With Regards of the Authors

MID-CRETACEOUS (ALBIAN TO TURONIAN) BIOSTRATIGRAPHY OF NORTHERN CALIFORNIA

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ABSTRACT

Preliminary correlation is established by means of mega- and microfossils for two coeval mid-Cretaceous sections in northern California-one represents a deep-water slope environment ranging in age from Albian to Turonian on the west side of the Great Valley sequence at Dry Creek, Tehama County, California, and the other a shallower water, shoreward locality of Turonian age on the east side of the Great Valley sequence at Redding, Shasta County, California.

Correlations of local range zones of ammonites and planktonic foraminifers between the two areas are diachronous and demonstrate the problems of correlating on both a local and international scale.

INTRODUCTION

Cretaceous sedimentary rocks are widespread in northern California where they occur in two coeval but different facies : a deep-water, structurally complex assemblage known as the Franciscan ; and a shallower water, structurally simple assemblage designated as the Great Valley sequence (Bailey, Irwin, and Jones, 1964). Only the latter is sufficiently fossiliferous in continuous, unbroken sections, to furnish biostratigraphic data. Although the relationships between the Franciscan and the Great Valley sequence are of considerable theoretical interest and have been the subject of numerous published reports (see Blake, Jones, and Landis, 1974, for a recent summary), this report is concerned solely with biostratigraphic data obtained from two nearby areas within the Great Valley sequence in northern California. The significance of these data in terms of the geologic history of the Pacific border of North America will be discussed in later contributions to the Mid-Cretaceous Events Program.

GREAT VALLEY SEQUENCE

Over 15,000 meters of sandstone, mudstone, and conglomerates are exposed along the west side of the Great Valley of California (fig. 1) where they form the eastdipping limb of a large north-trending synclinal structure. These rocks range in age from Late Jurassic (Kimmeridgian or early Tithonian) to Late Cretaceous (Campanian or younger) and rest depositionally on an Upper Jurassic ophiolite complex (oceanic crust ; see Bailey, Blake, and Jones, 1970). On the east side of the Great Valley, a much thinner sequence of sandstone, shale, and conglomerate is exposed which dips gently westward and which lies on older deformed Mesozoic sedimentary and igneous rocks. This eastern part of the Great Valley sequence ranges in age from Turonian to Campanian.

The internal stratigraphy of the Great Valley sequence is complex and characterized by rapid facies changes and lenticularity of mappable units (see Bailey and Jones, 1973). Rocks on the western side of the valley are dominantly turbidites (Ojakangas, 1968) in which megafossils are relatively rare. Rocks on the eastern side of the valley were deposited in shallower water, and generally contain a more abundant molluscan fauna. Correlation from east to west across the synclinal structure is difficult, however, due to lack of intervening exposures and to the pronounced discontinuity of strata. Detailed correlation along strike on both sides of the Great Valley is also difficult for the same reasons in addition to the presence of major faults that interrupt the sequence in several places (Jones, Bailey, and Imlay, 1969).

Because of these difficulties, and the uncertainties and complexities introduced by the consideration of a very large area, we have restricted our analysis for this report to two localities each characteristic of a distinct depositional facies, one on the west side of the Great Valley along Dry Creek, the other to the northeast near Mill Creek (see fig. 1). In both these areas, our overall knowledge of rock distribution and structure is fairly good, and both areas have yielded a sufficient number of fossils to permit biostratigraphic zonation and ecologic interpretation.

DRY CREEK SECTION

Over 3,500 meters of dominantly dark-gray mudstone with very minor amounts of sandstone and conglomerate of Albian to Turonian ages are exposed along Dry Creek (fig. 2). These rocks were mapped geologically by Murphy and others (1969), and contained microfossils described by Marianos and Zingula (1966) and Dailey (1973). Distribution of selected megafossils is shown on figure 3, and planktonic foraminifers on figure 4. Studies of radiolaria and nannofossils are now underway by Emile E. Pessagno, Jr., and his students at the University of Texas at Dallas. Their results will be coordinated with the present data on completion of their studies.

The Dry Creek section will be particularly important to the Mid-Cretaceous Project as a local standard of reference because of the joint occurrence of persistant well-preserved faunas of planktonic foraminifers, radiolaria, and nannofossil floras, with a fair number of ammonites and *Inoceramus*, all in a readily accessible section of nearly similar lithology that is unbroken by major faults. Much more work will be required, however, before the potential of this section is fully realized.

Biostratigraphic boundaries

Aptian-Albian : Control is poor for this boundary. Based on megafossils the boundary is placed above a small specimen of *Cheloniceras* and below *Puzosia* sp. (fig. 3). Planktonic foraminifers also fail to provide a more precise definition and the boundary is placed prior to the first appearance of *Ticinella primula* Luterbacher and *Hedbergella beegumensis* Marianos and Zingula (Fig. 4). Benthic foraminifers add additional support for this stratigraphic position as the boundary falls between the last occurrence of *Epistomina caracolla* (Roemer), *Gubkinella californica* Church, *Lenticulina eichenbergi* Bartenstein and Brand, *L. heiermanni* Bettenstaedt, and *Praebulimina churchi* Dailey and the first occurrence of *Clavulina gaultina* Morozova, *Dorothia almadenensis* Cushman and Todd, *Eggerella popenoei* Daily, *Osangularia californica* Dailey, *O. occidentalis* Dailey, and *Reinholdella ultima* Dailey.

Albian-Cenomanian : On the basis of ammonites, this boundary is placed at the first occurrence of *Desmoceras (Pseudouhligella) japonicum* Yabe. This correponds to the first occurrence of : *Rotalipora greenhornensis* (Morrow), *Globigerinelloides caseyi* (Bolli, Loeblich, and Tappan), *Hedbergella trocoidea* (Gandolfi), and the last occurrence of *Planomalina buxtorfi* (Gandolfi). Other ammonites from Dry Creek are discussed by Matsumoto (1960, p. 27-29), but the locality data for most of these specimens are too imprecise to permit their utilization.

Cenomanian-Turonian : This boundary on Dry Creek is placed between the last occurrence of *Desmoceras (Pseudouhligella)* sp. and *Inoceramus labiatus*, on the basis of megafossils. This corresponds to the first occurrence of the following planktonic foraminifera : *Globotrucana marianosi* Douglas, *G. sigali* Reichel, *Hedbergella archaeocretacea* (Pessagno), and the last occurrence of : *Rotalipora cushmani* (Morrow), *R. greenhornensis* (Morrow), and *R. evoluta* Sigal.

Turonian-Coniacian : This boundary cannot be established on Dry Creek, as strata of Coniacian age are not exposed. The upper part of the Turonian is characterized by *Collignoniceras* cf. *C. woolgari* and *Globotruncana pseudolinneiana* Pessagno, *Hedbergella murphyi* Marianos and Zingula, and *H. kingi* (Trujillo).

REDDING SECTION

Turonian strata of the Redding region crop out in three disconnected areas lying to the north and east of the city of Redding, and are composed principally of cross-bedded, nearly horizontal sandstone. The base of the Cretaceous section is a thin conglomerate which lies upon older metavolcanics and metasedimentary rocks.

The best, largest and most important Turonian exposure of the Redding region crops out over an area of 15 or 16 square km along the channel and on the northwest drainage area of Little Cow Creek, about 15 to 26 km northeast of Redding, and bisected by the Redding-Alturas Highway U.S. 299 (fig. 5). The stratigraphy and faunas of this exposure will be the main subject of the remainder of this report.

A third, quite limited, exposure of Turonian strata is found in the channel of Swede Creek, about 26 km northeast of the center of Redding.The Swede Creek exposures are notable in being the only area where Turonian beds are in contact with younger Cretaceous strata and for two localities that heve supplied abundant large specimens of the ammonite *Romaniceras deveroide* (de Grossouvre).

STRATIGRAPHY

The Turonian beds of Little Cow Creek valley are readily divisible into three lithologic units which are herein informally named, in ascending order, the Bellavista sandstone, the Frazier siltstone, and the Melton sandstone. The combined thickness of these units is about 790 meters. Fossils occurring commonly are found in all three members, generally in rather localized lentils rather than in extensive beds. At least 150 species of gastropods, bivalves, and ammonites occur, but many species are still undescribed. (fig. 6).

The basal formation, the Bellavista sandstone, consists of about 180 meters of rather coarse-grained, cross-bedded, feldspathic and micaceous sandstone, with thin intercalated beds of sandy siltstone 10 or. 12 cm thick near the top. A cobble conglomerate generally less than 6 meters thick occurs at the base, with clasts mainly derived from Jurassic metasedimentary and metavolcanic rocks exposed in the mountains to the north.

The Frazier siltstone, which overlies the Bellavista sandstone conformably and gradationally, is sandy siltstone with minor thin beds and lentils of sandstone similar to the Bellavista formation below.

The Melton sandstone, the uppermost Cretaceous unit in little Cow Creek valley, is a light-gray to cream-colored, cross-bedded soft sandstone approximately 150 meters thick. The contact of the Melton sandstone with the Frazier siltstone is very poorly exposed, being in most of its extent hidden by soil and by overlying Tertiary gravels and pyroclastics. In the two or three places where the contact may be observed, the transition from siltstone to sandstone is abrupt, with a thin pebble conglomerate not more than 1.5 meters thick at the base of the Melton formation.The two formations may thus be disconformable.

The strike of the Melton formation, in the very few places where it can be estimated, approximately parallels that of the Frazier siltstone below. Recorded southeasterly dips are less than 10° and usually less than 5°.

BIOSTRATIGRAPHY

Fossils are locally abundant in these three formations. The fauna, which is still poorly known, totals probably more than 150 species. The megafauna is made up almost exclusively of Mollusca with representatives of other invertebrate phyla rare or absent. The fauna is readily divisible into two different assemblages, which probably reflect different ecological conditions. The sandstone formations contain principally heavy shelled and robust forms, of which bivalves are numerically dominant. The Frazier siltstone fauna conversely is made up of thin-shelled delicate forms that are commonly crushed and distorted, and to a large part represented only by molds and impressions. Species that are abundant in the Bellavista sandstone and that disappear from the section at or near of the Frazier siltstone, reappear in higher sandy lenses in the silt and in the rather scanty faunas of the Melton sandstone. For this reason, a biostratigraphical zonation based on bivalve and gastropod occurrences appears to be impracticable.

The gastropods and bivalves listed in the checklist (table 1) are principally those species that have been described and figured in earlier publications. These species are also those that are commonly abundant locally and wide-ranging geographically, some, for example *Glycymeris pacificus*, *Gyrodes conradiana*, and *Cucculaea gravida* range from southern Oregon to the Santa Ana Mountains in southern California or to Cedros Island, Baja California. Conversely a few species, of which *Acteon politus* and *Gymnarus manubriatus* are notable examples, are very abundant in Turonian faunas at Redding and farther north but are not known in the Santa Ana Mountains faunas to the south ; and similarly species such as *Trigonarca californica* that are prolific in the Santa Ana Mountains do not appear in the northern California faunas.

The portion of Turonian time represented by the Redding beds is uncertain. The Bellavista sandstone has yielded only one ammonite species, *Tragodesmoceras ashlandicum*, from its lower part. This species has been recognized at a number of other localities in the Turonian of California and southern Oregon. In tle Colyear Springs quadrangle, which is immediately south Dry Creek, *T. ashlandicum* occurs in the lower Turonian, at about the same level as *Inoceramus labiatus* (Jones and Bailey, 1973). A similar age seems probable for the Bellavista sandstone.

The lower part of the Frazier siltstone contains abundant specimens of *Romaniceras deverioide*, which is approximately of middle Turonian age, whereas the upper part contains *Collignoniceras* sp. and other ammonites of late Turonian age.

Other ammonites from the Frazier siltstone are listed by Matsumoto (1960, p. 4-6) and include :

Otoscaphites puerculus (Jimbo)
Neophylloceras cf. *N. ramosum* (Meek)
Mesopuzosia pacifica Matsumoto
Romaniceras aff. *R. uchauxiensis* Collignon
Eucalycoceras (?) shastense (Reagan)
Subprionocyclus sp.
Tetragonites glabrus (Jimbo)
Bostrychoceras occidentale Anderson
Hyphantoceras sp.
Scaphites pittensis Anderson
Otoscaphites sp.
Kossmaticeras (?) sp.
Scalarites cf. *S. mihoensis* Wright and Matsumoto
Scaphites condoni Anderson

Planktonic foraminfers reported by Trujillo (1960) from the upper part of this formation include :

Praeglobotruncana renzi (Gandolfi)
P. helvetica (Bolli)
Globotruncana sigali Reichel

Globotruncana pseudolinneiana Pessagno and *Hedbergella praehelvetica* (Trujillo) have longer ranges and occur also in the lower part of the formation (fig. 6).

The faunas from Melton sandstone (equals Member II of previous usage) are discussed in detail by Matsumoto (1960, p. 6, 7), who lists the following forms :

Subprionocyclus neptuni (Geinitz)
Inoceramus cf. *I. teshioensis* Nagao and Matsumoto
Neophylloceras ramosum (Meek)
Mesopuzosia sp.
Subprionocyclus normalis (Anderson)
Tetragonites glabrus (Jimbo)
Scalarites cf. *S. mihoensis* Wright and Matsumoto

The similarities in fauna between the Frazier siltstone and the Melton sandstone suggests that they might be in part time equivalents. No planktonic foraminifers are known from the Melton to help resolve this problem.

PROBLEMS OF CORRELATION BETWEEN DRY CREEK AND THE REDDING AREA

The process of constructing a useful world-wide time scale based on biostratigraphic zonations is a difficult one, and the inherent problems, uncertainties, and contradictions should be not overlooked or ignored. Basically, these difficulties stem from the uncertainties evident in local correlations as shown by the imprecisions and lack of correspondence in sections only a few tens of miles apart. The Turonian rocks of Dry Creek and of the Redding area are grossly comparable in age, and rocks of early, middle, and late Turonian age can be identified in each place. A few ammonites, such as *Romaniceras deverioide* and *Collignoniceras* sp., are avilable to provide reasonable ties, but the overall faunas are quite different and ranges of species appear to vary widely. This is particularly apparent in the foraminiferal data ; here strata bearing *Globotruncana sigali* cross correlation lines based on ammonites (fig. 7). This problem is primarily twofold. First, the data base for the Redding area is taken from earlier reports written prior to the advent of newer taxonomic studies–hence stratigraphically important species may be present but unreported. Second, the depositional environment of the various units strongly affects the abundance, stratigraphic distribution, and preservation of foraminifers especially planktonic species, so that locally recovery is sporadic and preservation may be poor.

Rocks in these two areas were deposited under different ecological conditions. Those of Dry Creek represent a deeper water, bathyal environment with lower energy levels and access to open marine conditions. The rocks of Redding were deposited in a shallower water environment with fluctuating energy levels that lay adjacent to a shoreline not many kilometres to the east and consequently received increased amounts of coarse clastics. Thes difference alone interject so many complexities that simple correlation between the two nearby areas is precluded.

When one considers the additional complexities imposed by climate, differing faunal provinces with known endemic species, tectonics, including large horizontal displacements and other geologic vagaries, it is obvious that much careful, detailed field and laboratory work must be carried out before final decisions and world-wide zonation can be reached.

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Dépôt du manuscrit : 30 Septembre 1975

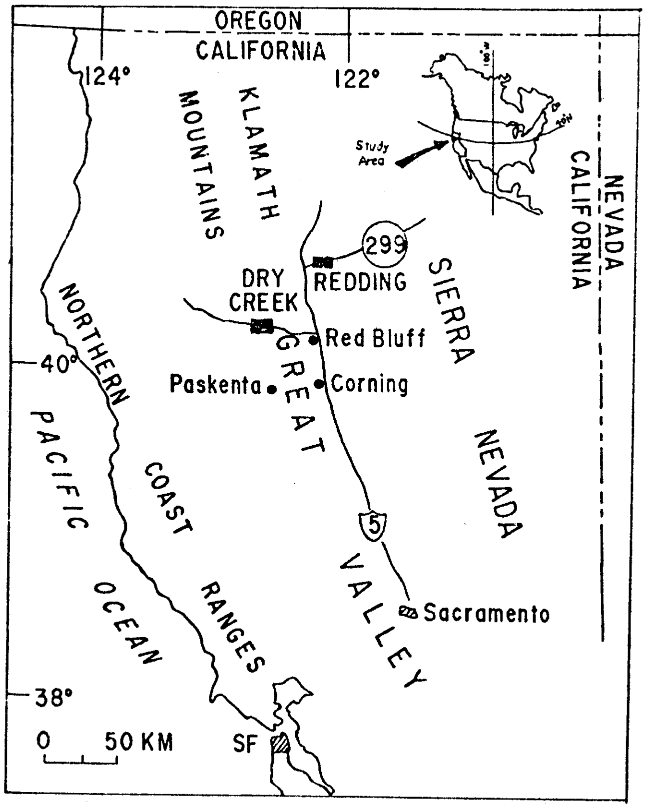

OREGON
CALIFORNIA
124°
122°
KLAMATH
MOUNTAINS
Study Area
NEVADA
CALIFORNIA
299
DRY CREEK
REDDING
SIERRA
NORTHERN
Red Bluff
GREAT
40°
Paskenta
Corning
PACIFIC
COAST
NEVADA
5
OCEAN
RANGES
VALLEY
Sacramento
38°
0 50 KM
SF

Fig. 1

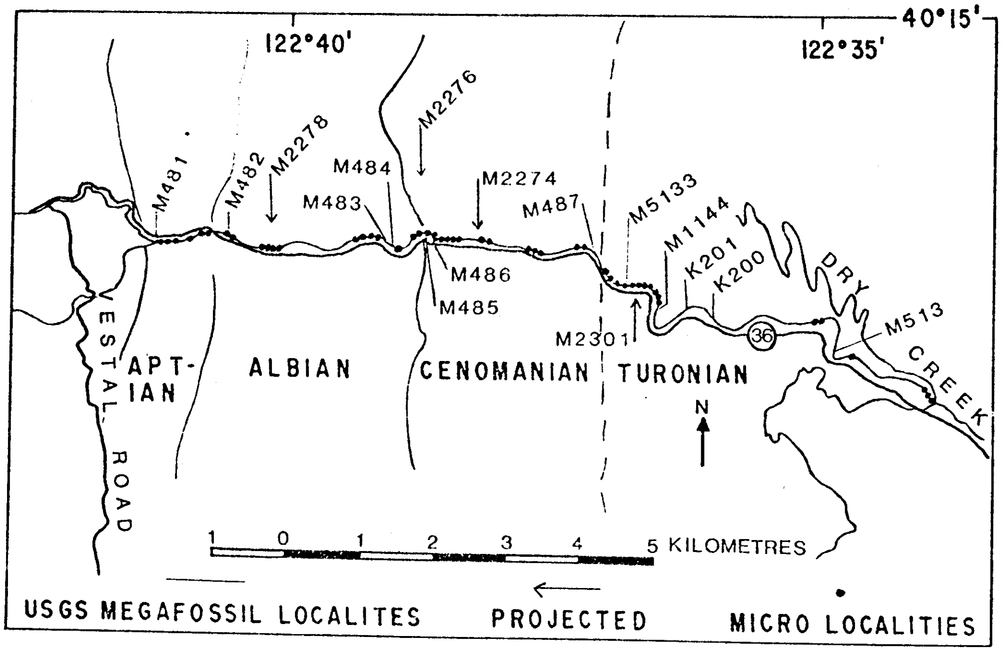

40°15'
122°40'
122°35'
M481
M482
M2278
M2276
M484
M483
M2274
M487
M5133
M1144
K201
K200
DRY CREEK
M486
M485
M2301
36
M513
VESTAL ROAD
APT-IAN
ALBIAN
CENOMANIAN
TURONIAN
N
1 0 1 2 3 4 5 KILOMETRES
USGS MEGAFOSSIL LOCALITES
PROJECTED
MICRO LOCALITIES

Fig. 2

Figure 1. — Map of northern California showing locations of Dry Creek and Redding mid-Cretaceous sections.

Figure 2. — Dry Creek section, Ono quadrangle, northern California, showing U.S. Geological Survey megafossil localities (M numbers) and microfossil localities (unnumbered dots). Arrows represent megafossil data projected into Dry Creek section.

Figure 3. — Dry Creek stratigraphic section showing lithology and megafossil localities. Dashed lines = shale ; stippled = sandstone ; circles = conglomerate.

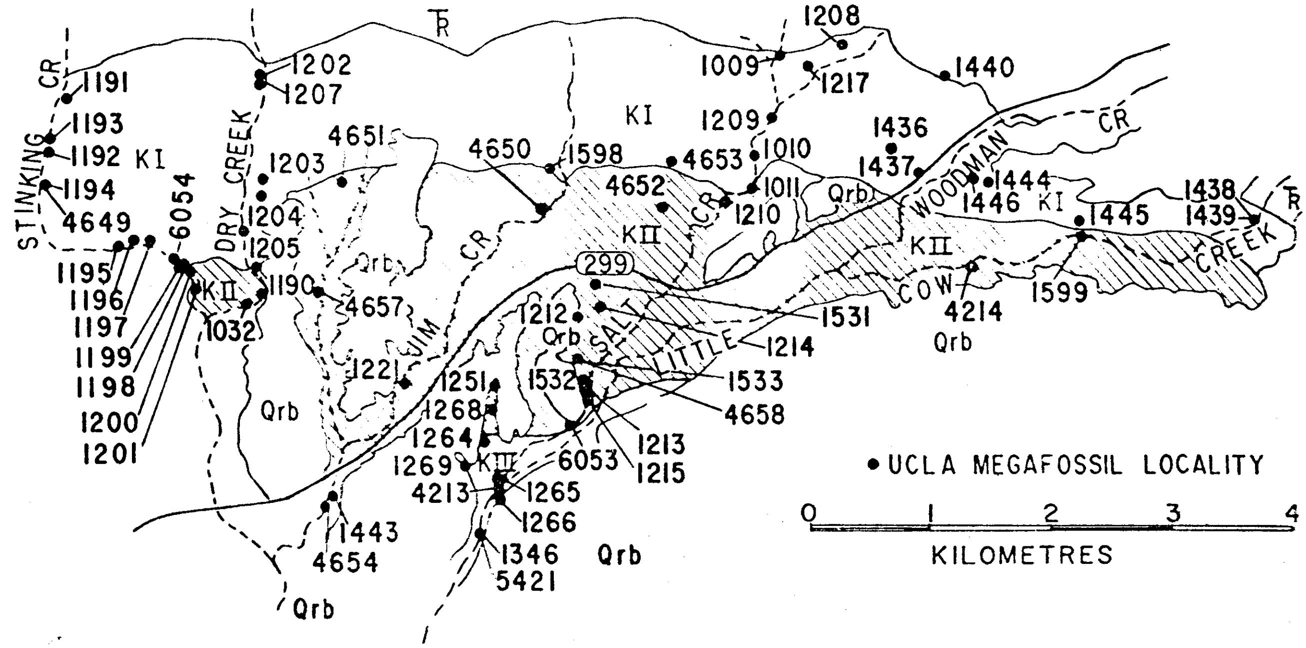
Figure 4. — Dry Creek microfossils localities. Dots represent U.S. Geological Survey localities.

Figure 5. — Map of Redding area showing magafossil localities and distribution of rock units. KI = Bellavista sandstone, KII = Frazier siltstone, KIII - Melton sandstone.

Figure 6; — Stratigraphic section in Redding area showing mega- and microfossil distribution. Lithologic symbols as on figure 3.

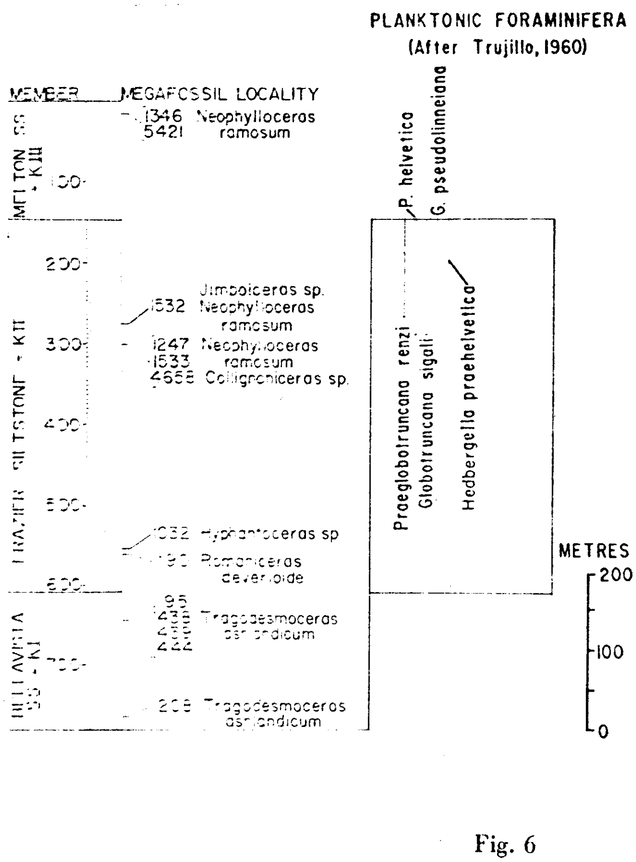
Figure 7. — Preliminary correlation between Dry Creek and Redding area showing mega- and microfossil correlations and apparent discrepancies. Broken lines are based on the ammonites *Collignoniceras* and *Romaniceras*. shaded zone is correlation based on *Globotruncana sigali*.

Table 1. — Turonian megafossils from Redding area, California. R. Rare, 1-4 specimens ; C Common, 5-19 specimens ; A Abundant, 20 specimens.



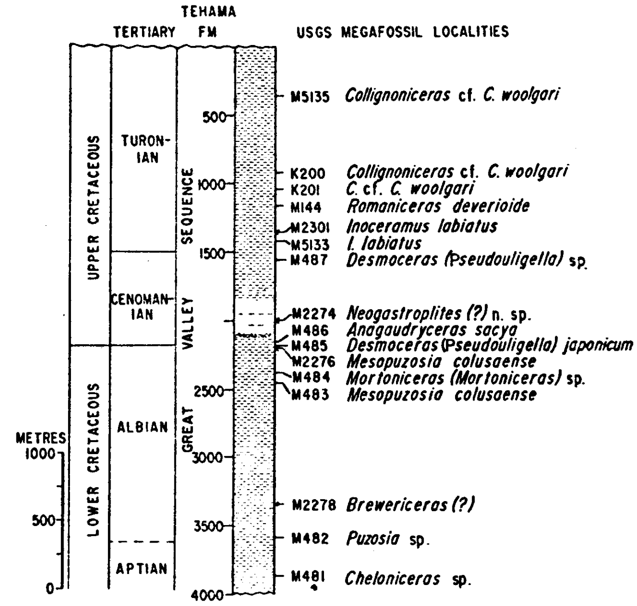
Ŧ
R
STINKING CR
DRY CREEK
JIM CR
SALT CR
LITTLE COW CREEK
WOODMAN CR
COW CREEK
KI
KII
KIII
Qrb
299
1191
1193
1192
1194
4649
1195
1196
1197
1199
1198
1200
1201
6054
1202
1207
1203
1204
1205
1190
1032
4651
4650
1598
4657
1221
1251
1268
1264
1269
4213
1265
1266
1346
5421
1443
4654
1212
1532
6053
1213
1215
1533
4658
1214
1531
1208
1009
1217
1440
1209
1436
1437
4653
1010
4652
1011
1210
1444
1446
1445
1438
1439
1599
4214
• UCLA MEGAFOSSIL LOCALITY
0
1
2
3
4
KILOMETRES

Fig. 5



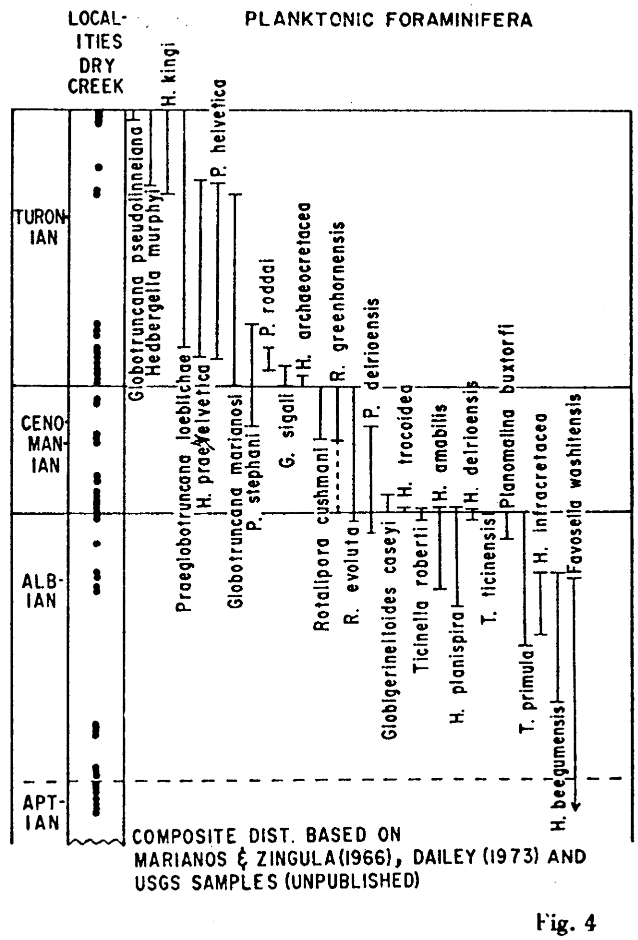
PLANKTONIC FORAMINIFERA
(After Trujillo, 1960)
MEMBER
MEGAFOSSIL LOCALITY
1346
5421
Neophylloceras ramosum
MELTON SS. - KIII
100
200
Jimboiceras sp.
1532
Neophylloceras ramosum
300
1247
Neophylloceras ramosum
1533
4658
Colligniceras sp.
400
500
1032
Hyphantoceras sp
Romaniceras deverioide
600
700
Tragodesmoceras ashlandicum
Tragodesmoceras ashlandicum
P. helvetica
G. pseudolinneiana
Praeglobotruncana renzi
Globotruncana sigali
Hedbergella praehelvetica
METRES
200
100
0

Fig. 6



TEHAMA FM
TERTIARY
USGS MEGAFOSSIL LOCALITIES
UPPER CRETACEOUS
LOWER CRETACEOUS
TURON-IAN
CENOMAN-IAN
ALBIAN
APTIAN
GREAT VALLEY SEQUENCE
METRES
1000
500
0
500
1000
1500
2500
3000
3500
4000
M5135 Collignoniceras cf. C. woolgari
K200 Collignoniceras cf. C. woolgari
K201 C. cf. C. woolgari
M144 Romaniceras deverioide
M2301 Inoceramus labiatus
M5133 I. labiatus
M487 Desmoceras (Pseudouligella) sp.
M2274 Neogastroplites (?) n. sp.
M486 Anagaudryceras sacya
M485 Desmoceras (Pseudouligella) japonicum
M2276 Mesopuzosia colusaense
M484 Mortoniceras (Mortoniceras) sp.
M483 Mesopuzosia colusaense
M2278 Brewericeras (?)
M482 Puzosia sp.
M481 Cheloniceras sp.

Fig. 3



LOCAL-ITIES DRY CREEK
PLANKTONIC FORAMINIFERA
TURON-IAN
CENO-MAN-IAN
ALB-IAN
APT-IAN
H. kingi
P. helvetica
Globotruncana pseudolinneiana
Hedbergella murphyi
Praeglobotruncana loeblichae
H. praehelvetica
Globotruncana marianosi
P. stephani
P. roddai
G. sigali
H. archaeocretacea
Rotalipora cushmani
R. greenhornensis
R. evoluta
P. delrioensis
Globigerinelloides caseyi
H. trocoidea
Ticinella roberti
H. amabilis
H. planispira
H. delrioensis
T. ticinensis
Planomalina buxtorfi
T. primula
H. infracretacea
H. beegumensis
Favusella washitensis
COMPOSITE DIST. BASED ON MARIANOS & ZINGULA (1966), DAILEY (1973) AND USGS SAMPLES (UNPUBLISHED)

Fig. 4

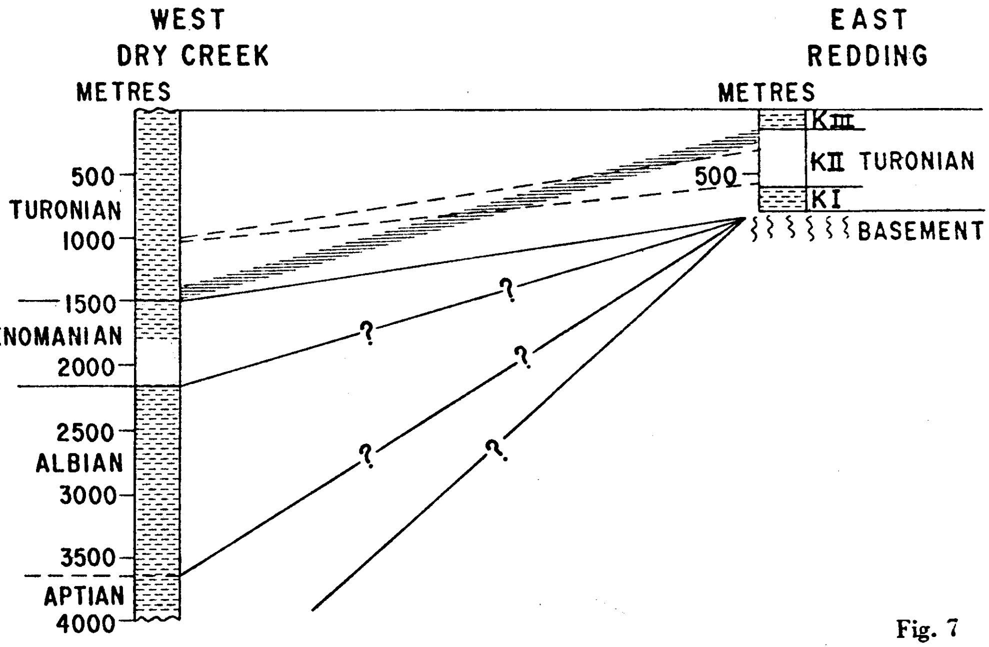


Fig. 7

Table 1. Turonian megafossils from Redding area, California

R Rare, 1-4 specimens; C Common, 5-19 specimens;

A Abundant, > 20 specimens.

	Fossil localities	Gyrodes conradiana Gabb	Anchura condoniana Anderson	Arrhoges californicus Gabb	Conia californica (Gabb)	Volutomorpha mitraeformis (Gabb)	Glycymeris pacificus (Anderson)	Pterotrigonia klamathonia (Anderson)	Mesopuzosia sp.	Neophylloceras ramosum (Meek)	Scalarites cf. S. mihoensis Wright and Matsumoto	Tetragonites cf. T. glabrus (Jimbo)	Subprionocyclus normalis (Anderson)	Acteonella oviformis Gabb	Gymnarus manubriatus (Gabb)	Rostillinda dilleri (White)	Cucullaea gravida (Gabb)	Ostrea malleiformis Gabb	Pteruluter uthnius Saul	Willimactra putida Saul	Ampullina pseudoalveata (Packard)	Crassatella gamma Popenoe	Subprionocyclus neptuni (Geinitz)	Collignoniceras(?) sp.	Calva regina Popenoe	Biplica isoplicata Popenoe	Liocium punctatum Gabb	Meekia lirata Saul and Popenoe	Atresius liratus Gabb	Jimboiceras sp.	Trigonarca sp.	Otoscaphites cf. O. planus (Yabe)	Cucullaea melhaseana Anderson	Acteon politus Gabb	Tenea sp.	Gyrodes dowelli White	Hyphantoceras sp.	Kumeniceras deverioide (de Grossouvre)	Tetragonites glabrus (Jimbo)	Eriphyla ovoides (Packard)	Garramites sp.	Meekia takeoena Saul and Popenoe	Turritella hearni Anderson	Acteonella frazierensis Anderson	Glauconia robusta (Gabb)	Mellitia salsa Saul	Tragodesmoceras ashlandicum Anderson	Otoscaphites puerculus (Jimbo)
MELTON SANDSTONE	5421	C	R	A	R	R	A	C	R	C	R	R	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1266	R	-	R	R	-	-	-	-	-	-	-	-	C	A	A	R	R	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4213	R	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1265, 1269	-	-	C	-	R	-	-	-	-	-	-	-	-	C	-	-	R	C	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1264	R	-	R	-	-	-	C	-	-	-	-	-	R	R	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FRAZIER SILTSTONE	4654	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1443	-	-	-	-	-	-	C	-	-	-	-	-	R	-	-	R	-	-	-	-	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6053	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1268, 1215	C	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	A	R	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1532	R	-	A	-	-	-	-	-	A	C	-	-	-	-	R	-	-	-	-	-	-	-	-	-	R	R	-	C	R	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1267	-	-	-	-	-	-	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1533, 4658	-	-	-	-	-	-	C	-	A	C	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1221	R	A	A	C	-	R	C	-	-	-	-	-	-	-	A	-	-	-	-	-	C	-	-	-	-	-	-	R	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1212	R	A	A	R	-	R	R	-	-	-	-	-	-	-	A	-	R	-	-	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1531	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4650, 4214	-	A	-	-	-	-	-	-	-	-	-	-	-	-	R	-	A	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-
	4652	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-
	1032	R	A	-	R	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-
	1190	-	C	-	R	-	-	-	R	-	-	-	-	-	-	R	-	R	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	A	-	-	R	R	-	-	-	-	-	-	-	-	-
	1201	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	C	-	-	-	-	-	-	-	-	R	-	-	C	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-
	4651	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-
	1210, 1599	R	R	-	-	-	-	R	-	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	R	A	-	-	-	-	-	R	-	-	-	-	-	-	-
	1011, 1033, 1206, 1200	R	A	C	R	-	-	R	-	-	-	-	-	-	-	-	A	C	-	-	-	-	-	-	-	R	-	-	A	-	-	-	-	A	A	R	-	-	-	-	-	C	-	-	-	-	-	-
BELLAVISTA SANDSTONE	1199	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1198, 1445	-	R	-	-	-	-	-	-	-	-	-	-	-	A	-	R	R	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	C	-	-	-	-	-
	1203, 4653	A	A	-	-	A	-	C	-	-	-	-	-	R	A	A	-	A	-	-	-	-	-	-	A	R	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	C	-	-	-	-	-	-
	6054	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1195, 1438, 1439, 1444	A	R	-	-	C	A	R	-	-	-	-	-	R	A	-	A	C	-	R	-	-	-	-	A	R	R	-	-	-	-	-	-	-	-	C	-	-	-	-	A	C	-	A	R	R	R	-
	1010, 1194, 1196, 1197	C	-	-	-	R	A	-	-	-	-	-	-	A	A	-	-	R	-	R	R	-	-	-	A	C	R	-	A	-	-	-	-	A	A	[illegible]	-	-	-	-	-	C	C	-	R	-	-	C
	1446	A	-	-	-	R	-	-	-	-	-	-	-	-	A	-	A	R	-	-	-	-	-	-	R	A	R	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-
	1436, 1437	C	-	-	-	C	R	-	-	-	-	-	-	R	A	-	R	R	-	-	R	-	-	-	-	A	-	-	-	-	-	-	-	-	-	R	-	-	-	-	R	C	A	-	R	-	-	-
	1205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1192, 1209	-	-	-	-	-	R	R	-	-	-	-	-	R	-	-	-	A	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-
	1193	R	-	-	-	-	R	-	-	-	-	-	-	A	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
	1204	R	R	-	-	R	-	-	-	-	-	-	-	-	A	-	C	R	-	-	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	R	-	-	-	-
	1207	A	-	-	-	A	A	R	-	-	-	-	-	A	-	-	R	-	-	-	R	-	-	-	-	R	-	-	-	-	-	-	-	R	-	R	-	-	-	-	-	-	-	-	C	-	-	-
	1202	-	-	-	-	-	A	-	-	-	-	-	-	R	R	-	-	-	-	-	R	-	-	-	R	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-
	1191, 1217	-	-	-	-	-	R	-	-	-	-	-	-	A	R	-	-	-	-	-	-	-	-	-	R	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-
	1208	C	-	-	-	R	A	-	-	-	-	-	-	A	A	-	R	-	-	R	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	-
	1009	R	-	-	-	-	R	-	-	-	-	-	-	C	R	-	-	C	-	-	R	-	-	-	-	-	-	-	-	A	-	-	-	R	-	-	-	-	-	-	-	-	-	R	A	-	-	-
	1440	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-

PLATE 1

EXPLANATION OF ILLUSTRATIONS — GASTROPODA

All figures are natural seize except where otherwise stated.

Fig. 1. — *Acteon politus* Gabb.

Hypotype. loc. no. 1257, Bellavista sandstone, Swede Creek, X 4.

Fig. 2. — *Acteonella frazierensis* Anderson.

Hypotype. Loc. no. 1439, Bellavista sandstone, Little Cow Creek.

Fig. 3. — *Acteonella oviformis* Gabb.

Hypotype Loc. no. 1208, Bellavista sandstone, Salt Creek

Fig. 4, 5. — *Biplica isoplicata* Popeneo.

Holotype, apertural and abapertural views, X 5. Loc. no. 1208, Bellavista sandstone, Salt Creek.

Fig. 6. — *Volutoderma mitraeformis* (Gabb).

Hypotype. loc. no. 1001, Sand Creek, 4 miles north of Redding, Bellavista sandstone.

Fig. 7. — *Rostellinda dilleri* (White)

Hypotype. loc. 1212, Little Cow Creek, Frazier siltstone.

Fig. 8, 9. — *"Trophon" condoni* White.

Hypotype. loc. no. 1212 (ibid.) Frazier siltstone.

Fig. 10. — *Arrhoges californicus* Gabb.

Hypotype. loc. no. 1212 (ibid.) Frazier siltstone.

Fig. 11. — *Gymnarus manubriatus* (Gabb).

Hypotype. Loc. no. 1197, Bellavista sandstone.

Fig. 12. — *Oonia ? californica* (Gabb).

Hypotype. loc. no. 1032, basal Frazier siltstone, Dry Creek.

Fig. 13-14. — *Gyrodes dowelli* White.

Hypotype, apertural and apical views. Loc. no. 1195, Bellavista sandstone, Stinking Creek.

Fig. 15. — *Anchura condoniana* Anderson.

Hypotype. loc. no. 4214, bed of Little Cow Creek, Frazier siltstone.

Fig. 16-17. — *Gyrodes conradiana* (Gabb).

Hypotype. Loc. no. 1195, Stinking Creek. Bellavista sandstone.

X Fig. 18. — *"Ampullina" pseudoalveata* (Packard).

Hypotype. loc. no. 2323, Baker Canyon Sandstone, Silverado Canyon, Santa Ana Mountains, Orange County, California.

Fig. 19. — *Glauconia ? robusta* (Gabb).

Hypotype. loc. no. 1194, Dry Creek, Bellavista sandstone.

Fig. 20. — *Atresus liratus* Gabb.

Hypotype, X 5. Loc. no. 1532, right bank Little Cow Creek. Melton sandstone.

Fig. 21. —*Lioicium punctatum* Gabb.

Hypotype. Loc. no. 1532 (ibid.), X 2 Right bank Little Cow Creek, Melton sandstone.

Fig. 22. — *Garramites* sp.

Panoche formation, near Moore Cabin, Arroyo Pinoso, Dark Hole (1961)7 1/2 USGS topographic quadrangle, near center of sec. 26, T. 22 S., R. 15 E., Fresno County, California. X 5.