 60482. Locality: Steinbeck Ranch. Fossils from 1 thick, dark gray, extensively burrowed, fine-grained sandstone with abundant shell molds.

Mollusca

Bivalvia

*Cryptomya?* sp.

Gastropoda

*Lirabuccinum?* sp.

Naticidae, indeterminate

Neogastropoda, indeterminate

*Olivella* sp.

CAS 60484 to CAS 60487, CAS 60489 are from an old dump site on Mark Scott Ranch, southeast side of Roblar Road, western Sonoma County, California. The dump site has 3 levels of cut slope and fill benches. Fossiliferous sands and tuffaceous sediments are exposed principally in the large cuts. Beds dip about 9° northwest and essentially the same sequence is exposed in each cut.

Topographically the lowest exposures are in a small gully and low cut above the E end of the lower bench. The next highest exposures are in long, high cuts about the east end of the middle bench.

The highest exposures are in a long, cut above the central part of the upper bench. Fossils were collected from the middle and upper benches. Localities in the middle cut are 13,800 west and 19,600 to 19,800 south, and the upper cut locality is 14,000 W and 20,600 south of northeast corner of the Two Rocks 7.5 quadrangle. Collected by Raj Naidu, Frank Perry, Mike Mullen, Barry Roth, and Peter Rodda, 8/1979.

CAS 60484. Locality: Roblar Road. This locality is in lower part of 4 thick tuffaceous sandstone with layers of very fine-grained gray ash about 52+ below top of exposure. Field No.: DS-1.

Mollusca

Bivalvia

Mactridae?, indeterminate

*Siliqua* sp.

*Solen* sp.

Gastropoda

*Nassarius* sp.

CAS 60485. Locality: Roblar Road. This locality is in lower part of 4 thick tuffaceous sandstone with layers of very fine-grained gray ash about 52 below top of exposure. Field No.: DS-2.

Mollusca

Bivalvia

Mactridae, indeterminate

Gastropoda

Naticidae, indeterminate

CAS 60486. Locality: Roblar Road. This locality is in lower part of 24 thick slightly tuffaceous, fine-grained, gray to tan, cross-bedded and channeled sandstone about 46 below top of exposure. Field No.: DS-3.

Mollusca

Bivalvia

Lucinidae, indeterminate

Mactridae, indeterminate

*Solen* sp.

CAS 60487. Locality: Roblar Road. This locality is in upper part of 24 thick slightly tuffaceous, fine-grained, gray to tan, cross-bedded and channeled sandstone about 34 below top of exposure. Field No.: DS-4.

Mollusca

Bivalvia

*Anadara* sp.

Cardiidae, indeterminate

Mactridae, indeterminate

*Siliqua?* sp.

*Yoldia* sp.

Gastropoda

Naticidae, indeterminate

CAS 60489. Locality: Roblar Road. This locality is in upper part of 24 thick slightly tuffaceous, fine-grained, gray to tan, cross bedded and channeled sandstone about 28 below top of exposure. Field No.: DS-3.

Mollusca

Bivalvia

Cardiidae, indeterminate

*Macoma?* sp.

Mactridae, indeterminate

Pectinidae, indeterminate

*Siliqua* sp.

*Solen?* sp.

Gastropoda

*Nassarius?* sp.

Naticidae, indeterminate

*Trophosycon* sp.

CAS 60613. Locality: Salmon Creek. Same shelly bed as at CAS 60310 and CAS 60312 with abundant *Crepidula* and bone fragments. Locality on north side of Salmon Creek near bend. Field No.: SA-9.

Mollusca

Bivalvia

*Clinocardium?* sp.

*Macoma* sp.

*Panope* sp.

*Protothaca staleyi* (Gabb)

*Solen?* sp.

*Tresus pajaroanus* (Conrad)?

Veneridae, indeterminate

Gastropoda

*Crepidula princeps* (Conrad)

*Lirabuccinum?* sp.

CAS 60750. Locality: Meacham Hill. Specimens from road cut along U.S. Highway 101 on the south side of Meacham Hill about 610 to 790 m (2,000 to 2,600 ) southeast of basalt quarry shown on Cotati 7.5 quadrangle, Sonoma Co., California. Collected by R. B. W. Naidu, 1959.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)?

*Siliqua* sp.

Gastropoda

*Nassarius* sp.

Naticidae, indeterminate

*Nucella* sp.

Arthropoda

Crustacea

Indeterminate crab parts

CAS 60765. Locality: Meacham Hill. Specimens from basal pebble-cobble conglomerate overlying volcanics in road cut along U.S. HIGHWAY 101 on the south side of Meacham Hill about 625 m (2,050 ) southeast of basalt quarry shown on Cotati 7.5 quadrangle., Sonoma Co., California.

Mollusca

Gastropoda

*Olivella* sp.

CAS 60783. Locality: Wilson Grove. At southwest end of same northwest facing bluff as CAS 54680 and about 180 m (200 yd.) southwest. Consists of steep lower slope (18 m; 60 ) followed by a sequence of alternating hard and soft beds of medium to fine sandstone, with abundant shells (6 m; 20 ) and an upper sequence of similar shelly sandstone, poorly exposed (6 m; 20 ). Fossils were collected from the basal bed of the lower sandstone sequence, Sonoma County, California. NW1/4, section 28 (projected), T. 8 N., R. 9 W., Healdsburg 7.5 (1955 ed.) quad. Collected by R.B.W. Naidu, P. Rodda, and M. Wolterding, July 15, 1980.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)?

*Macoma* sp., cf. *M. nasuta* (Conrad)

*Protothaca* sp.

*Solen?* sp.

*Tresus* sp., cf. *T. nuttallii* (Conrad)

CAS 60819. Locality: Meacham Hill. Specimens from road cut along U.S. HIGHWAY 101 on the south side of Meacham Hill about 610 m (2,000 ) southeast of basalt quarry shown on Cotati 7.5 quadrangle., Sonoma Co., California. Collected by R. B. W. Naidu, 1959. [Ex Sonoma State College Geology Department via R. Naidu].

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)?

Veneridae, indeterminate

Gastropoda

*Nassarius* sp.

Arthropoda

Crustacea

Indeterminate crab parts

CAS 60934. Fossils from an iron-rich sandstone of Merced Formation in section 31, T. 7 N., R. 9 W., Camp Meeker 7.5 quadrangle, Sonoma Co., California. Collected by T. Bedrossian, 9/23/80; field no. B-55.

Mollusca

Bivalvia

*Tresus pajaroanus* (Conrad)?

CAS 60937. Fossils from an iron-rich sandstone of Merced Formation in section 20, T. 6 N., R. 9 W., Two Rocks 7.5 quadrangle, Sonoma Co., California. Collected by T. Bedrossian, 11/13/80; field no. A-138.

Mollusca

Bivalvia

Veneridae, indeterminate

CAS 69236. Locality: Wilson Grove. Wilson Ranch SW of Windsor about 1 mi north of Trenton Station on Mark West Creek, Russian River Valley, Sonoma County, California. Collected by H.G. Schenck, A.J. Dusenbury, Jr., P. Reinhart, and D.L. Fizzell, May 13, 1932. Schenck numbers S569, S630, S633-S640.

Mollusca

Bivalvia

*Clinocardium* sp.

*Cryptomya californica* (Conrad)

*Macoma* sp., cf. *M. addicotti* Nikas

Mactridae, indeterminate

*Protothaca* sp., cf. *P. staleyi* (Gabb)

*Solen* sp.

Gastropoda

*Crepidula* sp.

*Olivella biplicata* (Sowerby)

*Nucella transcoana* Arnold

#### Los Angeles County Museum of Natural History

LACMIP 2378. Locality: River Road. Marine invertebrate fossils presented to the museum by Mr. Harold Meals with label that reads: Pliocene / Merced Fm. / Guerneville River Road / Just over River Bridge / 4.8 mi from 101 sub. St. This is west of U.S. Highway 101. Reference: Addicott, W. O., 1969, Proc. Calif. Acad. Sci., ser. 4, v. 37, no. 3, pp. 57-93. One paired *Nuttallia jamesi* Roth & Guruswami-Naidu, 1974 given to UCLA: Jan. 1975. Sonoma Co., CA. Collected by Harold S. Meals, 4/1971.

Mollusca

Bivalvia

*Macoma* sp., cf. *M. addicotti* Nikas

*Nuttallia jamesi* Roth and Guruswami-Naidu

*Protothaca staleyi* (Gabb)

*Siliqua?* sp.

*Solen* sp.

*Yoldia* sp.

Gastropoda

*Astyris?* sp.

*Megasurcula* sp.

*Nassarius* sp., cf. *N. grammatus* (Dall)

Naticidae, indeterminate

*Nucella transcoana* Arnold

*Nucella* sp.

*Olivella biplicata* (Sowerby)

*Ophiodermella* sp., cf. *O. graciosa* Arnold

LACMIP 4509. Locality: Wilson Grove. Buff colored sandstone with abundant fossils exposed on W side of small hill (Wilson Grove Redwoods) E of Russian River, approximately 2.9 mile[s] north of River Road and about 6 mile[s] due south of the town of Healdsburg, Sonoma Co., CA. Healdsburg 7.5 quadrangle. Collected by T. Susuki, 7/6/1962.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)  
*Clinocardium* sp., cf. *C. meekianum* (Gabb) *s.l.*  
*Cryptomya californica* (Conrad)  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Macromeris* sp., cf. *M. polynyma* (Stimpson)  
Mactridae, indeterminate  
*Modiolus* sp.  
*Pandora* sp.  
*Protothaca staley* (Gabb)  
*Solen* sp.

Gastropoda

*Astyris?* sp.  
*Calicantharus?* sp.  
*Fusitriton* sp., cf. *F. oregonensis* (Redfield)  
*Nassarius* sp., cf. *N. californicus* (Conrad)  
*Nassarius* sp., cf. *N. grammatus* (Dall)  
Naticidae, indeterminate  
*Nucella* sp., cf. *N. transcoana* Arnold  
*Olivella biplicata* (Sowerby)  
*Ophiidermella* sp., cf. *O. graciosa* Arnold

LACMIP 11774. Locality: Whittiker Bluff and vicinity (Middle Road). UCD locality A-275: Sebastopol quadrangle, 2 miles directly south of Valley Ford on Whittiker Bluff Road. / About 3 meters above the base of the road lies a gray, well cemented, fine[-grained] sandstone shell bed containing unidentifiable fragments. Sonoma Co., CA. Collected by J. Coughlin, prior to 5/1988.

Mollusca

Bivalvia

*Clinocardium* sp.

LACMIP 11775. Locality: Salmon Creek. UCD locality A-277: Sebastopol quadrangle, 1/2 mile north of the town of Freestone, 200 feet east of the railroad tressel (Dickerson s locality 413, 1922). In the stream bed lies a poorly sorted, yellow-brown sandstone containing abundant molds and casts of the *Cryptomya* community. Sonoma Co., CA. Collected by J. Coughlin, prior to 5/1988.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)  
Mactridae, indeterminate  
*Solen* sp.

LACMIP 11776. Locality: River Road. UCD locality A-281: Healdsburg quadrangle, on Eastside Road 1 mile north of the fork with Trenton-Healdsburg Road. A poorly sorted, gray sandstone interspersed with hardened lenses is found about 3 feet from the base of the road. The fauna in this outcrop is similar to that of locality A-280. Sonoma Co., CA. Collected by J. Coughlin, prior to 5/1988.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

Mactridae, indeterminate  
*Protothaca* sp., cf. *P. staley* (Gabb)  
*Securella*? sp.  
*Siliqua*? sp.  
*Solen* sp.

Gastropoda

*Crepidula princeps* Conrad  
*Nassarius* sp., cf. *N. californicus* (Conrad)  
*Nassarius* sp., cf. *N. grammatus* (Dall)

LACMIP 11777. UCD locality A-279: Sebastopol quadrangle, Thorn residence on Lewis Road, 1/8 mile south of intersection with Vine Hill Road. About 2 feet above the road cut lies a poorly sorted, gray to yellow-brown sandstone. Molds and casts of the *Cryptomya* pelecypod community are found, but gastropods have not been discovered. Sonoma Co., CA. Collected by J. Coughlin, prior to 5/1988.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)  
Mactridae, indeterminate  
*Protothaca staley* (Gabb)

Gastropoda

*Nassarius* sp., cf. *N. grammatus* (Dall)

LACMIP 11778. Locality: River Road. UCD locality A-280: Sebastopol quadrangle, on River Road 1/10 mile east of the intersection with Vine Hill Road. At the top of the hill, about 20 feet above the base of the road, lies a very well sorted, loosely consolidated, gray sandstone. It is underlain by a one-foot-thick, hard shell-bed and contains abundant fossils of the *Macoma* community including large numbers of *Nassa* sp., *Olivella biplicata*, and *Siliqua* sp. Sonoma Co., CA. Collected by J. Coughlin, prior to 5/1988.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)  
*Macoma* sp., cf. *M. addicotti* Nikas  
Mactridae, indeterminate  
*Solen* sp.

Gastropoda

*Nassarius* sp., cf. *N. californicus* (Conrad)  
*Nassarius* sp., cf. *N. grammatus* (Dall)  
Naticidae, indeterminate  
*Olivella biplicata* (Sowerby)

LACMIP 15341. Locality: Wilson Grove. Specimens in the UCLA collection with labels that have species names and read: State: California, County: Sonoma, T. 8 N., R. 9 W., M.D.W. / Wilson's Ranch southwest of Windsor, about one mile north of Trenton Station on Mark West Creek. The locality is in the Russian River Valley. Formation: Merced, Age: Pliocene. Collected by A. Dusenbury, D. L. Frizzell, P. W. Reinhart, and H. G. Schenck, 5/13/1932.

Mollusca

Bivalvia

*Protothaca staley* (Gabb)

Museum of Paleontology, University of California at Berkeley

UCMP 3614. Merced Formation from near Petaluma, Sonoma Co., California. Latitude: 38.1°N; longitude: 122.2°W. Collector unknown.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)

*Anadara* sp.

*Panope?* sp.

Indeterminate bivalves

Gastropoda

Neogastropoda indeterminate

UCMP 7025. Bennett Valley 5.5 mi southeast of Santa Rosa on the left bank of Mantanzas Creek about 4 mi north of Grangers Hall, Sonoma County, California. Santa Rosa 7.5 quadrangle (?).

Latitude: 38.1°N; longitude 122.2°W. Collected by R. Miller.

Mollusca

Bivalvia

*Solen* sp.

Indeterminate bivalves

UCMP 7033. Locality: Wilson Grove. 3.5 mi southwest of Winsor on Wilson Ranch, east bank of Russian River, (also Sather Tower), Sonoma Co., California. Latitude: 38.2°N; longitude 122.2°W.

Collector unknown.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)

*Clinocardium* sp., cf. *C. meekianum* (Gabb)

*Cryptomya californica* (Conrad)

*Macoma* sp., cf. *M. addicotti* Nikas

*Macoma* sp.

*Macromeris* sp., cf. *M. albaria* (Conrad)

Mactridae, indeterminate

*Ostrea* sp.

*Protothaca* sp., cf. *P. staleyi* (Gabb)

*Protothaca?* sp.

*Siliqua* sp.

*Solen* sp.

*Tresus?* sp.

Gastropoda

*Crepidula princeps* Conrad

*Crepidula* sp.

*Cryptonatica?* sp.

*Megascurcula carpenteriana* (Gabb)

*Nassarius californianus* (Conrad)

*Nassarius grammatus* (Dall)

*Nassarius* sp.

Naticidae, indeterminate

*Olivella biplicata* (Sowerby)

*Ophiodermella* sp., cf. *O. graciosana* Arnold

UCMP 10753. Locality: Whittaker Bluff and vicinity (Arroyo San Antonio). SE/4, SW/4, SW/4, section 10 (projected), T. 5 N., R. 10 W., Valley Ford 7.5 quadrangle, Sonoma Co., California.

Latitude: 38°17'8" N; longitude: 122°57'8" W. Collected by D. Dippel; field number Dippel s MRN. 1.

Mollusca

Bivalvia

*Patinopecten?* sp.

UCMP 10754. Locality: Whittaker Bluff and vicinity (Middle Road). SW/4, NE/4, SW/4, section 14 (projected), T. 5 N., R. 10 W., Valley Ford 7.5 quadrangle, Sonoma Co., California. Latitude: 38;16 30 N; longitude: 122;55 52 W. Collected by D. Dippel; field number: MRN. 2.

Mollusca

Bivalvia

*Patinopecten?* sp.,

UCMP 10755. Locality: Whittaker Bluff and vicinity (Whittaker Bluff). SE/4, SW/4, NE/4, section 15, T. 5 N., R. 10 W., Valley Ford 7.5 quadrangle, Sonoma Co., California. Latitude: 38;16 40 N; longitude: 122;56 35 W. Collected by D. Dippel; field number: MRN. 3 lower.

Mollusca

Bivalvia

*Tresus* sp., cf. *T. pajaroanus* (Conrad)

Indeterminate bivalve

Gastropoda

*Lirabuccinum?* sp.

*Nassarius?* sp.

Naticidae, indeterminate

Neogastropod, indeterminate

Scaphopoda

*Dentalium?* sp.

UCMP 10756. Locality: Whittaker Bluff and vicinity (Arroyo San Antonio). SE/4, NW/4, SW/4, section 15, T. 5 N., R. 10 W., Valley Ford 7.5 quadrangle, Sonoma Co., California. Latitude: 38;17 8 N; longitude: 122;57 8 W. Collected by D. Dippel; field number: MRN. 4.

Mollusca

Bivalvia

Mactridae, indeterminate

*Modiolus* sp.

Pectinidae, indeterminate

Indeterminate bivalve

Gastropoda

*Fusitriton?* sp.

Neogastropoda, indeterminate

UCMP 10757. Locality: Whittaker Bluff and vicinity (Arroyo San Antonio). SW/4, NE/4, SE/4, section 16 (projected), T. 5 N., R. 10 W., Valley Ford 7.5 quadrangle, Sonoma Co., California. Latitude: 38;16 32 N; longitude: 122;57 29 W. Collected by D. Dippel; field number: MRN. 5.

Mollusca

Bivalvia

Mactridae, indeterminate

*Modiolus* sp.

*Panomya* sp.

*Solen* sp.

*Tresus* sp., cf. *T. pajaroanus* (Conrad)

Indeterminate bivalve

Gastropoda

Neogastropoda, indeterminate

Arthropoda

Crustacea

Indeterminate crabs (2 taxa)

Echinodermata

Echinoidea

Indeterminate sea urchin

UCMP 10758. Locality: Whittaker Bluff and vicinity (Middle Road). NW/4, NW/4, SE/4, section 14, T. 5 N., R. 10 W., Valley Ford 7.5 quadrangle, Sonoma Co., California. Latitude: 38;16 36 N; longitude: 122;55 33 W. Collected by D. Dippel; field number: MRN. 15.

Mollusca

Bivalvia

*Lituyapecten* sp., cf. *L. turneri* (Arnold)

Mactridae, indeterminate

Pectinidae, indeterminate

Gastropoda

*Nassarius* sp.

UCMP A863. Locality: Wilson Grove. West side of small hill 0.25 mile west of highway at Wilson s Ranch, east of Russian River and about 2 miles north of south edge of Healdsburg quadrangle, Sonoma County, California. Latitude 38.2;N; longitude 122.2;W. Collected by F. Johnson.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

*Macoma* sp., cf. *M. addicotti* Nikas

Mactridae, indeterminate

*Protothaca* sp., cf. *P. staleyi* (Gabb)

*Tresus?* sp.

UCMP A864. Locality: Wilson Grove. Same locality as UCMP A863 except in large shell reef. UCMP A863 located: West side of small hill 0.25 mile west of highway at Wilson s Ranch, east of Russian River and about 2 miles north of south edge of Healdsburg quadrangle, Sonoma County, California. Latitude 38.2;N; longitude 122.2;W. Collected by F. Johnson.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)

*Clinocardium* sp.

*Cryptomya californica* (Conrad)

*Macoma* sp., cf. *M. addicotti* Nikas

*Macoma* sp.

*Macromeris* sp., cf. *M. albaria* (Conrad)

*Modiolus* sp.

*Pandora* sp.

*Protothaca* sp., cf. *P. staleyi* (Gabb)

*Solen* sp.

*Tresus* sp.

Gastropoda

*Crepidula* sp.

*Nassarius grammatus* (Dall)

Naticidae, indeterminate

*Nucella* sp., cf. *N. transcoana* Arnold

*Ophiodermella* sp., cf. *O. graciosa* Arnold

UCMP A865. Locality: Wilson Grove. Canyon 0.5 mile southeast of Wilson s Ranch, east of Russian River and about 2 miles north of south edge of Healdsburg quadrangle, Sonoma County, California. Latitude 38.2;N; longitude 122.2;W. Collected by F. Johnson.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)  
*Clinocardium* sp.  
Mactridae, indeterminate  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
*Mactromeris* sp., cf. *M. polynyma* (Stimpson)  
*Protothaca* sp., cf. *P. staleyi* (Gabb)

UCMP A866. Locality: Bloomfield Quarry(?): 1 mile southeast road 4 miles west of Dunham school just above Franciscan contact with the Merced Formation. Three fossiliferous beds are present, the lowest is UCMP A867, the middle is UCMP A866, the upper is UCMP A868, Sonoma County, California. T. 6 N., R. 9 W., Sebastopol 7.5 quadrangle. Latitude: 38.1°N; longitude 122.2°W. Collected by F. Johnson.

Mollusca

Bivalvia

Cardiidae, indeterminate  
*Clinocardium* sp.  
*Macoma* sp.  
Pectinidae, indeterminate  
*Protothaca* sp.  
Veneridae, indeterminate

Gastropoda

*Nucella* sp.

UCMP A867. Locality: Bloomfield Quarry(?). 1 mile southeast road 4 miles west of Dunham school just above Franciscan contact with the Merced Formation. Three fossiliferous beds are present, the lowest is UCMP A867, the middle is UCMP A866, the upper is UCMP A868, Sonoma County, California. Latitude: 38.1°N; longitude 122.2°W. T. 6 N., R. 9 W., Sebastopol 7.5 quadrangle. Collected by F. Johnson.

Mollusca

Gastropoda

*Olivella biplicata* (Sowerby)

UCMP A868. Locality: Bloomfield Quarry(?). 1 mile southeast road 4 miles west of Dunham school just above Franciscan contact with the Merced Formation. Three fossiliferous beds are present, the lowest is UCMP A867, the middle is UCMP A866, the upper is UCMP A868, Sonoma County, California. Latitude: 38.1°N; longitude 122.2°W. T. 6 N., R. 9 W., Sebastopol 7.5 quadrangle. Collected by F. Johnson.

Mollusca

Bivalvia

*Protothaca staleyi* (Gabb)

Arthropoda

Crustacea

*Balanus?* sp.

UCMP A869. Locality: Salmon Creek. 0.5 mile N of Freestone and about 200 east of trestle over Salmon Creek, Sebastopol 7.5 quadrangle, Sonoma County, California. Latitude: 38.1°N; longitude 122.2°W. Collected by F. Johnson.

Mollusca

Bivalvia

*Cryptomya* sp.  
*Macoma* sp.  
Mactridae, indeterminate  
*Panope abrupta* (Conrad)

*Saxidomus?* sp.  
*Solen* sp.  
*Tresus?* sp.  
Veneridae, indeterminate

Gastropoda

*Calyptraea* sp.  
*Crepidula princeps* Conrad  
*Fusinus?* sp.  
*Lirabuccinum portolaensis* (Arnold)

UCMP A870. Across road from UCMP A866 (to west) near the top of the ridge (368 ) above Franciscan contact with Merced Formation, Sonoma County, California. Latitude: 38.1°N; longitude 122.2°W. Sebastopol 7.5 quadrangle. Collected by F. Johnson.

Mollusca

Bivalvia

*Securella?* sp.  
*Protothaca* sp., cf. *P. staley* (Gabb)  
*Protothaca* sp.

UCMP A873. On top of small hill 0.5 mile east of road connecting the Two Rocks-Bloomfield Road with the Two Rocks-Fallon Road, and about 1.25 miles north from connection of this road with the Two Rocks-Fallon Road, Sonoma County, California. Latitude: 38°17' N., longitude: 123°38' 17" W. Sebastopol Quadrangle. Collected by F. Johnson.

Mollusca

Bivalvia

*Macoma?* sp.  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
*Solen* sp.  
Indeterminate bivalve

Gastropoda

Naticidae, indeterminate  
*Olivella biplicata* (Sowerby)

UCMP A4189. Gray coarse sand and olive-gray silt in cliff on right bank of a tributary to Haggin Creek (see USGS Santa Rosa Quadrangle, 1916 ed.), at an elevation of about 300 . Approximate bearings and distance from 3 points in southern ninth of Santa Rosa Quadrangle: (1) 6,900 S36°W from Stony Butte (953); (2) 7,000 N15.5°E from road intersection 167 (at Waugh School); and (3) 5,400 S38°E from road intersection 199, Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Cotati 7.5 quadrangle. Collected by T. F. Harriss and J. W. Thomas, 2/9/1942; field number: 3-25.

Mollusca

Bivalvia

Veneridae, indeterminate

UCMP A4190. Olive-drab clayey silt at lip of waterfall in unnamed creek about 0.75 mile W of Adobe Creek at an elevation of about 270 . Approximate bearings and distance from 3 points in southern ninth of Santa Rosa Quadrangle: (1) 5,500 N44°E from road intersection 125 ; (2) 1,900 N52°W from hill 427; and (3) 9,200 N20°W from Adobe Fort (see USGS Santa Rosa Quadrangle, 1916 ed.), Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Glen Ellen 7.5 quadrangle. Collected by T. F. Harriss, 1/15/1942; field number: 4-45.

Mollusca

Gastropoda

Indeterminate gastropods

UCMP A6886. Locality: Whittaker Bluff and vicinity. From green sand exposed in road cut on road running east along north side of Estero de San Antonio, Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Sebastopol quadrangle. Collected by H. T. Harlyn and Z. M. Arnold, 1/5/1951.

Mollusca

Bivalvia

*Lituyapecten turneri* (Arnold)

UCMP A6890. These fossils occur in a dark-gray, clayey, fine-grained, sandstone in a shallow creek at about the 275 contour about 3,600 N28°E of hill 593, Sonoma County, California. Latitude: 38.1°N.; longitude: 122.2°W. (Rectangular coordinates: 233100N., 1779100E). Two Rocks 7.5 quadrangle. Collected by R. B. Travis, 8/1949; field number: PS3.

Mollusca

Bivalvia

*Cryptomya* sp.

Gastropoda

*Nassarius* sp.

UCMP A6892. This locality is in the bottom of a small creek in the extreme northeast corner of section 16 (NE/4, NE1/4), R. 9 W., T. 7 N. The thin ledge of hard, gray, fine-grained, sandstone which hosts the fossils is exposed for 20-30 yds along the bottom of the creek. The owner of the property has made a picnic and BBQ area here so the locality is easily accessible, Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Sebastopol 7.5 quadrangle. Collected by R. B. Travis, 7/1948; field number: CS-13.

Mollusca

Bivalvia

*Anadara* sp.

*Clinocardium* sp.

*Cryptomya?* sp.

*Macoma* sp.

Mactridae?, indeterminate

*Protothaca?* sp.

Indeterminate bivalves

Gastropoda

*Nassarius* sp., cf. *N. grammatus* (Dall)

Naticidae, indeterminate

*Olivella* sp.

UCMP A6893. Poorly preserved fossils (apparently reworked) in beds are composed of soft, dark gray to brown, fine-grained, sandstone exposed in road cut about 600 east of road intersection at an elevation of about 172, Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Two Rocks 7.5 quadrangle. Collected by R. B. Travis, 6/1950; field number: LS-16.

Mollusca

Bivalvia

Pectinidae, indeterminate

Indeterminate bivalves

Gastropoda

Naticidae, indeterminate

Indeterminate gastropod

UCMP A6894. Locality: Whittaker Bluff and vicinity. Fossils well exposed in road cut 700 southeast along road from intersection (SW/4, NE/4, section 15, R. 10 W., T. 5 N.), in massive, yellow to buff, fine-grained sandstone, Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Valley Ford 7.5 quadrangle. Collected by R. B. Travis, 8/1949; field number: MS-2.

Mollusca

Bivalvia

*Lituyapecten* sp., cf. *L. turneri* (Arnold)  
Mytilidae, indeterminate

UCMP A6895. Fossils occur as cores in concretions of granular sandstone conspicuous on grassy slopes at an elevation of about 500 on a hill 2,400 N15.5;W of Hill 366, about 0.5 mile north of Bogeda, Sonoma County, California. Latitude: 38.1;N; longitude: 122.2;W (Rectangular coordinate system: 254600N, 1719800E). Valley Ford 7.5 quadrangle. Collected by R. B. Travis, 8/1949; field number: IS-4.

Mollusca

Bivalvia

*Macoma?* sp.  
Indeterminate bivalve

Gastropoda

*Crepidula princeps* Conrad

UCMP B2762. Locality: Ebabias Creek(?). Coarse, blue-gray sandstone in creek bed (at and near small water fall) on Ebabias Creek where dirt road on south side of creek crosses the creek from south to north. It is not quite 0.5 mile east of road running from Valley Ford to the Y where it meets the road running from Bodega to Freestone. Latitude: 38.1;N; longitude: 122.2;W. SE/4, NE/4, section 24, T. 6 N., R. 10 W., Valley Ford 7.5 quadrangle. Collected by R.L. Rose, 1956.

Brachiopoda

Inarticulata

*Discinisca?* sp.

Articulata

*Terebratalia?* sp.

Mollusca

Bivalvia

*Arca* sp.  
*Chlamys* sp.  
*Mytilus?* sp.  
*Panope* sp.  
*Patinopecten?* sp.  
Pectinidae, indeterminate  
*Tresus* sp., cf. *P. pajaroanus* (Conrad)

Gastropoda

*Calliostoma?* sp.  
*Calyptraea (Trochita)* sp.  
*Cancellaria?* sp.  
*Crepidula princeps* Conrad  
*Nassarius?* sp.  
Naticidae, indeterminate  
Neogastropoda, indeterminate

UCMP B4299. Locality: Whittaker Bluff and vicinity. Fossil collected in massive, gray, well consolidated sandstone under a natural bridge at the northwest end of a line of cliff-forming rocks (outcrops strike north-northwest – 350; dip 2-3; northeast), which forms large cavernous outcrops with occasional Pectens. Location near the south boundary line of the NW4, NW/4, section 22, T. 5 N., R. 10 W, almost on the 200 contour line, almost 0.5 mile due south of a large ranch house and barn, Sonoma County, California. Latitude: 38.1;N; longitude: 122.2;W. Valley Ford 7.5 quadrangle. Collected by Peck and Higgins, 6/26/1957; field number: P-160.

Mollusca

Bivalvia

*Lituyapecten* sp., cf. *L. turneri* (Arnold)

UCMP B4668. Locality: Salmon Creek(?). This locality is east of the road between Freestone and Occidental near the fork of a dirt road which forks about 0.25 mile east of the highway. The southeast fork goes to Sam Wells house and the locality is along the stream bed directly north of the house and runs northwest to where the north fork of the road crosses the stream, about 0.75 mile north of Freestone, Sonoma County, California. Latitude 38.1°N; longitude: 122.2°W. Camp Meeker 7.5 quadrangle. Collected by Gordon Chan (College of Marin), 3/1967.

Mollusca

Bivalvia

*Clinocardium* sp.

*Macoma* sp.

*Solen?* sp.

Indeterminate bivalve

Gastropoda

*Crepidula princeps* (Conrad)

Indeterminate gastropod

UCMP B5543. Locality: Whittaker Bluff and vicinity(?). From near Fallon, California in presumably Merced Formation. *Brisaster* sp. near *towsendi*, Sonoma County, California. Latitude: 38°16' N; longitude: 122°52' W (section 18?, T. 5 N., R. 9 W). Valley Ford 7.5 quadrangle. Collector unknown.

Echinodermata

Echinoidea

*Brisaster?* sp. [identified by R. Mooi, CAS]

UCMP B8027. Locality: Salmon Creek. *Pecten* (close to *P. hastatus*) found in a fossiliferous ledge in the bottom of a small creek on the south side of a secondary road which takes off to the east from the main road connecting Freestone and Occidental. The road junction is marked 251 on above map [Camp Meeker 7.5 quadrangle]. Locality is just north of a small house? and just east of a dead end road running southeast from secondary road which is continuing north-east. It is about 0.2 of a mile east of the Freestone-Occidental road and 1 mile north of Freestone, Sonoma County, California. Latitude: 38°22' 45" N; longitude: 122°55' 16" W. Camp Meeker 7.5 quadrangle. Collected by S. C. Bruff and others, 1964; field number 6491-1.

Mollusca

Bivalvia

*Chlamys hastata* (Sowerby)

UCMP D3072. Locality: Bloomfield Quarry(?). 2.5 miles west of Dunham School along Bloomfield Road and about 0.25 mile northwest of Bloomfield Road beneath a prominent knob in hillside, underlying (at the base of) 15' thick, white tuff, Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Two Rocks 7.5 quadrangle. Collected by A. Sarna-Wojcicki; field number: 758-169-C.

Mollusca

Gastropoda

Naticidae, indeterminate

UCMP D3079. Locality: Bloomfield Quarry(?). 2.66 miles west of Dunham School along Bloomfield Road in 1.5' thick cemented fossil bed lying 50' stratigraphically above 15' white tuff bed, Sonoma County, California. Latitude: 38.1°N; longitude: 122.2°W. Two Rocks 7.5 quadrangle. Collected by A. Sarna-Wojcicki; field number: 169H.

Mollusca

Bivalvia

*Securella?* sp.

*Protothaca* sp., cf. *P. staley* (Gabb)  
Gastropoda  
Naticidae, indeterminate

UCMP D3224. Locality: Bloomfield Quarry(?). Near Bloomfield Rd about 2.7 miles west of Dunham School and approximately 0.33 mile southwest of junction of Bloomfield Road with road to Knowles Corner. Locality is 0.12 mile up hillside, southeast of road, at approximately 240 elevation in large bulldozer scrape in hillside above garbage dump, Sonoma County, California. Latitude: 38;19 N; longitude: 122;48 W. Two Rocks 7.5 quadrangle. Collected by A. Sarna-Wojcicki; field number 758-173.

Mollusca

Bivalvia  
*Cryptomya* sp., cf. *C. californica* (Conrad)  
Gastropoda  
*Lirabuccinum?* sp.

UCMP D3235. Locality: Wilson Grove(?). Bed stands out as a ledge near the top of the steep west slope of the hill and is best exposed under and around the roots of many of the trees which cover the hill. On W slope of hill just southwest of UCMP D3232 to D3236, and UCMP D3240, Sonoma County, California. Latitude: 38.2;N; longitude: 123.1;W. Healdsburg 7.5 quadrangle. Collected by T. D. Cook, 1949; field number C34.

Mollusca

Bivalvia  
*Macoma* sp., cf. *M. addicotti* Nikas  
*Protothaca* sp.  
Gastropoda  
*Olivella* sp.

UCMP D3236. Locality: Wilson Grove. 25 west of the Hop Sheds which lie between the fossil locality and the main highway in the eastern-most exposures of shell-bearing beds on the uppermost of the two bulldozer road beds, southwest of Wilson Grove on the south slope of the first small hill west of the highway, Sonoma County, California. Latitude: 38.2 N; longitude: 123.1;W. Healdsburg 7.5 quadrangle. Collected by T. D. Cook, 1949; field number C30.

Mollusca

Bivalvia  
*Anadara trilineata* (Conrad)  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
Mactridae, indeterminate  
*Pandora* sp.  
*Protothaca?* sp.  
*Solen* sp.  
*Tagelus* sp.  
Gastropoda  
*Cryptonatica affinis* (Gmelin)

UCMP D3237. Locality: Wilson Grove. Stratigraphically about 7 higher in the section than UCMP D3238 but collected on the west slope of the same hill from a ledge which outcrops from beneath thick, black soil 40 down-slope from the old water tank in a small clearing on the hillside, southwest of Wilson Grove on the west slope of the first small hill west of the highway, Sonoma County, California. Latitude: 38.2 N; longitude: 123.1;W. Healdsburg 7.5 quadrangle. Collected by T. D. Cook, 1949; field number C32.

Mollusca

Bivalvia  
*Anadara trilineata* (Conrad)

*Macoma* sp.

UCMP D3238. Locality: Wilson Grove and vicinity(?). Stratigraphically about 2 below UCMP D3236 but collected 50 west of same from a bed composed mostly of shell fragments and fine sand, southwest of Wilson Grove on the south slope of the first small hill west of the highway, Sonoma County, California. Latitude: 38.2 N; longitude: 123.1 W. Healdsburg 7.5 quadrangle. Collected by T. D. Cook, 1949; field number C31. [The original locality description is confusing as it referred to both Wilson Grove (UCMP D3236) and Bolinas (UCMP D3240) localities, but the latter appears to be for descriptive purposes of the sediments].

Mollusca

Bivalvia

*Macoma* sp.

*Protothaca* sp., cf. *P. staminea* (Conrad)

Gastropoda

Turridae, indeterminate

UCMP D3355. Near summit of southward trending nose from Hill 641, elevation about 300 , on southeast slope 0.3 mile west of Americano Creek, about 2.2 miles east-northeast of Bloomfield, Sonoma County, California. Latitude: 38;18 30 N; longitude: 122;48 30 W. Two Rocks 7.5 quadrangle. Collected by D. W. Dippel and Tom Jackson, 8/10/1967. =UCMP V67221.

Mollusca

Bivalvia

Pectinidae, indeterminate

*Protothaca* sp.

*Securella?* sp.

*Siliqua?* sp.

Tellinidae, indeterminate

Veneridae, indeterminate

Indeterminate bivalve

Gastropoda

Naticidae, indeterminate

Neogastropod, indeterminate

*Neptunea* sp.

*Nucella* sp.

UCMP D3382 (= 68109). No locality data.

Note: The occurrence of *Nuttallia jamesi* Roth and Naidu suggests the River Road locality as it occurs nowhere else in the Wilson Grove Formation. The preservation and fauna also suggest the River Road locality.

Mollusca

Bivalvia

Lucinidae, indeterminate

*Macromeris* sp., cf. *M. albaria* (Conrad)

*Nuttallia jamesi* Roth and Naidu

*Protothaca* sp., cf. *P. staley* (Gabb)

Veneridae, indeterminate

*Yoldia* sp.

Gastropoda

Naticidae, indeterminate

*Nucella transcoana* Arnold

*Odostomia?* sp.

*Olivella pycna* Berry

*Ophiidermella* sp.

Arthropoda

Crustacea

Indeterminate crab parts

UCMP D3385. Locality: Whittaker Bluff and vicinity(?). Pecten collected from road cut (north side of road) west of Fallon, Calif. This is on the north side of Estero de San Antonio, Sonoma County, California. This is probably the same locality as UCMP A6894 and David Dippel's MRN 3 upper.

Mollusca

Bivalvia

*Lituyapecten turneri* (Arnold)

UCMP D5919. Locality: Ebabias Creek. From the extreme northwest corner of section 19, almost at the boundary of sections 19 and 18. At the head of a small gully (on the 200 contour) about 0.25 mile north of Ebabias Creek. This is east and a little south of Freestone, Sonoma County, California. Latitude: 38;21 42 N; longitude: 122;53 52 W. Valley Ford 7.5 quadrangle. Collected by R. Guruswami-Naider, 1971.

Mollusca

Bivalvia

*Patinopecten* sp.

Geology Department, University of California at Davis

UCD A271a. Light tan to yellowish brown, poorly sorted, iron stained, siltstone with granule interbeds [Bedrossian (1970) calls this tuffaceous conglomerate or tuff breccia] approximately 55 m from the curve at the top of the paved road, Sonoma County Refuse Disposal area on Roblar Road approximately 2.8 miles from its intersection with U.S. HIGHWAY 101, Sonoma County, California. Collected by T. Bedrossian.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

*Macoma* sp. [in part as *Dosinia* sp.]

Macluridae?, indeterminate [in part as *Dosinia* sp.]

Pectinidae, indeterminate [as *Pecten* sp.]

*Siliqua* sp.

*Solen* sp.

*Tagelus?* sp. [in part as *T. californianus* (Conrad)]

*Yoldia?* sp.

Indeterminate bivalves

Gastropoda

*Calyptrea* sp. [as *C. mamillaris* (Broderip)]

Columbellidae, indeterminate [as *Mitrella carinata* Hinds]

*Crepidula* sp. [as *C. onyx* Sowerby]

*Diodora* sp., cf. *D. aspera* (Rathke) [cast]

*Nassarius* sp. [as *Nassa mendica* (Gould) and *N. fossata* Woodring]

Naticidae, indeterminate [as *Euspira lewisii* (Gould) and *Neverita reclusianus* (Deshayes)]

*Lirabuccinum?* sp. [as *Nassa mendica* (Gould) and *N. fossata* Woodring]

Arthropoda

Crustacea

Indeterminate crab claws

UCD A271b. Light tan to gray, iron stained siltstone overlying brown sandstone approximately 90 m from the curve at the top of the paved road, Sonoma County Refuse Disposal area on Roblar Road

approximately 2.8 miles from its intersection with U.S. HIGHWAY 101, Sonoma County, California. Collected by T. Bedrossian.

Mollusca

Bivalvia

*Clinocardium?* sp. [in part as *Pseudocardium* sp.?]  
*Cryptomya californica* (Conrad) [abundant]  
Mactridae?, indeterminate  
Modiolidae? sp.  
*Macoma?* sp. [in part as *Dosinia* sp.]  
*Pseudocardium?* sp.  
*Solen* sp.  
*Siliqua* sp.  
Indeterminate bivalves [as *Protothaca staminea* (Conrad)]

Gastropoda

*Lirobuccinum?* sp. [in part as *Nassa fossata* (Gould)]  
Naticidae, indeterminate [as *Polinices* sp.]  
Indeterminate gastropods [in part as *Euspira*, *Ficus*, *Nassa fossata* (Gould), and *Neverita?*]

Arthropoda

Crustacea

*Balanus?* sp.

UCD A281a. Poorly sorted gray sandstone with hardened lenses about three feet from the base of Eastside Road 1 mile north of the fork with Trenton-Healdsburg Road. A poorly sorted, gray sandstone interspersed with hardened lenses is found about 3 feet from the base of the road, Sonoma County, California. Collected by T. Bedrossian.

Mollusca

Bivalvia

*Anadara* sp.  
Cardiidae, indeterminate  
*Cryptomya californica* (Conrad)  
*Macoma* sp.  
*Securella* sp.  
*Solen?* sp.

Gastropoda

*Nassarius californicus* (Conrad)  
*Nassarius grammatus* (Dall)

USGS, Menlo Park collections (now at UCMP)

These collections were identified by W.O. Addicott in 1970 and 1971

USGS M2806. Locality: River Road. Marine sand exposed south of fault contact with Franciscan Formation in road cut on northeast side of Fulton-Guerneville Road about 0.25 mile north of Trenton, in NW1/4, NW1/4, section 3 (projected), T. 7 N., R. 9 W., Sebastopol 7.5 quadrangle, Sonoma County, California. Collected by W.O. Addicott, 1966.

Mollusca

Bivalvia

*Macoma addicotti* Nikas  
Mactridae, indeterminate  
*Protothaca staley* (Gabb)

Gastropoda

*Astyris gausapata* (Gould)  
*Cryptonatica affinis* (Sowerby)  
*Megasurcula remondi* (Gabb)

*Nassarius grammatus* (Dall)  
*Odostomia* sp.  
*Olivella* sp.

USGS M4229. Unnamed formation indicated as Pliocene on Santa Rosa sheet of the California State geologic map (1963) exposed in small west-trending canyon above ranch house, 200 ft south and 2,800 ft east of 38;10 tick at W boundary of Petaluma 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, June, 1970. Field No.: BH70-F1.

Note: The *Tivela* appears to be conspecific with a species that occurs in the middle Miocene Temblor Stage farther S in California and in the upper Miocene of the San Pablo Group of nearby Contra Costa County, so this outcrop probably does not belong to the Wilson Grove Formation.  
Mollusca

Bivalvia

*Modiolus* sp.  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
*Tivela* sp., cf. *T. gabbi* Clark

Arthropoda

Crustacea

Indeterminate barnacles

USGS M4230. Locality: Wilson Grove. Road cut at Wilson Grove on Eastside Road, 375 ft south and 5,600 ft west of northeast corner of section 27, T. 8 N., R. 9 W., Headsburg 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, June, 1970. Field No.: BH70-F2.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)  
*Cryptomya californica* (Conrad)  
*Macoma nasuta* (Conrad)  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
*Modiolus* sp.  
*Protothaca staleyi* (Gabb)  
*Siliqua* sp.  
*Solen* sp.

Gastropoda

*Astyris gausapata* (Gould)  
*Crepidula princeps* Conrad  
*Cryptonatica* sp.  
*Littorina petricola* Dall  
*Nassarius californianus* (Conrad)  
*Nassarius grammatus* (Dall)  
*Nucella trancosana* (Arnold)  
*Olivella biplicata* (Sowerby)  
*Ophiidermella graciosa* (Arnold)

Arthropoda

Crustacea

Indeterminate barnacles

USGS M4231. Locality: Salmon Creek. In bed of Salmon Creek about 250 ft east of bridge, 1,475 ft north and 1,325 ft west of 122;55 at south boundary of Camp Meeker 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, June, 1970. Field No.: BH70-F13.  
Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

*Macoma* sp.  
*Macoma* sp., cf. *M. nasuta* (Conrad)  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
*Mya truncata* Linnaeus  
*Panope abrupta* (Conrad)  
*Patinopecten healeyi* (Arnold)  
*Protothaca staleyi* (Gabb)  
*Saxidomus* sp.  
*Tresus pajaroanus* (Conrad)

Gastropoda

*Aulacofusus? recurva* (Gabb)? [internal mold]  
*Crepidula princeps* Conrad  
*Lirabuccinum portolaensis* (Arnold)  
*Nassarius californianus* (Conrad)  
*Turcica brevis* Stewart?

USGS M4232. Locality: South Valley Ford. Road cut on Valley Ford — Franklin School road about 0.5 mile southwest of Valley Ford, 2,250 ft S 39; W of BM42 at Valley Ford, Valley Ford 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, June 1970. Field No.: BH70-F15.

Mollusca

Bivalvia

*Tresus pajaroanus* (Conrad)

Gastropoda

*Crepidula princeps* Conrad

USGS M4233. Locality: Whittaker Bluff and vicinity. Road cut on Whittaker Bluff Road about 10,450 ft north and 4,200 ft east of 122;57 30 tick at south boundary of Valley Ford 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, June 1970. Field No.: BH70-F16.

Mollusca

Bivalvia

*Lituyapekten turneri* (Arnold)

USGS M4287. Locality: Roblar Road. Sonoma County Dump, 1,750 ft north and 2,100 ft west of southeast corner T. 6 N., R. 9 W., Two Rocks 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow, 1970.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

*Siliqua* sp.

*Solen* sp.

Gastropoda

*Nassarius* sp.

*Nucella?* sp.

USGS M4511. Locality: Meacham Hill. Highway cut on northeast side of US route 101 near southeast end of Meacham Hill about 2.5 miles south-southeast of Cotati; 4,350 ft S 35; E of 508 ft survey station on summit of Meacham Hill, Cotati 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, March 1971. Field No.: BH70-F30.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

*Macoma nasuta* (Conrad)?

*Modiolus* sp.  
*Protothaca* sp.  
*Siliqua* sp.  
*Solen* sp.  
*Tresus pajaroanus* (Conrad)?  
 Gastropoda  
*Nassarius* sp.  
*Polinices* sp.  
 Arthropoda  
 Crustacea  
*Cancer?* sp.  
 Echinodermata  
 Echinoidea  
 Indeterminate sand dollar pieces

USGS M4512. Locality: Wilson Grove. Outcrop at southwest end and near summit of small hill east of Russian River about 0.25 mile southwest of Wilson Grove; 3,850 ft east and 1,050 ft south of northwest corner of section 28, T. 8 N., R. 9 W., Healdsburg 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, March 1971. Field No.: BH70-F19.

Mollusca  
 Bivalvia  
*Anadara trilineata* (Conrad)  
*Macoma nasuta* (Conrad)  
*Mactromeris* sp., cf. *M. albaria* (Conrad)  
*Protothaca staleyi* (Gabb)  
*Protothaca tenerrima* (Carpenter)?  
*Siliqua* sp.  
*Solen* sp.  
*Tresus pajaroanus* (Conrad)?  
 Gastropoda  
*Littorina petricola* Dall  
*Nassarius grammatus* (Dall)

USGS M4513. Locality: River Road. Merced Formation exposed south of fault contact with Franciscan Formation in cut on northeast side of Fulton — Guerneville Road about 0.25 mile east of Trenton in NW1/4, NW1/4, section 3 (projected), T. 7 N., R. 9 W., Sebastopol 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow and W.O. Addicott, March 1971. Field No.: BH70-F18.

Mollusca  
 Bivalvia  
*Axinopsida serricata* (Carpenter)  
*Cryptomya* sp.  
*Macoma addicotti* Nikas  
*Protothaca staleyi* (Conrad)  
*Siliqua* sp.  
*Spisula* sp.  
*Yolida (Kalayoldia)* sp.  
 Gastropoda  
*Astyris gausapata* (Gould)  
*Calicantharus* sp.  
*Cryptonatica affinis* (Sowerby)  
*Megasurcula* sp., cf. *M. remondi* (Gabb)  
*Nassarius grammatus* (Dall)  
*Nucella* sp.

*Odostomia* sp.  
*Olivella biplicata* (Sowerby)  
*Ophiidermella graciosa* (Arnold)?

Arthropoda

Crustacea

Indeterminate crab chela

USGS M5845. Locality: Roblar Road. Cut at county dump site, 2,000 ft S 40°W from intersection of Roblar Road and Canfield Road in E1/2 (projected), section 36, T. 6 N., R. 9 W., Two Rocks 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow, 1973.

Mollusca

Bivalvia

*Siliqua* sp.

Gastropoda

*Nassarius* sp.

Indeterminate minute gastropod

Field No.: BH70-F-26. Large cut at end of road near southwest corner of Two Rocks Ranch Station Military Reservation, 6,200 ft north and 1,000 ft west of southeast corner (projected) T. 5 N., R. 9 W., Point Reyes 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow, 1970.

Mollusca

Bivalvia

*Mactromeris* sp., cf. *M. albaria* (Conrad)

*Yolida (Kalayoldia)* sp.

Gastropoda

*Calicantharus?* sp.

*Nucella?* sp.

*Polinices* sp.

Field No.: BH-70-F-28. Middle of large highway cut on east side of Pt. Reyes — Petaluma Road about 0.1 mile north of bridge over San Antonio Creek, 3,200 ft south and 400 ft east of northwest corner of section 17, T. 4 N., R. 7 W., Petaluma 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow, 1970.

Mollusca

Bivalvia

*Chlamys*-like specimens

Indeterminate bivalves

Gastropoda

Acmaeid or fissurellid

*Calyptrea* sp.

Field No.: E-14. Roadcut at ranch driveway on southwest side of Grandview Road about 0.25 mile northwest of Bodega Road, 8,100 ft east and 1,800 ft south of southeast corner of T. 7 N., R. 10 W., Camp Meeker 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow, 1970.

Mollusca

Bivalvia

*Panope* sp. (fragments)

*Tresus pajaroanus* (Conrad)

Field No.: P-4. Road cut on north side of Eastman Lane about 0.5 west of its intersection with Bodega Ave., 3,000 ft north and 1,000 ft east of southwest corner of section 31, T. 5 N., R. 7 W., Petaluma 7.5 quadrangle, Sonoma County, California. Collected by J.A. Bartow, 1970.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)?  
*Protothaca* sp., cf. *P. staley* (Gabb)

USGS field collections (deposited at UCMP)

Field No.: JA072901A. Recent excavation, in tan sandstone, about 1 mile S 60° E of the road cut at Wilson Grove on the west side of Mark West Station Road where it turns west, Healdsburg 7.5 quadrangle, Sonoma County, California. Collected by James Allen, 7/29/01. Latitude: 38°30' 16" N, longitude: 122°50' 56" W.

Mollusca

Bivalvia

*Anadara trilineata* (Conrad)

*Macoma?* sp.

Veneridae, indeterminate

Indeterminate fragments

Field No.: JA100501A. East side of Sonoma Mountain Road about 0.6 km south of reservoir southeast of Bennett Valley Grange Hall, southeast of Santa Rosa, Santa Rosa 7.5 quadrangle, Sonoma County, California, in tan, iron stained, fine-grained sandstone. Collected by James Allen, 10/5/2001. Mapped as Petaluma Formation. Latitude 38°23' 03" N, longitude 122°41' 36" W.

Mollusca

Bivalvia

Indeterminate fragments

Arthropoda

Crustacea

Possible barnacle plate

Indeterminate crab claws

Field No.: JA021202A. Sample from gray silty shale exposed in gully slightly north of Adobe Road and across the road from a small unnamed reservoir, about half way between Frates and Stage Gulch roads, east of Petaluma, Petaluma River 7.5 quadrangle, Sonoma County, California. Collected by James Allen, 2/12/02. Mapped as Petaluma Formation. Latitude 38°14' 45" N, longitude 122°32' 27" W.

Mollusca

Gastropoda

*Polinices draconis* (Dall) [identified by L. Marinovich, CAS]

Field No.: JA A. Marine transitional facies between the Petaluma and Wilson Grove Formations on the southwest side of U.S. Highway 101 slightly north of due east of Quarry on the west side of Meacham Hill, north of the town of Liberty, Cotati quadrangle, Sonoma County, California. Collected by James Allen, 2002.

Mollusca

Bivalvia

*Cryptomya californica* (Conrad)

Field No.: JA C. Collected from highly fossiliferous, tan, fine-grained, sandstone exposed in road cut at top of hill on the south side of dirt road north of Spring Hill Road, a little over 3 miles due east of McNear School in southern Petaluma, Petaluma 7.5 quadrangle, Sonoma County, California. Latitude: 38°13' 26" N, longitude: 122°41' 45" W. Collected by James Allen, 2002.

Mollusca

Bivalvia

*Protothaca?* sp.

*Siliqua?* sp.

Veneridae, indeterminate

Indeterminate bivalve fragments

USGS field collection (deposited at CAS)

Field No.: JA D and CP072003A. Medium to fine sandstone exposed along bottom of deep gully just north of small waterfall and south of small bridge over gully on dirt road, just south of Spring Hill Road and a little over 3 miles due east of McNear School in South Petaluma, Petaluma 7.5 quadrangle, Sonoma County, California. Collected by Charles Powell, II and James Allen, 2002 & 7/2003.

Echinodermata

Echinoidea

*Scutellaster* sp., cf. *S. oregonensis* (Clark)