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FORMATION OF CALIFORNIA

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MOLLUSCA OF THE CRETACEOUS BALD HILLS FORMATION OF CALIFORNIA

PART I

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ABSTRACT—A well preserved molluscan fauna has been collected from previously undescribed Cretaceous rocks in the northwestern Sacramento Valley, California. The fossils occur in the Bald Hills formation, a 1000-foot to 1900-foot thick south-east dipping conglomerate, graywacke, and mudstone unit which ranges in age from Late Albian to Late Cenomanian. The gastropod and cephalopod elements of this fauna number thirty-two species, seventeen of which are new.

New species described are: *Solariella stewarti*, *Tessarolax trinalis*, *Gyrodes allisoni*, *Gyrodes greeni*, *Ampullina stantoni*, *Ampullina mona*, *Euspira popenoei*, *Euspira marianus*, *Paleosephaea sacramentica*, *Clinura anassa*, *Acteon sullivanae*, *Cyllichia andersoni*, *Mariella (Mariella) fricki*, *Turrilites (Turrilites) dilleri*, *Puzosia puma*, *Puzosia sullivanae*, *Eogunnarites matsumotoi*.

INTRODUCTION

A LARGE number of well preserved Cretaceous mollusks has been collected from previously undescribed rocks in the northwestern Sacramento Valley, Shasta County, California. This paper describes and discusses the cephalopod and gastropod elements of this fauna and defines the Bald Hills formation, the unit in which they occur.

The writers wish to acknowledge the comments and suggestions of Ralph Imlay, David Jones, Tatsuro Matsumoto and Willis Popenoe concerning the systematic part of this paper, and the financial assistance of the Humble Oil and Refining Company, the University of California, Riverside Intramural Research Fund and the National Science Foundation during the field investigations.

THE BALD HILLS FORMATION

The Bald Hills formation is a conglomerate, sandstone and mudstone unit cropping out in the northeast quarter of the Ono Quadrangle (see index map). It rests conformably on the dark gray mudstone of the Ono formation (Murphy, 1956, p. 2105-2111) and is overlain conformably by an as yet unnamed Upper Cretaceous mudstone

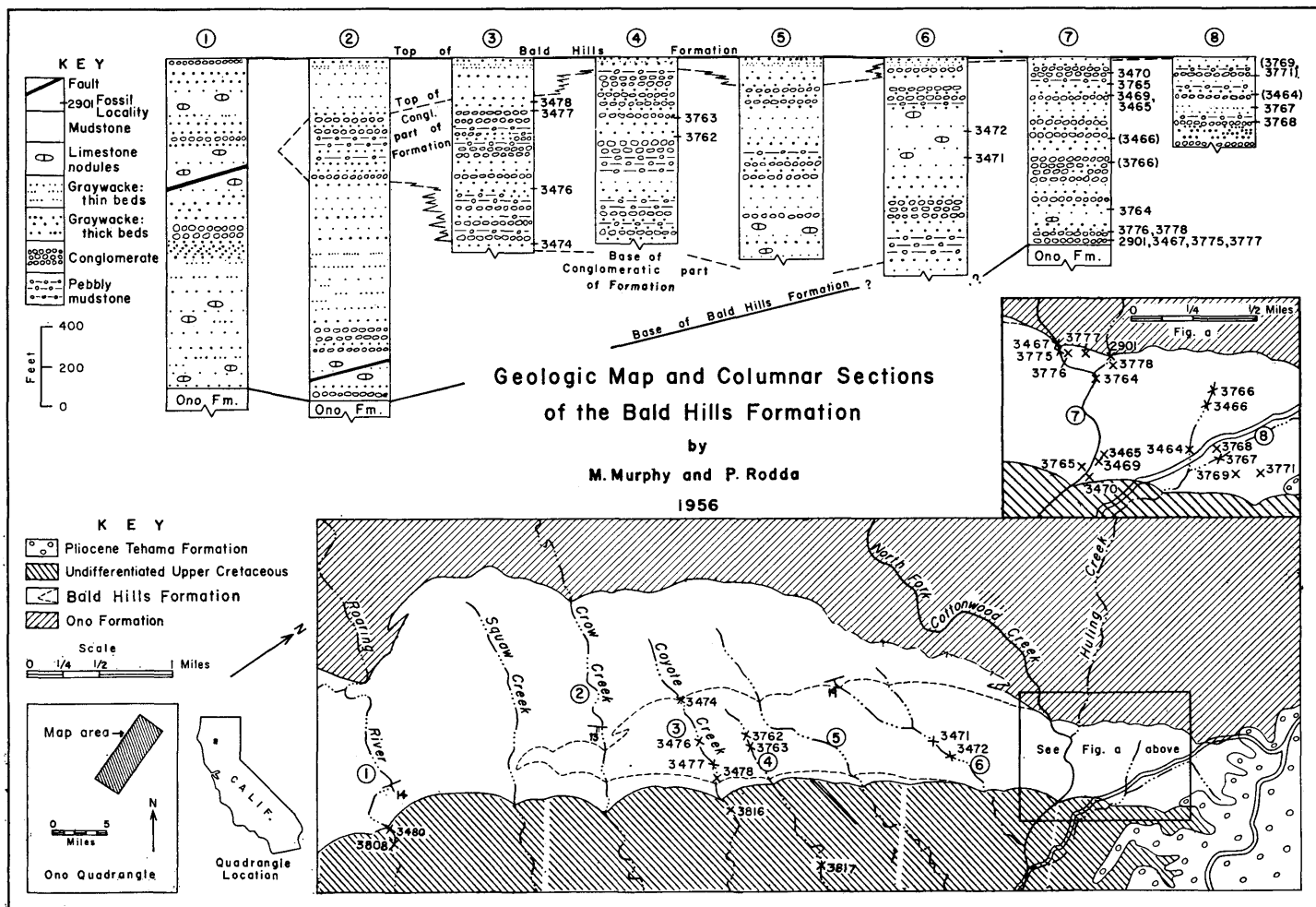
unit. The formation as presently recognized has been traced from the Igo-Cottonwood road south-southwest to Roaring River and supports the relatively high ridges of the Bald Hills from which it derives its name. The conglomerate units in this part of the section on Dry Creek in Tehama County probably should be included in the formation but detailed mapping in that area is not yet complete.

In the area adjacent to the North Fork of Cottonwood Creek the base of the formation is marked by a fossiliferous bed of cobble conglomerate about 10 feet thick. This conglomerate or a similar unit is exposed at the base of the formation at outcrops between the North Fork and Crow Creek. The base of the formation farther south on Roaring River is marked by a thick bed of graywacke.

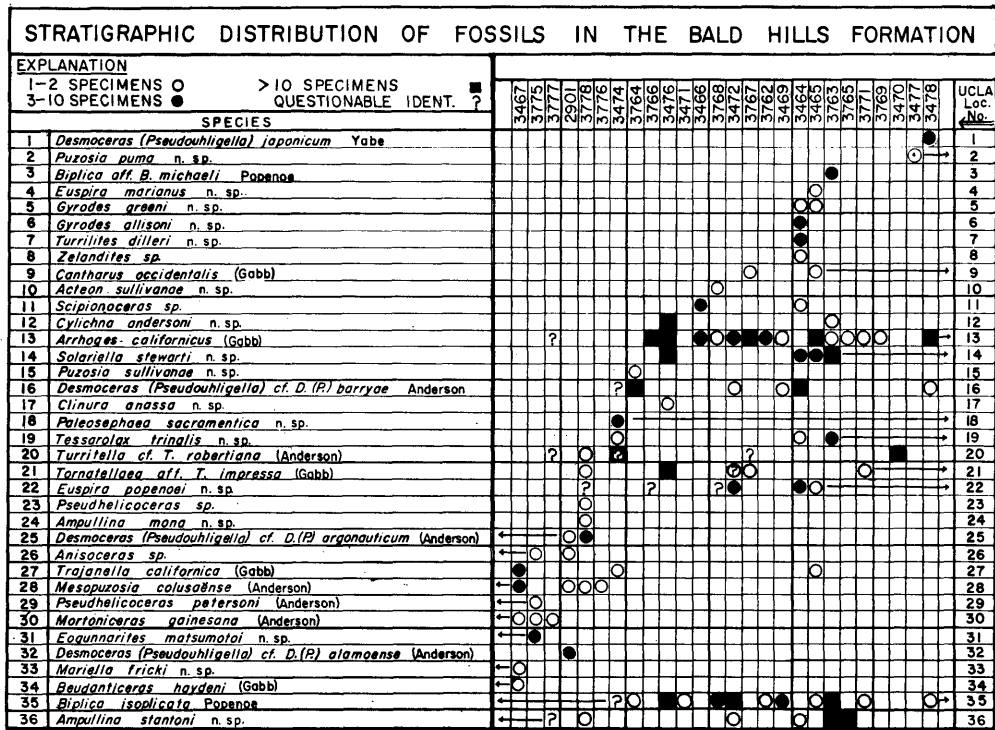
The top of the Bald Hills formation is usually marked by a sequence of closely spaced, thin graywacke beds (see columnar sections 2 to 6, plate 1) followed by one or two thick graywacke beds which, in turn, are overlain by the mudstone of the overlying formation. On the North Fork of Cottonwood Creek the contact is gradational between coarse-grained sandstone and conglomerate and the mudstone of the overlying formation.

At the northeastern end of its outcrop area the Bald Hills formation contains many conglomerate beds distributed throughout

¹ Cost of two plates borne by National Science Foundation.



TEXT-FIG. 1—Geologic map and columnar sections of the Bald Hills formation.



TEXT-FIG. 2—Stratigraphic distribution of gastropods and pelecypods in the Bald Hills formation. Arrows indicate that the species has also been found above, or below, the Bald Hills formation.

the section. Some of these beds have been traced for strike distances of half a mile before pinching out or being lost under a soil and vegetation cover. As the formation is traced southward the highly conglomeratic portion of the section becomes restricted to the upper part of the formation and fewer conglomerate beds are present. This part of the formation is outlined on the map by a somewhat arbitrarily placed dashed line.

Other conglomerates are exposed in the lower part of the formation on Roaring River and Crow Creek. On Crow Creek a small lens about 150 feet thick occurs about 300 feet above the base of the formation. A strongly conglomerate section about 75 feet thick occurs about 700 feet above the base of the formation on Roaring River. This conglomerate is apparently the northern extension of a conglomerate unit that extends at least as far south as the Middle Fork of Cottonwood Creek. Its northern limit is the first small valley north of Roaring River.

The conglomerates of the Bald Hills formation are similar throughout. The grain size ranges from fine sand to boulders with the average cobble about 2 inches in diameter. The clasts are usually well rounded and set in a matrix of medium- to coarse-grained graywacke or very sandy mudstone. The majority of the cobbles are dark colored porphyritic volcanic rocks. The remainder includes metamorphic and granitic rocks, cherts, and mudstone and limestone clasts. The conglomerates are sometimes fairly well bedded, especially near their tops. The bases of the conglomerate units are usually irregular, perhaps as a result of channeling or other disturbances of the underlying sedimentary rocks which are predominantly mudstones. At their tops the conglomerate beds almost always grade upward to massive, then finely bedded sandstone.

The type section of the Bald Hills formation is in the Bald Hills along Crow Creek in sections 25, 26, and 31, T. 30 N., R. 7 W.,

Mount Diablo Base and Meridian. The type section was chosen here because it is almost continuously exposed from base to top and shows a more or less usual sequence of rock types for this stratigraphic interval in the Ono Quadrangle.

LITHOLOGY OF THE TYPE SECTION

350'	graywacke and mudstone—alternating sequence in which the thickness of the graywacke beds gradually diminishes from bottom to top, averaging 3' per bed in the lower part of the unit, 1' per bed in the middle part of the unit and 6 inches per bed in the upper part of the unit. At the top of the sequence is a graywacke bed two feet thick. This unit marks the top of the Bald Hills formation.
10'	conglomerate and graywacke
180'	mudstone and graywacke (60%) alternating with pebbly mudstone (40%).
50'	graywacke and mudstone—as below
6'	pebbly mudstone—scattered cobbles averaging two inches in diameter in a matrix of sandy mudstone.
50'	graywacke and mudstone—as below.
2'	conglomerate
370'	graywacke (60%) and mudstone (40%)—as below; graywackes range in thickness from 4 inches to 1 foot.
500'	mudstone—massive, dark gray mudstone with a few thin, flaggy graywacke beds intercalated
150'	conglomerate—cobble conglomerate lentil that lenses out rapidly in both directions in the outcrop.
200'	graywacke and mudstone—medium—to coarse-grained graywacke beds ranging in thickness from a few inches to about two feet interbedded with approximately equal thicknesses of finer grained graywacke and mudstone; the graywacke beds are very well indurated and rarely contain fossils.
2'	conglomerate, fossiliferous, average cobble size about 2 inches
1870'	Total

THE AGE OF THE BALD HILLS FORMATION

The Bald Hills formation ranges in age from upper Albian through Cenomanian and possibly into the lower Turonian.

The oldest definitely dated bed is the nodular mudstone lying next above the lowest conglomerate on Huling Creek. This unit has yielded specimens of *Pseudhelicopteras*, *Desmoceras* (*Pseudouhligella*) and *Mesopuzosia*. This assemblage places it in the upper Albian even though this position

is far below the reported range of *Mesopuzosia*.

The top of the formation in the area adjacent to the North Fork of Cottonwood Creek is below the last occurrence of *Eogunnarites* and *Desmoceras* (*Pseudouhligella*) and, therefore, is probably of Cenomanian age. The top of the formation on Roaring River is just a few feet below U.C.L.A. Locality 3808 which has yielded a specimen of *Gaudryceras* cf. *G. densiplicatum* (Jimbo), a form not found below the Turonian in Japan.

The lowest unit of the formation on the North Fork of Cottonwood Creek and on Huling Creek is a very fossiliferous cobble conglomerate from which the majority of the ammonite specimens collected in the formation have come. On the North Fork this unit consists of a lower 2–3 feet of conglomerate with a sandy matrix. This grades upward into a typical "pebbly" mudstone about three to four feet thick. The upper four feet of the unit consists of cobble conglomerate in a mud and sand matrix. The clasts are largely of limestone derived from the underlying formation or from deposits accumulating penecontemporaneously in other areas. It is in the limestone nodules that the bulk of the well-preserved fossils occurs. It is impossible in many cases to tell whether these nodules are indigenous or derived from another source but in many instances it is clear that they are clasts in the conglomerate. The evidence for reworking is as follows:

- (1) the presence of ammonites otherwise only known from the Aptian or Barremian parts of the section in the nodules e.g. *Phylloceras* sp. (an Aptian form) and *Shastrioceras* sp. (a Barremian form);
- (2) hemispherical nodules with the edges of the flat side angular because of breaking during transportation;
- (3) blocks of *Cucullaea truncata*-bearing sandstone in a muddy sandstone or mudstone matrix of different grain size, color and texture;
- (4) all fossils found in the matrix are broken and weathered and show evidence of transportation, whereas the fossils in the nodules are excellently preserved and most are different species;
- (5) no evidence that fossils only partially enclosed in nodules were ever present in the adjacent matrix;
- (6) the nodules are oriented in the conglomerate against other clasts as would be expected for clasts, i.e., they touch but never

fit around other clasts; they have shell debris plastered on the outside but never incorporated in the nodule; they are arranged with their long dimensions at various angles to the bedding, a condition not yet encountered in the nodular mudstones in other parts of the section.

From the above listed data it is inferred that most, if not all, the forms occurring in nodular limestone in the conglomerate are reworked. The age of this bed is upper Albian. This age assignment is based on the stratigraphic position of the bed between the upper Albian bed bearing *Pseudhelicoceras* which lies immediately above, and the upper Albian beds below bearing *Mortonicerias*, *Desmoceras* (*Pseudouhligella*), and *Zelandites*.

Some of the species found in the nodules and other reworked sedimentary rocks were extant at the time this conglomerate unit was deposited. For example, *Mesopuzosia colusaense* (Anderson) occurs free in the matrix, in nodular limestone clasts in the conglomerate, and in the nodular mudstone above the unit; *Cucullaea truncata* Gabb occurs below, above and in the matrix of the conglomerate as well as in the clasts in the conglomerate.

Many of the fossils found in clasts in the conglomerate are also upper Albian in age. This age is certain as the lowest occurrence of many of the genera in the clasts is upper Albian, e.g. *Eogunmarites*, *Mariella*, *Desmoceras* (*Pseudouhligella*), and *Anisoceras*. Beds with *Pseudhelicoceras*, whose range is middle and upper Albian, lie immediately above the conglomerate.

These facts show that during the upper Albian active uplift and erosion of Cretaceous sediments ranging in age from at least Barremian to Albian was taking place in northern California, probably in areas not too distant from the present outcrop of this unit. The direction of these localities is as yet unknown.

SYSTEMATIC DESCRIPTIONS

Class GASTROPODA

Family TROCHIDAE

Genus SOLARIELLA Wood, 1842

SOLLARIELLA STEWARTI n. sp.

Pl. 103, figs. 4, 5

Shell small, low spired, turbinata, spire about one half the height of the shell; whorls

number about 5; shell covered by numerous spiral lines which are most prominent in the umbilicus and on the shoulder and faintest, sometimes nearly absent, at the middle of the whorl; lines of growth slant well forward from just above the umbilical edge to the posterior margin of the whorl; distinct rib-like crenulations are present on the shoulder and umbilical angle; the crenulations are prominent and about 45 in number on the penultimate whorl but poorly developed on the last whorl; aperture sub-circular, acute posteriorly; umbilicus perspective, deep.

Types.—The holotype and paratype are numbers 28622 and 28623, respectively, in the U.C.L.A. Invert. Paleo. Catalogue. Dimensions: height 8 (7) mm., height of spire 4 (3½) mm., maximum width of shell 10 (7½) mm., respectively.

Remarks.—The species is found in abundance at localities 3476 and 3763 in the upper part of the Bald Hills formation. It also occurs in the overlying formation.

S. stewarti somewhat resembles published figures of *S. angulata* (Gabb) (Gabb, 1869, pl. 28, fig. 55; Stewart, 1926, pl. 24, fig. 17), but adequate comparisons are difficult to make. *S. angulata* appears to have a higher spire, a more gently sloping posterior flank, and an angulate whorl profile. The type lot of *S. angulata* has been examined, but the lectotype was not present, and is presumably lost. None of the other specimens in the type lot appears to be conspecific with *S. angulata*, but two other species are represented, one of which is *S. stewarti* n. sp. The other species is undescribed. Gabb reported *S. angulata* only from Martinez.

This species is named for Ralph Stewart.

Family PSEUDOMELANIIDAE

Genus TRAJANELLA Popovici-Hatzeg, 1899

TRAJANELLA CALIFORNICA (Gabb)

Pl. 101, fig. 30

Acteonina californica Gabb, 1864, p. 114, pl. 19, fig. 68; Stewart, 1926, p. 433, pl. 24, fig. 21; Anderson, 1958, p. 156, pl. 29, fig. 1.

Shell large, thick, elongate conoid; spire about one half the height of shell; whorls high and number about 7; ornamented only by sinuous lines of growth that are usually faint but sometimes incised and prominent; whorls shallowly and evenly convex; suture shallowly impressed; inner lip and part of

the base of aperture covered by moderate to heavy callus.

Type specimen.—Stewart (1926, p. 433, pl. 24, fig. 21) studied Gabb's original material but did not select a lectotype. According to Stewart two lots of the type material exist. The material at the Academy of Natural Sciences of Philadelphia is labeled "Benicia." The remaining material is at the University of California, Berkeley and is labeled "8 M. N. of Yreka and Martinez." Anderson (1958, p. 156, pl. 29, fig. 1) chose a specimen from Thompson Creek, Yolo County (C.A.S. Loc. 31918) as the neotype. This designation must be considered invalid as the original material has not been lost even though not well preserved. In addition, Anderson's neotype is not from any of the localities listed by Gabb.

Hypotype.—The figured specimen is number 28624 in the U.C.L.A. Invert. Paleo. Catalogue. Dimensions: height 52 mm.; height of spire 32 mm.; maximum width of body whorl 25 mm. Locality: U.C.L.A. 3474.

Remarks.—*Acteonina californica* Gabb is probably a *Trajanella* and is likely conspecific with our specimens (see pl. 101, fig. 30). Gabb's figure is an outline drawing that has a whorl profile that is more inflated than our specimen. The figure is labeled "natural size" and, therefore, represents a specimen considerably larger than the ones from the Bald Hills formation. The specimen figured by Stewart is but a longitudinal section through the shell. Stewart's figured specimen is about the same height as the specimen figured in this paper, but is wider and has a lower spire. Apparently all of Gabb's material was fragmentary and Stewart did not select a lectotype. He did, however, state that there is "considerable variation in the height of the spire of these specimens and they may include more than one species, . . .". Although none of Gabb's material has been examined, a number of specimens of this genus collected by F. M. Anderson has been examined at the California Academy of Sciences. There is a great

EXPLANATION OF PLATE 101

All figures natural size except as otherwise indicated.

- FIGS. 1-4—*Biplica* aff. *B. michaeli* Popenoe, 1,3, two views of specimen 28651 U.C.L.A. Invert. Paleo. Cat. showing plication on columella and ornamentation and shape of shell; 2,4, two views of specimen 28650 U.C.L.A. Invert. Paleo. Cat. showing excavated aperture and posterior plication, $\times 2$.
- 5-8—*Tornatellaea* aff. *T. impressa* (Gabb), 5, ornamentation of body whorl of specimen 28644 U.C.L.A. Invert. Paleo. Cat.; 6, view illustrating spire of small specimen. U.C.L.A. Invert. Paleo. Cat. 28646; 7, specimen 28645 U.C.L.A. Invert. Paleo. Cat.; 8, apertural view of specimen 28643 U.C.L.A. Invert. Paleo. Cat. showing columellar plication, $\times 2$.
- 9-11—*Ampullina stantoni* n. sp. 9, view illustrating shape of shell, ornamentation of body whorl of holotype U.C.L.A. Invert. Paleo. Cat. 28631; 10, apertural view of specimen 28632 U.C.L.A. Invert. Paleo. Cat. showing umbilicus; 11, view of specimen 28633 U.C.L.A. Invert. Paleo. Cat. showing shape of aperture, outer lip slightly damaged.
- 12,13—*Ampullina mona* n. sp. Two views of holotype; specimen 28634 U.C.L.A. Invert. Paleo. Cat.
- 14-17—*Biplica isoplicata* Popenoe. 14,15, apertural views specimen 28647 U.C.L.A. Invert. Paleo. Cat. showing columellar plications; 16, view showing spire and ornamentation of specimen 28649 Invert. Paleo. Cat.; 17, view showing complete outer lip and ornamentation of specimen 28648 U.C.L.A. Invert. Paleo. Cat., $\times 2$.
- 18-20—*Gyrodres allisoni* n. sp. 18,19 two views of holotype, 28629 U.C.L.A. Invert. Paleo. Cat., showing ornamentation and shape of shell; 20, view of a small specimen, 28639 U.C.L.A. Invert. Paleo. Cat., showing the double angulation between the umbilicus and whorl flank.
- 21-23—*Euspira popenoei* n. sp. Three views of holotype, 28635 U.C.L.A. Invert. Paleo. Cat.
- 24-26—*Euspira mariana* n. sp. Three views of holotype, 28636 U.C.L.A. Invert. Paleo. Cat.
- 27-29—*Gyrodres greeni* n. sp. Three views of holotype, 28630 U.C.L.A. Invert. Paleo. Cat.
- 30—*Trajanella californica* (Gabb). Apertural view of specimen 28624 U.C.L.A. Invert. Paleo. Cat.